CDC's Early Response to a Novel Viral Disease, Middle East Respiratory Syndrome Coronavirus (MERS-CoV), September 2012–May 2014

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ABSTRACT

The first ever case of Middle East Respiratory Syndrome Coronavirus (MERS-CoV) was reported in September 2012. This report describes the approaches taken by CDC, in collaboration with the World Health Organization (WHO) and other partners, to respond to this novel virus, and outlines the agency responses prior to the first case appearing in the United States in May 2014. During this time, CDC's response integrated multiple disciplines and was divided into three distinct phases: before, during, and after the initial activation of its Emergency Operations Center. CDC's response to MERS-CoV required a large effort, deploying at least 353 staff members who worked in the areas of surveillance, laboratory capacity, infection control guidance, and travelers' health. This response built on CDC's experience with previous outbreaks of other pathogens and provided useful lessons for future emerging threats.

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Within the past eight decades, an average of five or six emerging infectious diseases have appeared annually worldwide.[1] In an era of rapid global travel, a novel pathogen can quickly disseminate and cause widespread illness and death, which can stress health-care systems and devastate economies. Almost any emerging illness, regardless of its origin, has the potential to become a public health emergency. On September 20, 2012, one such illness was reported in the online Program for Monitoring Emerging Diseases (ProMED). The report noted that a novel human coronavirus had been isolated from a patient in Saudi Arabia. Three days later, Public Health England sent a notification through the Early Warning and Response System for Communicable Diseases[2] about the presence of a novel coronavirus in a patient from Qatar (in the United Kingdom) with severe respiratory illness. Under the International Health Regulations (IHRs),[3] the British agency alerted the World Health Organization (WHO) to the issue. With these notices, countries began to quickly initiate surveillance to detect additional cases of this new disease, describe its features, and monitor the evolution of the illness.

Working with WHO and using lessons learned from previous global outbreaks,[1,4,5] the U.S. Centers for Disease Control and Prevention (CDC) quickly launched a response to this novel virus, later referred to as the Middle East Respiratory Syndrome Coronavirus (MERS-CoV). The emphasis of the response was on prevention, case identification, and mitigation, as there were (and still are) no vaccines available and no antivirals recommended for MERS-CoV. This article describes how CDC used a multidisciplinary approach to prepare for possible cases of MERS-CoV in the United States and to assist both domestic and international partners. It details the array of public health activities undertaken in the various stages of the response, describes the domestic and global collaboration that has been needed to strengthen the response, highlights successful strategies, and identifies additional lessons learned.

This article is not offered as a critique of CDC's performance during the MERS-CoV response; rather, it is intended to provide a glimpse of the many kinds of activities that comprised the early response, explain how the activities were coordinated internally at CDC, and comment on what worked well. Insights from this response are already being used to help strengthen planning for threats from future emerging diseases. Although cases of MERS-CoV are continuing to occur in the world as of May 2015, this article focuses on the period of time after the initial recognition of the disease and before the first case of MERS-CoV was reported in the United States, on May 2, 2014.

BACKGROUND

When MERS-CoV began to emerge, public health authorities recognized that lessons learned from previous global outbreaks (e.g., the Severe Acute Respiratory Syndrome [SARS] pandemic in 2002–2003 and the 2009 pandemic of influenza A [H1N1] virus in 2009) could prove highly useful. An Institute of Medicine report[4] had critically examined the response to SARS and noted the importance of early detection through global disease surveillance, effective communication, promotion of research and development, strategies for containment, and multinational collaboration in implementing response strategies.[5–10] The multipronged strategies mentioned in these reports included adequate and timely production of vaccines and antivirals; equitable access to antivirals and vaccines; community mitigation strategies; case-management strategies, including case ascertainment and strong diagnostics; health resource management; health-care system readiness, including educating health-care workers about the threat; health education for the public; rumor control; improved integration of health care and public health; consideration of a "one health" approach that focuses on the interaction among animal and human health within an environmental context; and effective and timely communication with the public (including specific information for patients and significant others), health-care workers, news media, policy makers, and within the response teams. The literature emphasized that global communication and technical collaboration among countries is essential for response networks, such as the Global Outbreak Alert and Response Network,[11] to function efficiently. Lastly, adequate resources, both financial and technical, are needed to ensure a robust response.

To bolster global public health efforts to address potential public health emergencies, the IHRs (revised in 2005 and enacted in 2007) now say that all member states have obligations for surveillance, response, and collaboration when facing a global disease threat.[12] However, developing countries face large challenges in meeting the requirements of the IHRs, due to insufficient capacity for planning and preparedness, inadequate health infrastructure, and a paucity of technical expertise.[13] In these circumstances, the need for collaborative support and resources from other countries becomes critical.[6,13] Consideration of these lessons learned and a strong history of outbreak response laid the framework for CDC's preparations for MERS-CoV and preceded recognition of the first case in the United States.

CDC EARLY RESPONSE TO A NOVEL DISEASE

A new disease emerges

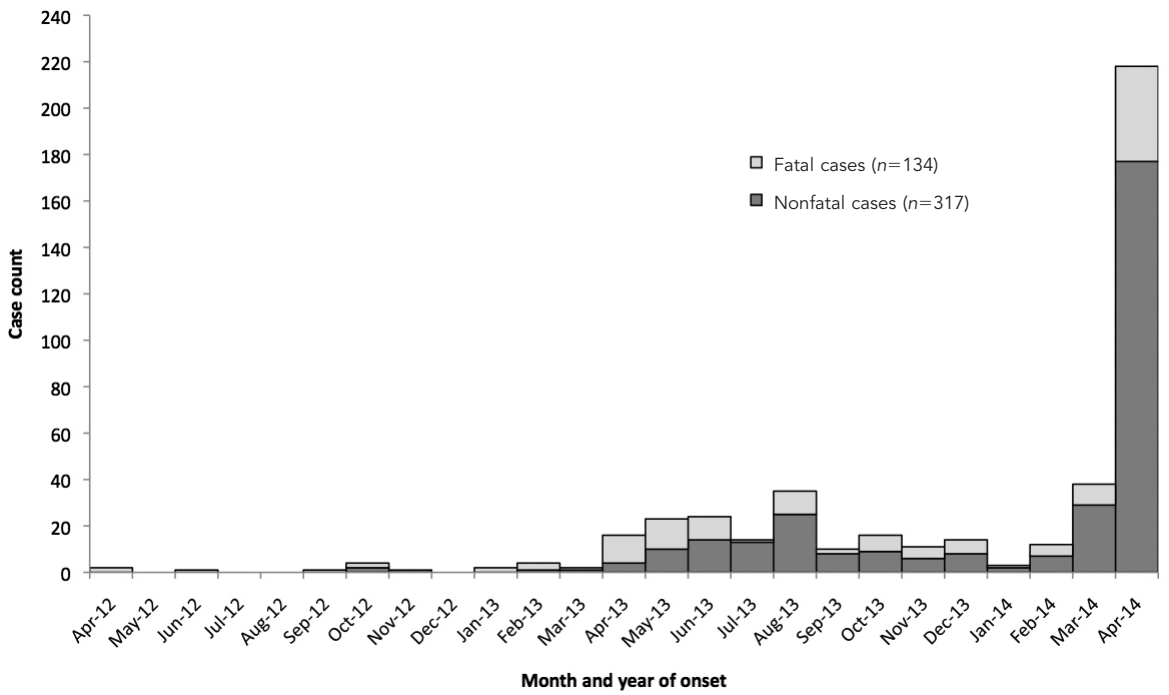
In June 2012, Erasmus Medical Center in the Netherlands sequenced a previously unknown human coronavirus from a patient from the Kingdom of Saudi Arabia (KSA). This first case of MERS-CoV was reported in September 2012. Later and retrospectively, CDC and the global community learned of a hospital-associated outbreak of respiratory illnesses that had occurred in Jordan in April 2012; at that time, no cause of the illnesses was identified, and testing for other respiratory pathogens was negative. In September 2012, however, available specimens from two individuals tested positive for MERS-CoV.

Following the report in ProMED in September 2012, CDC, acting with its domestic and global partners (including WHO), initiated response activities. WHO published an interim case definition on September 25, 2012. CDC published the first *Morbidity and Mortality Weekly Report* on MERS-CoV on October 12, 2012.[14] On September 27, 2012, methods for the first diagnostic molecular assays for MERS-CoV were published, and assay reagents were made available by the Institute of Virology, University of Bonn Medical Center.[15] In November 2012, the complete genome sequence was published by a multinational group of scientists.[16]

WHO convened two meetings of the IHR Emergency Health Committee on July 9 and July 17, 2013, to assess the situation.[17] The committee determined that the situation was serious and of great concern, but the conditions for a public health emergency of international concern[18] had not been met. During the second of the July meetings, and in subsequent meetings on September 25, 2013, December 4, 2013, and May 13, 2014, members of the committee stressed the need for investigations, including international case-control, serological, environmental, and animal–human interface studies, to better understand the epidemiology and risk factors.[19]

The first U.S. case of MERS-CoV was reported on May 2, 2014. By that time, a total of 261 WHO-confirmed cases, with 93 deaths worldwide, had been reported. At that time, an additional 190 cases, including 41 deaths, were pending WHO's confirmation. Reported illness onset for confirmed cases occurred from April 2012 to April 2014 (Figure 1). Most of the confirmed cases resided in KSA (183 cases, 70.1%) and

Figure 1. Middle East Respiratory Syndrome Coronavirus (MERS-CoV) reported cases by outcome and month of onset, April 2012–April 2014 (451 total cases)[a]



[a]Cases to be confirmed are reported by the Ministry of Health and are pending World Health Organization confirmation. Data shown are as of May 1, 2014.

were male (178 cases, 68.2%), with a median age of 50 years (range: 2–94 years). All of the confirmed cases to that point either resided in or had recently traveled to the Arabian Peninsula or had been in contact with an ill traveler from that area. Importations of the disease had been reported in the United Kingdom, France, Tunisia, Italy, and Malaysia. Among the fatalities, as of May 2, 2014, information was not available for five cases. Among the remaining 88 fatal cases, 70 (84.3%) were male, with a median age of 59 years. Notably, 73 (83.0%) of these fatal cases had a comorbidity (e.g., chronic renal or cardiac disease). Reminiscent of SARS, health-care workers represented 59 (23%) cases. Twenty-four distinct spatiotemporal clusters had been reported (CDC. Unpublished surveillance data, 2014).

Early response phases and framework

CDC began its response to the emergence of MERS-CoV in September 2012, substantially before the first U.S. case was identified. CDC's early response can be divided into three phases, best illustrated in relationship to the activation of CDC's Emergency Operations Center (EOC): pre-EOC activation, during EOC activation, and post-EOC activation. Each phase was characterized by its own organizational structure, access to staff support, and scaling of operations up or down. Throughout the three phases, CDC collaborated widely with domestic and global partners and mounted an agency response that involved experts from across CDC's various centers. As of May 1, 2014, at least 353 CDC staff members had been involved in some aspect of this response.

Established in 2003, the EOC serves as CDC's command center for public health threats in the United States and globally. Staffed 24 hours per day, it coordinates response activities, provides resources to state and local public health departments, and supports the Secretary's Operations Center of the U.S. Department of Health and Human Services.

Phase 1: pre-EOC activation (September 2012–June 2, 2013). After the electronic ProMED report, CDC staff members gathered additional data through professional contacts, media reports, and international health authorities. CDC's National Center for Immunization and Respiratory Diseases (NCIRD), Division of Viral Diseases, was the primary point of contact for all MERS-CoV-related activities and worked in collaboration with CDC's Center for Global Health (CGH), primarily the Global Disease Detection Operations Center of the Division of Global Health Protection, and the National Center for Emerging and Zoonotic Infectious Diseases, particularly the Division of Global Migration and Quarantine and the Division of Healthcare Quality Promotion. Subject-matter experts from many areas were recruited: virology, global migration and travelers' health, epidemiology, laboratory science, law, event-based surveillance, occupational health, medical care countermeasures, health-care systems response, health-care worker safety, statistics and mathematical modeling, policy analysis, and health and risk communication.

The agency focused on a variety of activities simultaneously. To maintain situational awareness and to ensure communication across all aspects of the response, the agency held twice-weekly senior leadership and daily briefings with staff members from NCIRD's Division of Viral Diseases. Other activities included creating essential documents (e.g., internal daily and monthly reports), fashioning key points of communication, and posting Web-based travel notice updates (e.g., electronic messaging on airport monitors). CDC also collaborated with WHO to develop and maintain a line listing of all reported cases. Legal agreements were written and signed to share biological samples, a critically important activity to validate assays and characterize the virus genome. By the end of February 2013, CDC had signed a cooperative research and development agreement with Public Health England and received serum samples and a viral isolate from a MERS-CoV patient in the United Kingdom. CDC also had collaborated in global field investigations related to MERS-CoV in Jordan and KSA.

Phase 2: EOC activation (June 3–August 13, 2013). To meet increasing demands for information and strengthen preparedness as the potential threat of MERS-CoV grew and the number of cases rose, CDC leaders activated the agency's EOC on June 3, 2013, at a level III. In a level III activation, response activities are conducted Monday–Friday during regular working hours, with the expectation that only the Incident Manager and other members of the command staff and/or experts will work extended hours and on weekends. Level III activation implies that, with minimal augmentation, the designated lead national center can address the primary needs of the response, with the EOC staff supporting Incident Management System (IMS) services.[20] The decision to activate the EOC was based on the increased work demands on the response team (i.e., number of briefings and level of reporting required) and the need to augment staffing. As for all such responses, CDC used an IMS structure.[21]

Once the EOC was activated, key management activities were completed quickly with the help of the EOC staff. An Incident Action Plan (IAP) was developed that detailed planning assumptions as well as agency

strategic and operational objectives, including parameters for deactivation. Staff members developed a daily routine that was meant to assist team coordination and communication across all areas of the response. Tasks and reporting became organized and systematized under the IAP and the daily staff rhythm. An organizational chart of the response was developed and updated as needed. An abbreviated version of the organizational chart illustrating the leadership, sections, and teams is shown in Figure 2.

During this phase, CDC staff members implemented a response framework based on the principles of IMS (Table 1). The framework was divided into three main components: Incident Command, Scientific Response Section, and Emergency Operations. Incident Command oversaw all response activities and was staffed by senior-level scientists. The same person held the position of Incident Manager throughout the early response, allowing for continuity of operations. The position of Deputy Incident Manager rotated among several senior scientists. The Command structure also had an Operations Coordinator, a liaison position that directly interfaced with CGH on global issues, a Chief Science Officer, an Associate Director for Science, and policy and communications teams. CDC experts on safety, security, ethics, and law assisted the response team.

The Scientific Response Section provides a good example of the teamwork required in this response. This section was divided into topic-specific teams led by disease-control experts who had become familiar with MERS-CoV when it first emerged. Teams included Epidemiology and Surveillance, Laboratory, International Response, Global Migration and Quarantine, Medical Countermeasures, Health-care Systems Response, Health-care and Worker Safety, Modeling, and State Coordination. Some of these areas were extensively staffed and contained subgroups. The teams comprised mostly staff members who already knew each other and had worked together in other job assignments, which reduced the time needed for training and team building. When needed, CDC staff members from other national centers were recruited for temporary duty. Overall, activating the EOC strengthened the early response to MERS-CoV in that it allowed staff members to focus more directly on response activities, while relying for support on the 22 Division of the Emergency Operations staff members who are permanently assigned to all response activities.

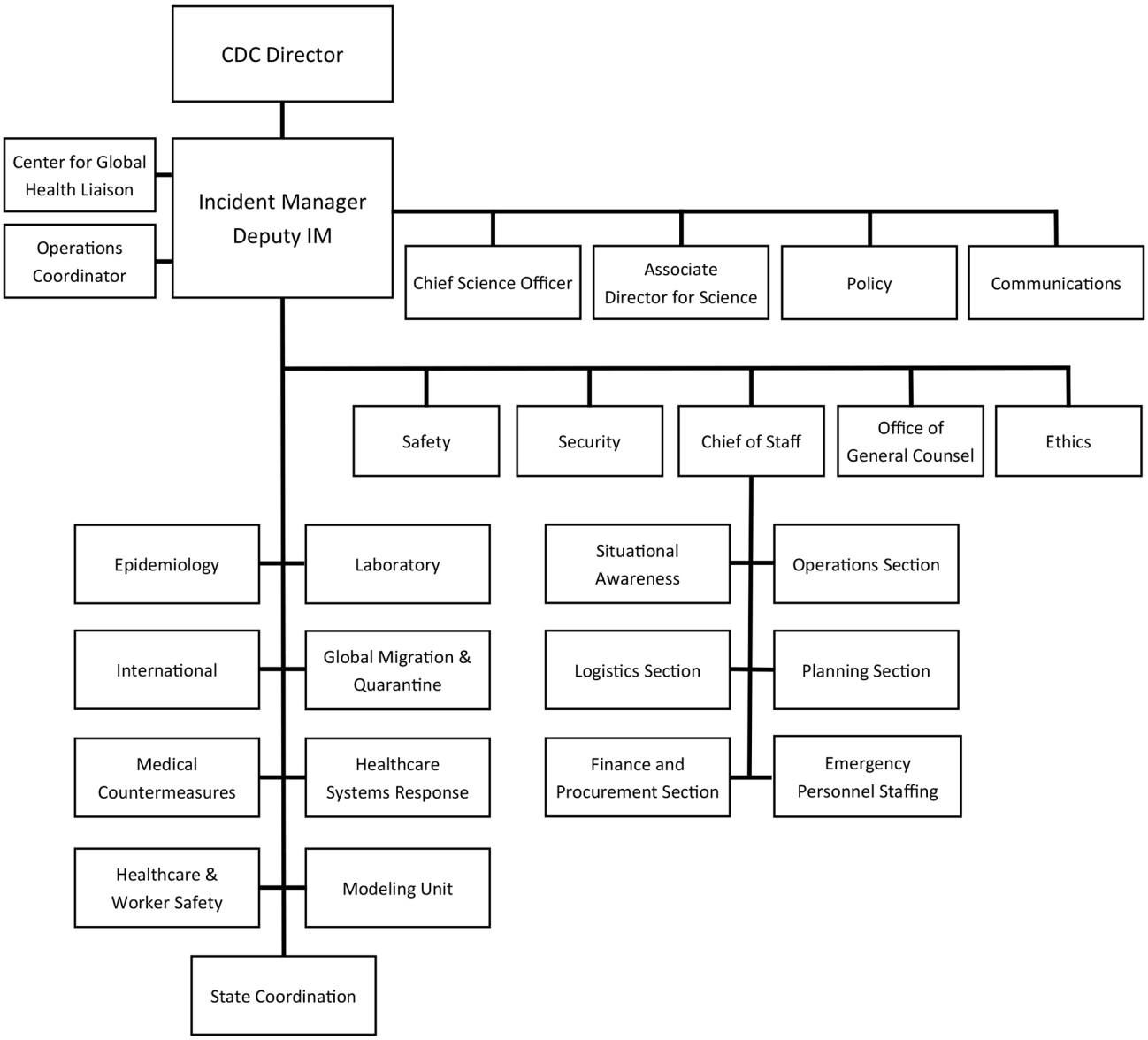
During this phase, staff members interacted frequently with global and domestic partners (Table 2). Activities focused on building laboratory capacity domestically and globally to detect MERS-CoV; testing specimens as they arrived from states or global partners; developing protocols for epidemiologic investigations; working with WHO to revise testing and surveillance recommendations; redesigning and updating the MERS-CoV Web pages; preparing clinicians, customs, and border protection agents, as well as laboratorians, for the potential importation of cases into the United States; strengthening potential border health measures; assessing air routes and traveler volumes into and out of the Arabian Peninsula to evaluate areas at potentially higher risk for MERS-CoV translocation; and educating the general public and international travelers about disease risks. Border health measures did not include screening travelers at quarantine stations. CDC signed material transfer agreements with global partners (i.e., Hong Kong University for the HKU5 N plasmid, Erasmus University for virus, and Koch Institute for serum), which made it easier to share specimens.

By August 13, 2013, 94 laboratory-confirmed cases and 47 deaths had been reported globally. However, the United States remained free of cases, and the course of the epidemic indicated that spread of the virus did not appear to have pandemic potential. By early August 2013, the scope and scale of the response was reduced. In addition, the planning objectives for the response had been met: multiple Web-based resources were available for the general public, international travelers, and public health/health-care practitioners that covered both prevention and management of imported cases. The triggers in the IAP for reducing the level of response had been met, and CDC began to reduce its scope and scale. CDC command staff and agency leadership deactivated the EOC for the MERS-CoV response on August 13, 2013. At the same time, given the uncertainty of information known about the trajectory and epidemiology of the disease, new triggers were developed for reactivating the EOC if needed.

Phase 3: post-first EOC activation (August 14, 2013–May 1, 2014). After the EOC was deactivated, response activities moved back to NCIRD and were scaled back considerably. During this third phase, command staff convened a MERS-CoV Task Force comprising the team leads from groups in the EOC Scientific Response Section and other experts. The Task Force continued to assess the threat of MERS-CoV through routine sharing of information, especially information on recent cases and laboratory advancements; through regular meetings in person; and by phone. The EOC reactivated on May 2, 2014, in response to the first U.S. case, but again deactivated on June 12, 2014, after no additional U.S. cases occurred and the number of new cases occurring globally slowed.

During this third phase, CDC continued to

Figure 2. Centers for Disease Control and Prevention abbreviated organizational chart for the Middle East Respiratory Syndrome Coronavirus response, 2013



CDC = Centers for Disease Control and Prevention
IM = Incident Manager

collaborate with domestic and global partners (e.g., sending epidemiologists to WHO headquarters in Geneva to assist WHO with the expanding case line listing and various international agreements regarding specimen sharing).

Throughout all three response phases, members of the response team were kept up to date with daily internal situational reports that summarized the epidemiologic data, a monthly summary of activities and key points regarding what was known to date about the disease, and maps displaying confirmed cases by country. The Task Force kept a daily timeline, which notated the response activities for each day. Accomplishments by the various teams are highlighted in Table 3.

LESSONS LEARNED

CDC's response to MERS-CoV has affirmed the importance of advanced preparation for successfully

Table 1. Examples of key Incident Management System roles and functions applied in an emergency setting

Role	*Function*
Incident Manager (IM)	Leads the response for the agency; member of Command Staff (consisting of IM, Deputy IM, and Chief of Staff).
Deputy Incident Manager	Fills the role of IM as needed and supplements leadership; member of Command Staff.
Chief of Staff	Oversees day-to-day functioning of staff, serves as liaison between Command Staff and EOC staff, manages personnel, and provides guidance on fiscal matters; member of Command Staff.
Regularly assigned EOC staff (staff units such as Planning, Logistics, and Situational Awareness)	Assists Command Staff and scientific staff by providing enhanced personnel, physical space for meetings, and dedicated phone lines; establishes formalized procedures (e.g., setting a daily set rhythm for meetings, reporting, and calls); standardizes a plan of action (referred to as the Incident Action Plan); creates plans for surge capacity as needed; and conducts task tracking (to help document who was working on the response and the number of hours devoted to the response). The EOC staff members are normal personnel who work in the EOC, regardless of the type of activation.

EOC = Emergency Operations Center

managing the response to a novel pathogen. Each new outbreak response should build on the knowledge gained from previous outbreaks, particularly if dealing with a similar pathogen, to save time and avoid the reinvention of materials that could be adapted from existing tools. The MERS-CoV response applied knowledge learned from responses to SARS, pandemic influenza, and, more recently, the CDC influenza A H7N9 response. The MERS-CoV response affirmed that the use of archived, readily accessible materials from previous responses can save time in the frenetic first days or months of a response. When MERC-CoV first emerged, few data on the new virus were available, but CDC was able to use the expertise it acquired in dealing with an outbreak of a similar pathogen, SARS. CDC subject-matter experts were able to use the knowledge they gained from the SARS outbreak to inform the development of pathogen-specific infection prevention and control guidance for MERS-CoV.

The MERS-CoV response also illustrates the impact of integrating information acquired across the response effort and communicating it in a timely manner. It is essential to quickly develop appropriate guidance in the key areas of epidemiology, laboratory science, travelers' health, and infection control, each of which requires a different set of experts. To develop such guidance, collaboration must occur across the agency and with external partners. During the MERS-CoV response, for example, the Epidemiology Team noted the critical importance of continuous dialogue with partners, such as the Council of State and Territorial Epidemiologists (CSTE) and Association of Public Health Laboratories.

Table 2. Key Centers for Disease Control and Prevention domestic and global partners in the Middle East Respiratory Syndrome Coronavirus early response, September 2012–May 2014

Key global partners	*Key domestic partners*[a]
World Health Organization headquarters and the Eastern Mediterranean Regional Office, Switzerland	Association of Public Health Laboratories
Public Health England, England	Association of State and Territorial Health Officials
Institute of Virology, University of Bonn Medical Center, Germany	Council of State and Territorial Epidemiologists
Robert Koch Institute, Germany	Local health departments
University of Hong Kong, Hong Kong	National Association of County and City Health Officials
Ministry of Health, Jordan	National Institutes of Health
Erasmus University, Netherlands	U.S. Departments of Health and Human Services, Defense, Homeland Security, State, and Agriculture
Ministry of Health, Kingdom of Saudi Arabia	U.S. Naval Medical Research Unit—No. 3[b]
Ministry of Health, Tunisia	U.S. state health departments

[a]Additional U.S. partners included the airline industry, travel agencies, and educational institutions that had business or travel interests in the affected areas.

[b]Located in Cairo, Egypt

This dialogue allowed information to flow both ways—CDC shared timely updates with the external partners, while the partners provided information that helped shape the content of the guidance, published reports, and alerts.

CDC's established relationships with these and other external partners provided a platform through which scientific knowledge and tools could be shared during the response. However, even with these relationships, the creation of policies such as data-sharing agreements, and the sharing of specimens and reagents among global partners, took an extended period of time, sometimes much longer than anticipated. For example, the sharing of data from affected countries proceeded at a slower pace than was originally anticipated.

Although the outbreak has continued for longer than two years, much remains unknown about this new virus and the illness it causes. In a 2013 summary publication from the WHO MERS-CoV Research Group[22] and a meeting of the IHR Emergency Committee on December 4, 2013, authorities stressed the need for formal, multinational, collaborative studies to better understand the epidemiology and risk factors of MERS-CoV. One main lesson learned from the MERS-CoV response has been recognition of the need for a priori arrangements for the global sharing of human and animal specimens, well-validated diagnostic reagents, preapproved human subjects research protocols, and a strong network of identified research and clinical sites willing and able to undertake needed studies, as well as effective surveillance strategies, early integrated responses, and open communication.[9,23,24] During the 2009 influenza A H1N1 pandemic in Mexico, for example, having preexisting signed agreements among several nations allowed for the rapid deployment of technical personnel, provided a means for timely and efficient exchange of information and biological samples, promoted the implementation of a collaborative public health response, and provided critical assistance for organizing a national response.[25] The Pandemic Influenza Preparedness Framework, which was in place for H1N1, is an illustration of a global framework that supports the IHR and fosters the sharing of influenza viruses with human pandemic potential.

The MERS-CoV response also has underscored the importance of domestic and global collaboration and communication. The CDC response was centered primarily in one national center (NCIRD) within the agency, but the response called on experts from across the agency. Continuity of operations was ensured by maintaining the same Incident Manager throughout

Table 3. Examples of activities and impacts of the Centers for Disease Control and Prevention's early response to the Middle East Respiratory Syndrome Coronavirus outbreak, September 2012–May 2014

Activities	*Impacts*
Created appropriate forms in multiple languages, such as case definition, guidance, and an epidemiology toolkit to guide epidemiologic investigations, along with supporting clinical and epidemiology training modules. Distributed widely to stakeholders. Investigated people with travel link and/or severe respiratory illness.	Improved ability to monitor the potential for importation.
Developed and disseminated polymerase chain reaction diagnostics. Developed serologic assay.	Enhanced U.S. states' and global partners' capacity to test their own samples. Identified full MERS-CoV genome to better characterize the virus and published this genome in GenBank, which facilitates research at CDC and partner agencies.
Developed and disseminated infection control guidance.	Strengthened health departments' and clinicians' ability to manage MERS-CoV and present further transmission.
Developed and disseminated essential travelers' health recommendations using electronic messaging at airports and quarantine stations, CDC's website, Traveler's Health social media, and outreach to partners.	Improved domestic capacity at entry points for the detection and management of possible imported cases of MERS-CoV.
Conducted an extensive communication campaign that included an up-to-date MERS-CoV website, multiple webinars focused on infection prevention and control, five *Morbidity and Mortality Weekly Reports* articles, three Health Alert Network notifications, and calls with senior state and local public health officials and partner organizations.	Strengthened public health and clinical preparedness and response efforts and educated public health agencies, health-care providers, public health preparedness programs, and global partners through extensive outreach to respond to emergent MERS-CoV.

MERS-CoV = Middle East Respiratory Syndrome Coronavirus

CDC = Centers for Disease Control and Prevention

all phases of the MERS-CoV early response and having the bulk of the core response staffing provided by one organization (NCIRD). This continuity of operations also provided an institutional memory from response experiences with previous novel respiratory pathogens. Even so, given the long length of time of the MERS-CoV early response, it was necessary to supplement staff from other CDC centers. Still, compared with other responses where key and/or Command Staff rotated every few weeks or months, the MERS-CoV response team has largely maintained its composition since the beginning. Maintaining consistent staff has strengthened staff cohesion and minimized some of the stressful dynamics that occur when teams of experts, unknown to one another, quickly organize, start working together, and then rotate off the team in a few weeks or months. At the same time, continuity of staff has meant continuous strain and fatigue for team members. By the time the EOC was activated for the MERS-CoV early response, some key members of the response team already were reporting a substantial level of fatigue. Contributing to the fatigue was the need of staff members (particularly the epidemiologists) to continue doing their regular jobs in addition to the work on MERS-CoV. Some of the fatigue and stress could have been mitigated by activating the EOC and using the IMS structure earlier in the response.

The decision to activate the EOC streamlined the management of the response. As cases climbed and the number of affected countries increased, activating the EOC strengthened the response and made valuable resources available (e.g., meeting coordination and emergency travel) that otherwise would have competed for administrative resources within supporting divisions. Relieved of some administrative demands, the technical staff members could turn their attention to pressing public health issues. For example, the EOC Joint Information Center was pivotal in providing assistance with developing websites, Health Alert Network notices, travelers' health notices, and social media messages.

Another lesson learned was that a large number of staff members had little actual experience using the IMS. Generally, to work in the EOC, CDC staff members who volunteer or are recruited to an EOC response take numerous classes (online and in person) to familiarize themselves with the functions and processes of an EOC. In this situation, work related to MERS-CoV had already gone on for months and people were reluctant to take time away from the response effort to complete these orientation courses. To meet the needs of the response team, EOC staff members quickly developed a two-hour just-in-time orientation on how the EOC functions and what the expectations are under the IMS. However, the IMS environment continued to be perceived as challenging by some deployed staff, resulting in a reluctance to use some of the management tools in the EOC.

RECOMMENDATIONS AND CONCLUSION

The main goal of the CDC early response to MERS-CoV was to prepare the United States for the possible importation of MERS-CoV. CDC is the only federal public health agency mandated to address emerging infectious disease for the whole United States, and it used its scientific, programmatic, and logistical expertise and resources to address the threat posed by MERS-CoV. To address the threat posed by MERS-CoV, CDC has worked collaboratively within the agency and external partners, maintained consistency in leadership and staffing, realized the advantages of preexisting professional relationships to build cohesion in the response team, and harnessed the assets of the EOC (Figure 3).

Rapid surveillance efforts assessed the spread of MERS-CoV globally, alerted leadership to new cases/deaths in a timely manner, improved infection control and epidemiology approaches, and informed policy decisions. Prevention, education, and mitigation strategies, applied through extensive global outreach that employed a variety of communication strategies, were used to notify and prepare public health agencies and programs, the general public, public health/health-care practitioners, international travelers to the affected regions, global partners, and other federal and nonfederal agencies about this novel virus.

The impact of these preparedness efforts was seen when the first case of MERS-CoV arrived in the United States on May 2, 2014. By the time this first case appeared, the response team had laid the groundwork for the response and established the needed relationships with partners. Public health agencies, health-care providers, public health preparedness programs, and global partners were already trained to identify and provide case management for MERS-CoV. For example, CDC had already (*1*) established with CSTE the preidentification points of contact for state public health authorities to receive information in a timely fashion; (*2*) developed a cleared and ready-to-go contact investigation protocol, which could be used to investigate the first imported case; and (*3*) developed training materials and education for volunteers to support the conveyance (air transport) contact investigation.

When a sharp increase in the number of cases reported worldwide occurred in March 2014, trained laboratorians already had the necessary assays needed

Figure 3. CDC early response to Middle East Respiratory Syndrome Coronavirus, September 2012–May 2014: what worked

What worked:
- Learned from previous outbreaks:
  - Able to build on previously developed recommendations for the sharing of human and animal specimens.
  - Able to use well-validated diagnostic reagents and preapproved human subject protocols that can be adapted to the current outbreak as needed.
- Called on existing collaborative relationships between CDC and external partners:
  - Strengthened cohesion across the response team.
  - Provided frequent and transparent communication about response activities.
- Maintained consistency in leadership and staffing during the course of the response.
- Used the pre-established assets of the CDC EOC to help manage the response.
- Instituted surveillance and provided timely updates of new developments to agency leadership.
- Utilized an array of communication methods to strengthen prevention, education, and mitigation strategies.
- Used multidisciplinary teams to guide the development of these evidence-based strategies.

CDC = Centers for Disease Control and Prevention
EOC = Emergency Operations Center

to test specimens from suspected cases. Having previously trained approximately 50,000 federal staff members, there was improved domestic capacity at entry points for the detection and management of imported cases of MERS-CoV. Also, a substantial amount of communications materials for travelers leaving and entering the United States had been developed. The prepared materials allowed for rapid dissemination of timely and accurate public health information for travelers during the first U.S. case importation.

CDC's preparedness efforts for MERS-CoV have been useful for other responses to imported infectious diseases. For example, as part of the MERS-CoV early response, CDC staff members were broadly cross-trained to support airline contact investigations, operations in the EOC, and data analysis in the Department of Health and Human Services' National Targeting Center, which serves to identify high-risk individuals and cargo entering the United States. These efforts proved invaluable for CDC's ability to quickly respond to the 2014 West African Ebola threat. Furthermore, CDC's communications team was able to leverage experience from social media activities and refine Ebola communications for travelers, businesses, and key stakeholders in a timely manner.

EPILOGUE

As of March 2015, the outbreak was continuing, but more quietly because of intense public health attention to the outbreak of Ebola in West Africa. As of March 17, 2015, a total of 1,060 laboratory-confirmed cases of MERS-CoV had been reported worldwide, including at least 394 deaths confirmed by WHO. Included in these cases were 183 (18%) health-care workers, of whom 11 died. Imported cases have also been confirmed in Austria, Turkey, Jordan, Philippines, and Germany (CDC. Unpublished surveillance data, 2015). Recent increases in the number of cases in health-care workers and travelers is concerning. CDC has been maintaining the MERS-CoV website and continues to disseminate key communications points internally and externally. CDC's priorities in the ongoing outbreak remain consistent: identification of cases, laboratory preparedness, advice to travelers, and infection control guidance. The Task Force has continued to meet regularly to inform the entire response team as to the status of the outbreak.

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