Understanding Pre-hospital Diagnostic Delays

Introduction

Errors in diagnosis, defined as “the failure to establish an accurate and timely explanation of the patient’s health problems or communicate that explanation to the patient,” represent an estimated 60 percent of all medical errors and may result in as many as 80,000 deaths per year in the United States.[1] Through research and quality improvement efforts, we understand many aspects of diagnostic error once a patient reaches a hospital or other care environment where an actual diagnosis can occur. However, we understand much less about delays that occur in the earliest stages of a patient’s diagnostic journey, reflecting the numerous factors that affect how patients perceive symptoms when they seek care, their interactions with EMS and other health care personnel, and how and when they reach an appropriate health care facility. We also lack insights into the potential of allied health professionals like physical and occupational therapists to facilitate diagnosis by recognizing symptoms worthy of follow up.

Focus on Three Conditions. Cancer, acute cardiovascular events (ACEs), and sepsis[2] -- provide a useful lens for exploring these pre-hospital diagnostic delays. A recent analysis of diagnostic errors that result in a malpractice claim shows that these conditions account for three-quarters of all serious harms, including death. Cancer and heart disease are the two most common causes of death in this country, claiming 700,000 each in 2020.[3] In addition, over 1.8 million people in the United States receive a cancer diagnosis each year.[4] Among ACEs, heart attacks and strokes each affect over 800,000 people,[5] with another 900,000 diagnosed with venous thromboembolism (VT).[6] Sepsis is responsible for 200,000 deaths, 750,000 hospitalizations, and 850,000 emergency department (ED) visits annually in the United States.[7]

The burden of these conditions falls disproportionately on communities of color and on populations in underserved urban and rural communities. These disparities manifest in worse outcomes and greater than average severity at the time of diagnosis for some populations,[8] suggesting that delays are also more common among these populations. Because cancer, cardiovascular events, and sepsis have relatively effective treatments when caught early enough, minimizing the time to diagnosis after the onset of symptoms is fundamental to high-quality care. However, symptoms that present in early disease can be varied and non-specific. Boxes A, B and C provide some basic information about each condition, the disparities they manifest, and how they are diagnosed.

Genesis and Organization of This Issue Brief. This publication is part of a collaboration between AcademyHealth and the Gordon and Betty Moore Foundation to bolster our understanding of pre-hospital diagnostic delays. It is intended to introduce this concept, explore its complexity, and identify implications for future health services research on the topic. It is not meant to be a comprehensive review of available evidence. In the coming months, AcademyHealth will publish a series of commissioned papers intended to do that, inclusive of a greater focus on diagnostic delay in the context of health equity. The papers and an associated workshop will serve as the basis for research grants that AcademyHealth and the Gordon and Betty Moore Foundation will solicit in February 2023. These grants aim to address some of the most crucial evidence gaps around the nature, frequency, and causes of pre-hospital diagnostic delays.

The issue brief is organized around the patient diagnostic journey and lays out factors that may be associated with delays that occur in the process. While it draws on some of the available published literature, a series of 15 semi-structured interviews conducted between January and May 2022 helped AcademyHealth frame the issue and provided background on specific issues. Appendix A lists these interviewees, and Appendix B reproduces the interview guide AcademyHealth used.

Summary

Cancer, acute cardiovascular events, and sepsis are common and consequential conditions that significantly burden patients, communities, and the health care system. These conditions have a diagnostic window for good outcomes; conversely, delays in their diagnosis can have serious implications for the course of patients’ disease, and ultimate prognosis. Quality improvement and research have begun to address the problem of delays once a patient reaches a hospital or other setting where their condition can be definitively and accurately diagnosed in a timely manner. Less is understood about the nature, extent, causes, and implications that occur before a patient reaches these facilities. However, existing evidence points to disparities in the timing of diagnosis and outcomes that disadvantage racial and ethnic populations and other populations. This issue brief explores pre-hospital delays in the diagnosis of these three conditions from the perspective of patients’ diagnostic journey. It is not a comprehensive literature review but provides an overview of factors that could play a role in these delays, including social determinants of health (e.g., cultural, language, financial, and geographic barriers to access), patients’ interpretation of symptoms, and the emergency medical system (EMS). Taken together, these factors begin to articulate a health services research (HSR) agenda that could provide the evidence needed to address pre-hospital diagnostic delays. As an area of health services research investigation, studying these delays presents both challenges and opportunities. Challenges include integrating clinical data from the health care system with data that captures patients’ lived experience in the community and tracking patients who die before entering the health care system. At the same time, the problem of pre-hospital delay creates opportunities to leverage (1) disciplines from the social and behavioral sciences less well-represented in the HSR enterprise, (2) emerging real-world data and methods, and (3) new, diverse voices from academia and communities.

Box A: Cancer

Approximately 40 percent of Americans will be diagnosed at some point during their lifetimes with cancer, a disease in which cells abnormally grow and spread throughout the body.[60] More than 100 types of cancers exist, the most common types including breast cancer, lung and bronchus cancer, prostate cancer, colon and rectum cancer, and melanoma.[61] Research has documented that racial/ethnic minorities and men, African American men, in particular, experience higher cancer mortality rates and are diagnosed at later stages than other groups.[10] The incidence of cancer is also greater among patients with a lower socio-economic status.[62]

Among the three conditions explored in this brief, cancer is distinctive in our ability to screen for a few types among asymptomatic patients. Despite recommendations from the U.S. Preventive Services Task Force for periodic breast, cervical, colorectal, and lung cancer screening, most cancer patients receive their diagnosis in response to symptoms rather than in follow-up to an abnormal screening result.[63] These symptoms vary by type of cancer and patient, and they are often not specific indicators of cancer. Once a patient seeks medical attention, cancer is typically diagnosed with lab tests, imaging, and, in most cases, a biopsy. Unlike ACEs and sepsis, cancer symptoms can be slow to manifest, making the need for medical attention and diagnosis more difficult to recognize.

Box B: Acute cardiovascular events

Acute cardiovascular events refer to a subset of conditions—usually stroke, acute coronary syndrome (ACS), and pulmonary embolisms (PE)—each has its own epidemiology and takes a significant toll in the United States.

Strokes, which affect 795,000 per year in the United States, are conditions in which the flow of blood and oxygen to the brain is disrupted. Eighty-seven percent of those are ischemic, meaning a blood clot blocks blood flow within the brain. The remaining are hemorrhagic stroke, in which an artery in the brain ruptures. The condition disproportionately affects African Americans, who are more than 50 percent more likely to experience and 70 percent more likely to die from a stroke than whites.[10] Strokes are diagnosed through clinical history and a neurologic exam and are confirmed through advanced imaging, including CT scans and MRIs of the brain.[64] Though strokes can be “silent,” typical symptoms include focal numbness or weakness, slurred speech, dizziness and loss of balance, changes in vision, headache, and confusion.[65]

Acute Coronary Syndrome (ACS) refers to sudden, reduced blood flow, usually due to plaque rupture in the coronary arteries. Myocardial infarctions (MI or heart attack) and unstable angina are manifestations of ACS in which a blood clot forms around the plaque, causing damage to the heart muscle by depriving it of oxygen and other nutrients.[66] In 2018, almost 110,000 people in the United States experienced a fatal MI. While death rates from heart disease overall have fallen over the last several decades for all racial and ethnic groups, systemic differences exist by both race and sex, with risk rising across all groups with age. African American men report the highest incidence of MIs and white women the lowest (Figure B-1).[67 68]

The first step in the diagnosis of ACS is usually an electrocardiogram (ECG), which can be done by EMS before a patient reaches the hospital. This is usually followed by blood tests for markers like troponin T, a protein found in the heart muscle which can be indicative of a heart attack and damage to the heart. More definitive diagnosis and treatment usually involves an invasive procedure such as a coronary catheterization that can determine the extent of a blockage. Other imaging, including echocardiograms, cardiac CT, or MRI scans, can also help determine the extent of damage to the heart.[69]

Box B: Acute cardiovascular events (Continued)

Venous thromboembolism (VT) occur when a blot clot forms in a vein. They include **pulmonary thromboembolisms (PEs)** in which one of these clots breaks free and travels to the lungs causing damage and potentially death, and **deep vein thromboembolism (DVT)** in which clots form in a deep vein, often in the leg. Collectively, DVT and PE affect about 300,000-600,000 people annually in the United States and result in about 100,000 deaths. African Americans have a 30 percent higher risk of DVT and PE than whites, but Asians and Native Americans have a 70 percent lower risk than their white counterparts.[70] As with other ACEs, diagnosis of PEs involves a combination of clinical history, ECG, blood tests, and imaging. High levels of D-dimer, a clot dissolver found in the bloodstream, along with low levels of blood oxygen, can be indications of a pulmonary embolism. Simple x-rays of the lungs can help rule out other conditions. CT pulmonary angiography and ventilation-perfusion scans are used to confirm the diagnosis of VTs.

Figure B-1: Incidence of Myocardial Infarction by age, sex, and race in the United States, 2005-2014

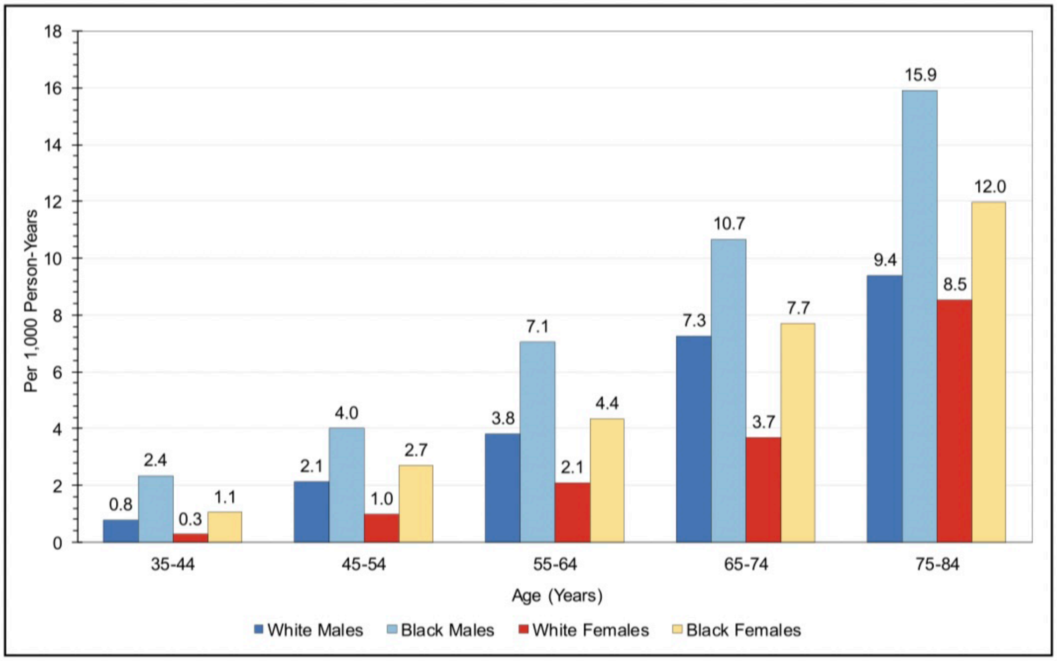


Chart 20-7. Incidence of myocardial infarction by age, sex, and race, United States (ARIC Surveillance, 2005–2014).
ARIC indicates Atherosclerosis Risk in Communities.
Source: Unpublished National Heart, Lung, and Blood Institute tabulation using ARIC, 2005 to 2014.[4]

The Patient's Diagnostic Journey

Efforts to reduce diagnostic error, including unnecessary delays in diagnosis, require an understanding of the diagnostic process and its component parts. A 2015 National Academy of Medicine (NAM) framework captures the iterative and complex nature of the process, variations in that process for different conditions, and the multiple factors that affect whether a patient receives a timely and accurate diagnosis (Figure 2). However, this framework focuses predominantly on the role of the health care system with less attention to the time period before a patient reaches a health care provider (depicted by the two small grey boxes to the left of the circle in Figure 1).[9] It provides little insight into what happens before a patient engages with the health care system – or at least with the setting in which an actual diagnosis can occur. In the case of stroke, existing research suggests that these early parts of the diagnostic journey account for the majority of the time from symptom onset to potential treatment.[10]

Cancer researchers have developed broader frameworks that try to capture the whole patient diagnostic experience broken down into intervals to conceptualize where delays may occur. Drawing on sociological and anthropological literature that establishes symptoms as social constructs, Andersen and colleagues proposed a General Model of Total Patient Delay at five distinct intervals from symptom onset until treatment initiation.[11] Andersen's model gives particular attention to the concept of "patient delay," which is defined as "the interval between the onset of symptoms and the first visit to the physician."[12] More recently, Walter et al. have suggested a refinement framework that breaks the process of diagnosing cancer into four distinct periods:

- **Appraisal Interval:** from detection of bodily changes to perception of a reason to discuss with a health care provider.
- **Help-seeking Interval:** from the time of that perception until the first consultation with a provider.
- **Diagnostic Interval:** from the first consultation until actual diagnosis.
- **Pre-treatment Interval:** from diagnosis to the start of treatment.

Walter's framework also notes the **patient-, health care provider-, health care system-, and disease-specific factors** that contribute to the length of each of these intervals.[13] In the case of cancer, pre-hospital delays discussed in this brief occur largely during Appraisal and Help-seeking Intervals, plus that portion of the Diagnostic Interval before a patient is referred for definitive diagnosis.

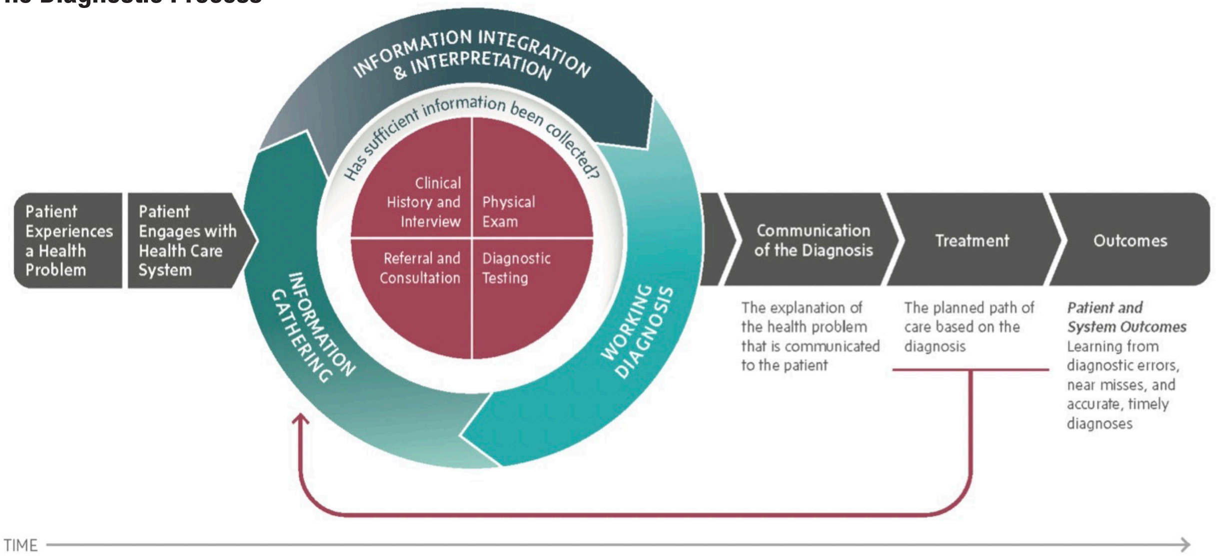
Because the Walter model was developed to better understand pathways to cancer diagnosis, it does not account for one important difference between cancer and the other two conditions discussed in this issue brief. Acute cardiovascular events and sepsis are more likely than cancer to manifest initially with symptoms that lead patients to emergently seek care. In particular, the Walter model does not capture:

- Patients' potential use of EMS, including the decision to call 911, 911 dispatchers' actions, the actions of EMS providers, and transportation to a hospital by ambulance;
- Patients' potential decision to seek urgent care from an outpatient provider such as an urgent care center or their primary care physician;
- Patients' potential decision to go directly to a hospital emergency department;

Each of these events and processes introduces their potential for diagnostic delay explored later in this brief. In Figure 2, we suggest one potential adaptation of the Walter model intended to account for these additional components of a patient's diagnostic journey.

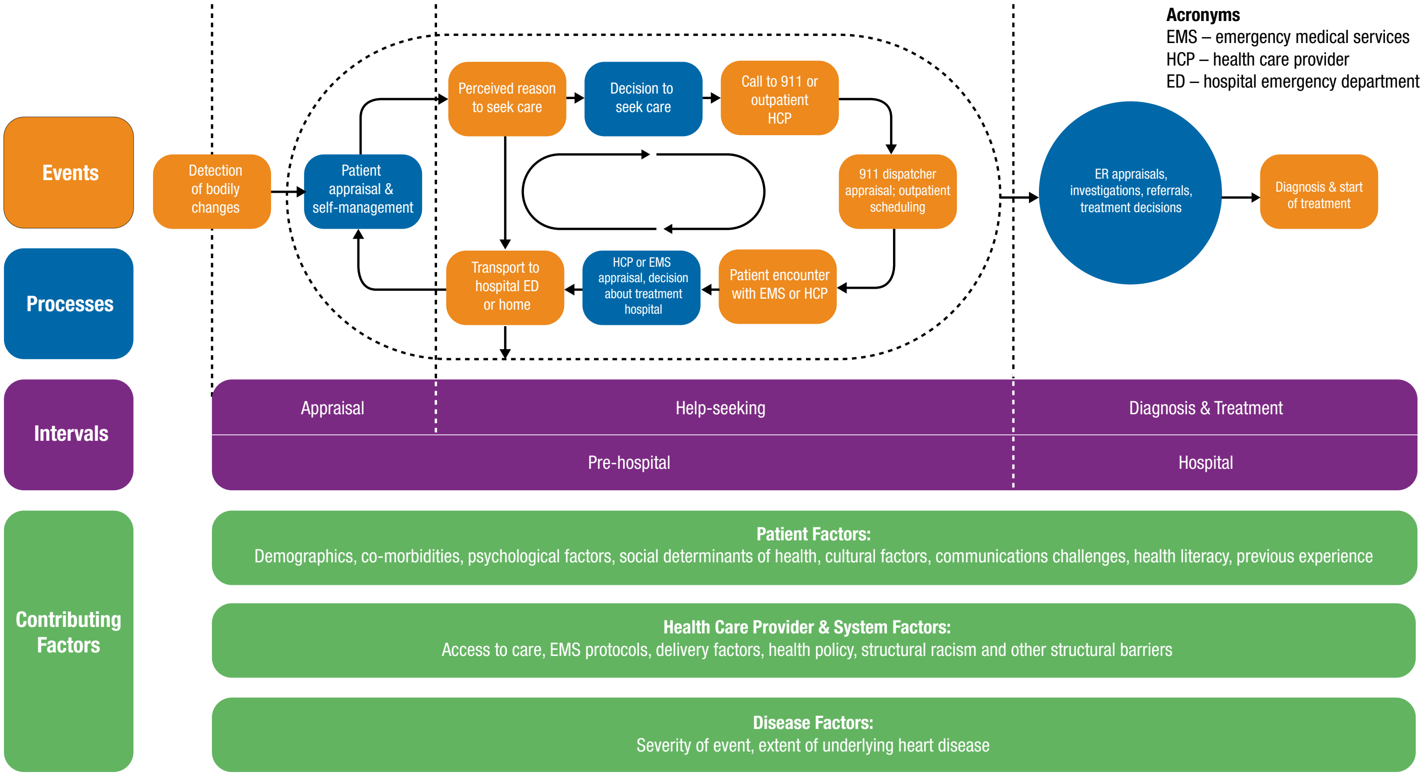
One feature of the diagnostic process in both the NAM model and our adaptation to the Walter model is the assumption that treatment occurs after diagnosis. In fact, providers often initiate treatment for some conditions before a definitive diagnosis is available.[14,15] As many as 30 percent of suspected stroke patients who are treated with thrombolytics turn out not to have had a stroke.[16]

Figure 1: The Diagnostic Process



Source: National Academies of Sciences, Engineering, and Medicine 2015. Improving Diagnosis in Health Care. Washington, DC: The National Academies Press. https://doi.org/10.17226/21794.

Figure 2: Pathways to Diagnosis and Treatment: Adaptation of Walter, 2012



Adapted from Walter F et al. The Andersen Model of Total Patient Delay: a systematic review of its applicatio in cancer diagnosis. J Health Serv Res Policy. April 2012. 17(2): 110-8.

Delays Along the Path to Diagnosis.

Delays in diagnosis can have consequences. In the case of heart attacks, every 30-minute delay in diagnosis increases a patient's risk of dying in the first 12 months by 7.5 percent. Similarly, research examining sepsis patients in a large, multicenter health system found that "each elapsed hour between emergency department registration and antibiotic administration was associated with a 9% increase in the odds of mortality."[17] A similar study from 2014 found a linear increase in the risk of mortality per each hour delay in antibiotic administration, highlighting the importance of timely diagnosis and intervention.[18] Other research has documented the relationship between delay in the treatment of ischemic stroke and permanent loss of neurons.[19] The frameworks suggested above provide an opportunity to define when in the diagnostic journey a delay occurs, for whom, and potentially why.

Disparities in Diagnostic Delays. Looking at the diagnostic journey as a whole, research has shown that certain groups are more likely to be diagnosed at a later stage or require a longer time to get a diagnosis. In the case of cancer, being part of a minoritized racial or ethnic group,[20,21] lower socio-economic status,[22] living in a rural area,[23] and having co-morbidities,[24,25] are all associated with delays. In the case of cardiovascular events, experts have noted similar disparities,[25] and research has documented racial and gender disparities in who gets referred to cardiac catheterization.[26] As for sepsis patients, individual factors such as insurance status, lower socio-economic status, and structural factors, including lack of access to care settings and lack of transportation, all contribute to delays in diagnosis.[27] Additionally, measurement bias from routinely used by medical devices and algorithms in hospitals and clinics also contribute to disparities in diagnostic delay.[28] For example, a clinical artificial intelligence algorithm intended to help identify potential skin cancers may perform less well among patients with darker skin if differences in pigmentation are not accounted for in the algorithm's design.[29]

Appraisal Interval Delays. The first step toward diagnosis for any patient is the Appraisal Interval, where the patient or caregiver recognizes and assesses symptoms. Hence, the first delay can occur if those symptoms are not recognized as requiring care, which in turn can reflect either the nature of the symptoms or characteristics of the patent. In terms of symptoms, cancer, cardiovascular events, and sepsis all present with non-specific symptoms (Table 2), which can mask their potential severity. Compared to cancer, which is signaled by the persistence of some symptoms, cardiovascular events are more likely to present with sudden onset. In fact, the first symptom in about twenty-five percent of people with a PE is sudden death.[30] Sepsis can arise suddenly, but it tends to present with acute or subacute symptoms such as a cough, sputum, or difficulty breathing. Supported by evidence around all three conditions, potential delays during the Appraisal Interval can be broken into several categories:

- **Knowledge**: A basic question is whether a patient knows their symptoms could indicate a serious problem. The extensive evidence base around patients' and caregivers health literacy and numeracy is relevant to this question.[31] Closely related to a patient's awareness and knowledge is whether they have an "instinct" that

Table 2: Common Symptoms of Cancer, Sepsis, and Acute Coronary Events

Cancer	Sepsis
• Persistent fatigue • Unexplained weight gain or loss of 10+ pounds • Eating problems or nausea/vomiting • Swelling or lumps • Unexplained skin changes or jaundice • Persistent cough or hoarseness • Unexplained bleeding or bruising • Changes in bowel habits • Pain or bleeding when urinating • Urinating more or less often • Fever or night sweats • Headaches • Vision or hearing problems • Mouth sores, bleeding, or numbness	• Rapid breathing and heart rate • Shortness of breath • Confusion or disorientation • Extreme pain or discomfort • Fever, shivering, or feeling very cold • Clammy or sweaty skin

Acute cardiovascular events		
Stroke	**Pulmonary Embolism**	**Acute Coronary Syndrome**
• Face drooping – Does one side of the face droop, or is it numb? Ask the person to smile. Is the person's smile uneven? • Numbness or weakness of the face, arm, or leg, especially on one side of the body. Ask the person to raise both arms. Does one arm drift downward? • Speech difficulty – Is speech slurred? • Confusion, trouble speaking or understanding speech • Trouble seeing in one or both eyes • Trouble walking, dizziness, loss of balance or coordination • Severe headache with no known cause	• Unexplained shortness of breath • Rapid breathing • Chest pain anywhere under the rib cage (may be worse with deep breathing) • Fast heart rate • Lightheadedness or passing out	• Chest pain or discomfort, which may involve pressure, tightness, or fullness • Pain or discomfort in one or both arms, the jaw, neck, back, or stomach • Shortness of breath • Feeling dizzy or lightheaded • Nausea • Sweating

Sources: American Heart Association. https://www.heart.org/en/health-topics/heart-attack/about-heart-attacks/acute-coronary-syndrome , https://www.heart.org/en/health-topics/venous-thromboembolism/symptoms-and-diagnosis-of-venous-thromboembolism-vte , and https://www.stroke.org/en/about-stroke/stroke-symptoms . Accessed April 28, 2022. American Cancer Society. https://www.cancer.org/treatment/understanding-your-diagnosis/signs-and-symptoms-of-cancer.html. Accessed July 25, 2022. Medline Plus. https://medlineplus.gov/sepsis.html . Accessed July 25, 2022.

something is wrong, compelling them to seek care.[18] Evidence from the U.K. shows that clinicians see public awareness as the main driver of timely diagnosis.[32] Both government and private groups have engaged in campaigns to make the public aware of disease symptoms, to communicate risk, and to encourage action. This has been especially true for cancer and cardiovascular events, but sepsis has recently been the subject of public education efforts.[33] While public awareness campaigns generally show an increase in the number of patients referred from a general practitioner to a specialist, there is little evidence in the case of cancer that they directly translated to an increase in diagnoses.[34,35,36 37] A related issue is that public awareness campaigns typically focus on the most common symptoms, which can lead to delays in diagnosis for patients with atypical symptoms.[38] Another factor in patients' (and providers') incomplete knowledge of symptoms is that older adults, women, and ethnic minorities have often been underrepresented in research studies that inform public awareness. This can result in an underappreciation of symptoms that occur more frequently among historically excluded populations.[39]

- **Patient perception of risk and symptoms.** Beyond patients' knowledge of symptoms is their interpretation of them. Family history, past experiences, and general concern about their health may affect whether a patient perceives themselves as at-risk for particular conditions, which in turn could affect the significance they attach to symptoms. Individuals with symptoms perceived as trivial may delay seeking help. In the case of stroke, researchers have shown that the decision to seek help is more dependent on perceived symptom severity than actual knowledge of stroke symptoms.[40] While the persistence of symptoms may increase concern, there is also evidence that persistent symptoms can desensitize patients to their presence and delay action.[41]

- **Patient attitudes and emotions.** Patients' general psychological make-up and the wide range of emotions they may associate with health and disease can also determine their likelihood of seeking care. These may include anxiety around the disease or encounters with the health care system, denying symptoms in hopes the symptoms will resolve on their own, or stoicism or fatalism that makes patients more likely to endure or self-manage symptoms without complaint.[18,42,43] Shame, embarrassment, and fear of stigma around symptoms have also been associated with delays in health-seeking behavior.[44] Research has found these various traits to be more common among men, ethnic minorities, and individuals of lower socio-economic status.[45,38]

- **Social influence and trust.** Other evidence suggests that social influence—particularly having family, friends, or physicians whom they trust and who encourage health-seeking behavior—can facilitate more timely action when patients experience symptoms.[18,24]

- **Technology.** The growing use of "wearables," such as Apple Watches or Fitbits and other technology intended to collect clinical data outside of a traditional health care setting, as well as the use of artificial intelligence-based algorithms, represents other potential tools to shorten the time to diagnosis by alerting patients and/or providers to a condition before concerning symptoms emerge.[46,47]

Help-Seeking Interval Delays. During the Help-Seeking interval, a patient decides whether to act—a decision that several factors could also influence:

- **Perceived urgency of the situation**: Does the patient call 911? Do they seek outpatient urgent care? Or does or a primary care or other community-based provider misinterpret the seriousness of their condition and make a non-urgent appointment when immediate care is needed? Here, the distinction between cancer, which is less likely to present with immediately concerning symptoms requiring prompt care, and more acute conditions like cardiovascular events and sepsis, may be key.

- **The patient's financial situation**: Does the patient have health insurance? Do they delay seeking care out of concern for the costs of the care they might need? Does their insurance limit them in their choice of providers or require prior authorization before seeking care (in non-emergency situations)?

- **Trust in the health care system**: Does the patient trust health care providers' ability to deliver high-quality, needed care? Do they believe providers, including 911 dispatchers and EMS personnel, will listen to them and act in their best interest? Experts interviewed by AcademyHealth underscored the value of having a diverse workforce and racial concordance between minority patients and providers in establishing trust and improving quality.[48]

- **Geography.** Where a patient lives can greatly affect their access to diagnostic procedures. For example, research shows that individuals from disadvantaged neighborhoods experience delays in receiving angiography.[49] In deciding what action to take, patients may consider their proximity to an emergency room or urgent care center along with their knowledge and beliefs about the quality of care and wait times at different facilities. Geography can also correlate with socio-economic status and other social determinants, often resulting in disparities in health care access and health outcomes. Research has shown that socio-economic distress in urban areas is associated with pre-hospital delays for acute ischemic strokes.[50] Similarly, a study using claims data found that treatment for sepsis in a disproportionately minority hospital is associated with a significantly increased mortality risk. Outcomes may be worse in predominantly minority hospitals because of overcrowded emergency rooms and/or ambulance diversion, which increase the delay of antibiotic therapy.[51]

Theoretically, at this stage, a call to 911 is the fastest path to a definitive diagnosis and emergent care. Still, the response of the 911 operator can introduce additional delays, potentially reflecting any of several factors:

- **Language and communications**: Are the patient (or the 911 caller) and the operator fluent in the same language? Does the caller use words to describe the symptoms that the operator similarly understands (e.g., discomfort versus pain)? Is the caller comprehensive in describing the symptoms? Do the caller and operator share an understanding of specific words used?

- **Implicit bias:** Does the operator unconsciously make decisions about the seriousness of the patient's condition and appropriate next steps based on implicit assumptions and bias about the patient's race, ethnicity, gender, age, or other characteristics?

- **Availability of EMS services when needed**: If the patient or caregiver calls 911, is there an EMS team and ambulance currently available? How long does it take the EMS team to get to the patient? Do they bring the ambulance most equipped for the situation?

Once the EMS provider reaches the patient, additional delays are possible. In addition to language barriers, miscommunications, and implicit bias, several additional factors can affect when a patient receives a correct diagnosis and treatment begins:

- **Ability to initially diagnose**: Does the EMS provider have the necessary knowledge and skills to identify the condition correctly and provide appropriate urgent care for reaching the hospital? Is the team equipped with available technology and training to diagnose the condition themselves? Are they in communication with hospital personnel? Are there established workflows and quality/performance improvement efforts that facilitate earlier diagnosis?

- **Proximity to available hospital:** How long does it take to transport the patient to a hospital? What is the ambulance diversion policy in the local jurisdiction if the closest hospital is unable to receive the patient?

If a patient turns to an urgent care center or seeks an appointment with a primary care or other type of outpatient provider additional factors can affect the time to diagnosis.

- **Work and family obligations and flexibility:** Does the patient need to take time off from work to travel to the doctor, and will they face punitive measures as a result? Will the patient need to find childcare to attend the appointment?
- **Appointment availability:** Can the patient get an appointment with a doctor within an appropriate timeframe? Can the patient get an appointment with a doctor they consistently see? Can that physician facilitate a timely referral for the appropriate diagnostic tests?

- **Diagnostic Phase Delays:** Provider and patient interactions are at the core of the Diagnostic Phase. For this consideration of pre-hospital diagnostic delays, we focus on the part of the Diagnostic Phase before a patient reaches the setting where their condition is definitively diagnosed. That could include urgent care or primary care settings, as well as initial interactions in a hospital emergency department.

At this stage, factors that affect interactions with 911 and EMS personnel, namely **provider knowledge and skill**, **implicit bias**, and **language and communications barriers** such as the providers' use of excessive jargon or culturally unfamiliar terms, could also affect the quality of care provided and the likelihood of referral for appropriate diagnostic procedures and treatment. A lack of provider skill can lead to an **inaccurate evaluation of a patient** or **cognitive biases** such as:

- **Anchoring/commitment to a steer**: does the provider focus too much on one piece of information or overly rely on their initial diagnostic impressions?
- **Availability**: does the provider overly rely on information that is easily available or already known?
- **Epidemiological optimism**: does the provider dismiss a potential diagnosis because the patient is low risk? [52,53,54]

Clinicians also cite **insufficient time with patients** as contributing to diagnostic delay.[31,32,55] For patients initially seen in a primary care setting, timely diagnosis can also depend on physicians ordering and quickly receiving the results of tests that allow them to narrow the potential cause of symptoms that could indicate many types of conditions.

For ACEs and sepsis, these factors could delay diagnosis by keeping a patient waiting or inappropriately sending them home rather than facilitating timely diagnosis and treatment by sending them to the ED by ambulance.

Implications for Health Services Research

Improving the timeliness of diagnosis and reducing disparities in that timing requires interventions. Assuring that those interventions are effective requires evidence from testing and evaluation, but even developing potential interventions requires evidence—namely, an understanding of the nature, causes, and consequences of diagnostic delay. AcademyHealth's interviews with experts highlighted emerging evidence on delays in the diagnosis of cancer, ACEs, and sepsis once a patient is in a hospital or other setting where a definitive diagnosis can occur. Building on other efforts to reduce medical error and improve quality of care, much of the existing research has taken place in clinical settings by researchers with a clinical orientation. At the same time, much of what we know about the role of social determinants of health, culture, and other factors identified above comes from the social sciences and is not specific to diagnostic delays or their disparities. This gap in evidence provides a significant new opportunity for health services research to bring these areas of inquiry together to understand their connections better.

One reason for the weaker evidence-base around pre-hospital delays relative to those that occur within the health care system may be the data challenges this research presents. Clinical researchers have access to electronic health records (EHRs) that integrate notes from clinical encounters, patient histories, and test results and/or insurance claims. On the other hand, social scientists have typically drawn on large, population-based surveys, other survey data, and community-based primary quantitative and qualitative data to study social determinants. Studying pre-hospital delays requires data and methods that can connect an understanding of patients' personal and community situations with their health care histories, including any ultimate diagnosis. In addition, there is relevant health care information about some patients that never make it into an EHR since acutely ill patients can die at home without ever reporting a symptom. To address these challenges, health services researchers may be able to draw on studies on other topics that faced and solved similar issues.

At the same time, however, efforts to understand pre-hospital diagnostic delay may present opportunities to leverage other emerging trends and tools in health services research:

- **A broader array of disciplinary perspectives**. Health services research, a field traditionally dominated by medicine, public health, and economics, is increasingly being undertaken by investigators with different disciplinary backgrounds – in particular, sociology, anthropology, psychology, and other social sciences. Each of these areas may yield theory and empirical evidence particularly relevant to pre-hospital diagnostic delay.
- **New data sources**. Researchers are increasingly using new sources of large "real-world" data drawn from our digital lives. Although they present their own methodological challenges, these data (from social media, internet searches, online consumer reviews, shopping histories, smartphones, smart watches, and other wearable devices) have the potential to provide new insights into individual, community, and population characteristics and behaviors, as well as statistical power not necessarily available from data based on sampling.[47] In addition, machine learning

and other forms of artificial intelligence represent methods for using these data that may have implications for health services research questions identified in this issue brief.[56]

- **Engage health equity experts in diagnostic research.** A more diverse, equitable, and inclusive research workforce is not only key to addressing structural racism in the health services research enterprise as a whole, but it also provides an opportunity for understanding health and health care from new voices and perspectives and leads to a greater understanding of the lived experience of all Americans.[57,58,59] Bringing traditionally marginalized voices to the table represents an essential tool in understanding and addressing disparities in timely diagnosis.

In sum, untangling the complexities of diagnostic delay represents a significant new opportunity for health services researchers and is a key component of efforts to achieve equitable outcomes in the health care system.

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Appendix A: Key Informants Interviewed[75]

Interviewee	Date Interviewed
Rinad Beidas, Ph.D. Professor of Medicine Director, Penn Medicine Nudge Unit Director, Penn Implementation Science Center University of Pennsylvania	January 24, 2022
Emily Brant, M.D., M.S. Assistant Professor Critical Care Medicine and Emergency Medicine University of Pittsburgh School of Medicine	February 9, 2022
John Brownstein, Ph.D. Chief Innovation Officer Boston Children's Hospital Harvard Medical School	May 17, 2022
Gregory Downing, D.O., Ph.D. Founder Innovation Horizons, LLC	January 27, 2022
Susan Gregurick, Ph.D. Director for Data Science Office of Data Science Strategy National Institutes of Health	March 1, 2022
Michael Howell, M.D. Chief Clinical Officer Deputy Chief Health Officer Google	March 9, 2022
Vincent Liu, M.D., M.S. Research Scientist Kaiser Permanente	January 19, 2022
Gregory Martin, M.D., M.Sc. Professor of Medicine Associate Division Director for Critical Care Director, Predictive Health Institute Emory University	February 9, 2022
Ziad Obermeyer, M.D., M.Phil. Associate Professor, Blue Cross of California Distinguished Professor School of Public Health University of Berkeley, California	February 22, 2022
Urmimala Sarkar, M.D. Professor of Medicine University of California, San Francisco	February 10, 2022
Elizabeth Sarma, Ph.D., M.P.H. Program Director Health Systems and Interventions Branch Healthcare Delivery Research Program Division of Cancer Control & Population Studies National Cancer Institute	January 27, 2022
Herman Taylor, M.D., M.P.H., FACC, FAHA Professor of Medicine Director, Cardiovascular Research Institute School of Medicine Morehouse University	January 20, 2022
Matthew Thompson, D.Phil., M.P.H., MBChB Professor of Family Medicine Adjunct Professor of Pediatrics University of Washington	February 16, 2022
Fiona Walter, M.A., M.D., FRCGP Director, Wolfson Institute of Population Health Queen Mary College, University of London	February 2, 2022
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Appendix B: Key Informant Interview Guide

This interview is part of an AcademyHealth project funded by the Gordon and Betty Moore Foundation to improve our understanding of delays in diagnosis of three serious conditions — sepsis, cancer, and acute cardiovascular events. Our focus is also on delays that occur before a patient has an encounter with a hospital. The work we're beginning now will ultimately lead to an AcademyHealth call for new research proposals to improve the evidence base around this topic. This interview will help us frame the issues and identify additional experts.

You will not be quoted or cited – in the report or in any related material – without your consent.

Introductory Questions

1. Tell us a little about your professional background and your prior work or expertise relevant to diagnostic delay.

Section I. The Scope and Consequences

1. At a high level and in your expert opinion, how much do we know from prior research about the frequency, causes, and consequences of diagnostic delay and ________ [sepsis, cancer, and/or acute cardiovascular events]?

   a. Which of these are specific to xx and which are systemic challenges?

2. To what extent do we know about disparities in the incidence of diagnostic delay across different populations?

3. What are the most important causes of delays in diagnosis prior to a patient seeking care in response to symptoms? (e.g., diversion and other EMS factors, interpretation/misinterpretation of symptoms, etc.)

   a. Which of these are specific to xx and which are systemic challenges?

4. How much do we know about the consequences of diagnostic delay in general and across different populations?

5. How has the COVID-19 pandemic affected the problem of diagnostic delay? What are the consequences?

6. How much do we know about potential interventions to reduce or eliminate diagnostic delay for ________ [sepsis, cancer, and/or acute cardiovascular events]?

7. In your opinion, what are the most important research questions to answer about diagnostic delay and ________ [sepsis, cancer, and acute cardiovascular events]?

Section II. Data Sources

1. What types of data have researchers used to understand diagnostic delay (incidence, causes, consequences, and disparities)? What are the strengths and limitations of different data sources?

2. Are there untapped data resources that could help us better understand this problem?

   a. We are particularly interested in ways to leverage social media and other "real world" data to provide novel insights.

   b. Also of interest are non-health related data that help us understand the role that various social determinants of health (SDOHs) play in diagnostic delay.

3. In finding existing research literature, do you have any advice about the appropriate MESH terms and search strategies?

4. Are there other concerns about the quality of existing literature and data we should be aware of?

5. What are key variables to measure when researching diagnostic delay?

Section III. Next Steps

1. Who else should we be talking with to understand delays in the diagnosis of ________ [sepsis, cancer, and/or acute cardiovascular events]?

2. What questions should we have asked that we didn't?

3. Do you have any other final thoughts before we conclude?

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