

Diagnostic Errors in the Emergency Department: A Systematic Review

Evidence Summary



Main Points

- Overall diagnostic accuracy in the emergency department (ED) is high, but some patients receive an incorrect diagnosis (~5.7%). Some of these patients suffer an adverse event because of the incorrect diagnosis (~2.0%), and some of these adverse events are serious (~0.3%). This translates to about 1 in 18 ED patients receiving an incorrect diagnosis, 1 in 50 suffering an adverse event, and 1 in 350 suffering permanent disability or death. These rates are comparable to those seen in primary care and hospital inpatient care.
- We estimate that among 130 million emergency department (ED) visits per year in the United States that 7.4 million (5.7%) patients are misdiagnosed, 2.6 million (2.0%) suffer an adverse event as a result, and about 370,000 (0.3%) suffer serious harms from diagnostic error. Put in terms of an average ED with 25,000 visits annually and average diagnostic performance, each year this would be over 1,400 diagnostic errors, 500 diagnostic adverse events, and 75 serious harms, including 50 deaths per ED. Although overall error and harm rates are derived from three smaller studies conducted outside the United States (in Canada, Spain, and Switzerland, with combined n=1,758), study methods were prospective and rigorous. All three were conducted at university hospitals, and, for the two studies used to estimate harms, about 92 percent of clinicians under study at those institutions had full training or formal certification in emergency medicine.

Continued on page 2



- Five conditions (#1 stroke, #2 myocardial infarction, #3 aortic aneurysm/dissection, #4 spinal cord compression/injury, #5 venous thromboembolism) account for 39 percent of serious misdiagnosis-related harms, and the top 15 conditions account for 68 percent. Variation in diagnostic error rates by disease are striking (range 1.5% for myocardial infarction to 56% for spinal abscess, with the other thirteen falling between 10% and 36%). Stroke, the top serious harm-producing disease, is missed an estimated 17% of the time. Among these 15 diseases, myocardial infarction is the only one with false negative rates near zero (1.5%), well below the estimated average rate across all diseases (5.7%).
- For a given disease, nonspecific or atypical symptoms increase the likelihood of error. For stroke, dizziness or vertigo increases the odds of misdiagnosis 14-fold over motor symptoms (those with dizziness and vertigo are missed initially 40% of the time).
- Variation in diagnostic error rates across demographic groups is present and sometimes fairly large in magnitude. The effect of age is heterogeneous and disease-specific (e.g., younger age increases risk of missed stroke 6.7-fold, while older age increases risk of missed appendicitis). Female sex and non-White race were often associated with important (20–30%) increases in misdiagnosis risk; although these disparities were inconsistently demonstrated across studies, being a woman or a racial or ethnic minority was generally not found to be “protective” against misdiagnosis (i.e., was neutral at best).
- Variation in diagnostic error rates across specific hospital EDs is wide. Methods of measuring diagnostic errors in the ED are highly variable. However, even when similar methods are used, measured diagnostic error rates vary up to 100-fold across hospitals. In individual studies, missed cases varied by hospital for subarachnoid hemorrhage (0% to 100%), myocardial infarction (0% to 29%), and appendicitis (1% to 16%). Error rates are usually found to be lower in academic/teaching hospitals, but it is unknown if this is an effect of increased availability/intensive use of diagnostic technologies or other factors.
- Root causes of ED diagnostic errors were mostly cognitive errors linked to the process of bedside diagnosis. Malpractice claims associated with serious misdiagnosis-related harms involved failures of clinical assessment, reasoning, or decision making in about 90 percent of cases. Similar findings were seen in incident report data. These issues are not unique to the ED—they are seen across clinical settings, regardless of study method.
- The strongest, most consistent predictors of ED diagnostic error were individual case factors that increased the cognitive challenge of identifying the underlying disorder, with nonspecific, mild, transient, or “atypical” symptoms being the most frequent.
- Our findings are tempered by limitations in the underlying evidence base, including issues related to data sources, measurement methods, and causal relationships. Nevertheless, overall diagnostic error and misdiagnosis-related harm rates are consistent with what has been found in other clinical settings (e.g., primary care and inpatient).



Background and Purpose

The National Academy of Medicine (NAM) has called diagnostic error a “blind spot” for modern medicine and improving diagnosis a “moral, professional, and public health imperative.”¹ Diagnostic errors occur across all clinical settings, but the ED is thought to be a high-risk site for diagnostic error.²⁻⁷ The scope of this evidence review, commissioned by the Agency for Healthcare Research and Quality, was limited to the ED setting.

The key decisional dilemma for this evidence review is “What are the most common and significant medical diagnostic failures in the ED, and why do they happen?” We conducted a systematic review to determine the following: (1) What clinical conditions are associated with the greatest number and highest risk of ED diagnostic errors and associated harms? (2) Overall and for the clinical conditions of interest, how frequent are ED diagnostic errors and associated harms? and (3) Overall and for the clinical conditions of interest, what are the major causal factors associated with ED diagnostic errors and associated harms?



Methods

We employed methods consistent with those outlined in the Agency for Healthcare Research and Quality Evidence-based Practice Center Program Methods Guidance (<https://effectivehealthcare.ahrq.gov/topics/er-methods-guide/overview>), and we described these in the full report. Our searches covered publication dates from January 2000 to September 2021. We included research studies and targeted grey literature reporting diagnostic errors or misdiagnosis-related harms in EDs in the United States or other developed countries with comparable ED care. Two reviewers independently screened search results for eligibility, serially extracted data regarding common diseases, error/harm rates, and causes/risk factors, and independently assessed risk of bias of included studies. We synthesized results for each question and extrapolated U.S. estimates. When possible, to describe uncertainty, we present 95 percent confidence intervals (CIs); otherwise, we present plausible range (PR) bounds for key estimates. See addendum in [main report](#) front matter for methods and results of Monte Carlo simulation.



Results

We identified 19,127 abstracts, screened 1,455 full text studies, and included 279 studies that addressed Key Questions 1, 2, and 3. The top 15 individual diseases associated with the greatest number of serious misdiagnosis-related harms in the ED, in rank order, were (1) stroke, (2) myocardial infarction, (3) aortic aneurysm and dissection, (4) spinal cord compression and injury, (5) venous thromboembolism, (6/7 – tie) meningitis and encephalitis, (6/7 – tie) sepsis, (8) lung cancer, (9) traumatic brain injury and traumatic intracranial hemorrhage, (10) arterial thromboembolism, (11) spinal and intracranial abscess, (12) cardiac arrhythmia, (13) pneumonia, (14) gastrointestinal

perforation and rupture, and (15) intestinal obstruction. Together, they accounted for 68 percent (95% CI 66 to 71) of all serious harms from diagnostic error in the ED. Grouped by organ system, neurologic diseases were the top category (34%). Disease-specific error rates were lowest for myocardial infarction (1.5%) and highest for spinal abscess (56%). Relative to myocardial infarction, stroke, the top serious harm-producing missed diagnosis, was missed approximately 10-fold more often (17%), despite having comparable disease incidence.

An estimated 5.7 percent (95% CI 4.4 to 7.1) of all ED visits will have at least one diagnostic error. The overall (not disease-specific), per ED visit, potentially preventable diagnostic adverse event rates were estimated as follows: any harm severity 2.0 percent (95% CI 1.0 to 3.6), serious misdiagnosis-related harms (i.e., permanent, high-severity disability or death) 0.3 percent (PR 0.1 to 0.7), and misdiagnosis-related deaths 0.2 percent (PR 0.1 to 0.4). For each misdiagnosis-related death, it is estimated that there are roughly 0.41 (PR 0.27 to 0.60) ED patients suffering non-lethal, permanent, serious disability. If generalizable to all US ED visits (130 million, 95% CI 116 to 144), these rates translate to 7.4 million (PR 5.1 to 10.2) ED diagnostic errors annually; 2.6 million (PR 1.1 to 5.2) diagnostic adverse events with preventable harms; and 371,000 (PR 142,000 to 909,000) serious misdiagnosis-related harms, including more than 100,000 permanent, high-severity disabilities and 250,000 deaths.

Although errors were often multifactorial, 89 percent (95% CI 88 to 90) of diagnostic error malpractice claims involved failures of clinical decision making or judgment, regardless of the underlying disease present. Key process failures were errors or delays in bedside diagnostic assessment, laboratory or imaging test ordering, and test interpretation. Most often these were attributed to inadequate clinical knowledge, skills, or reasoning, particularly in “atypical” or otherwise subtle case presentations. Unsurprisingly, “obviousness” predicted correct diagnosis and “subtlety” predicted incorrect diagnosis. Subtle diagnostic situations included diseases in the “wrong” age groups; transient, milder, non-specific, or atypical symptoms; and finding second, third, or fourth problems in patients who were very ill (e.g., polytrauma).



Strengths and Limitations

Overall, the evidence supported answers to all three Key Questions, including most subquestions. We were able to identify the top 15 diseases associated with serious misdiagnosis-related harms (Key Question 1), the frequency of errors and harms both overall and for many of these specific diseases (Key Question 2), and the chief causes of and risk factors for these errors (Key Question 3). Results for Key Question 1 relied heavily on two large studies (one of medical malpractice claims, the other incident reports). Although there are clear biases in malpractice claims, there was a high degree of concordance between claims and incident reports with respect to diseases causing serious harms. Overall (i.e., not disease-specific) error and harm rates for Key Question 2 relied heavily on three studies from centers outside the United States which were given greater weight relative to the larger body of literature because of rigorous, prospective methods. Preventable harm rate estimates derived from two studies conducted at academic centers (1 in Canada, 1 in Switzerland) at which about 92 percent of ED clinicians under study

had formal training in emergency medicine. The Canadian study measured preventable harms by requiring a high-bar standard on record review—at least two of three independent raters with emergency medicine training had to agree that the adverse event was causally related to the diagnostic error and preventable with a level of certainty of at least 5 on a 6-point Likert scale. The Swiss study assessed deaths as an outcome among admitted patients and found a 2.3-fold increase in mortality with a 4.8 percent absolute difference (8.6% of those initially misdiagnosed in the ED ultimately died versus 3.8% of those correctly diagnosed). Estimated misdiagnosis-related mortality from the Canadian study (0.2%, PR 0.1 to 0.4) was bolstered by similarity to the mortality estimate calculated from the two Western European studies (PR 0.2% to 0.3%) and preventable deaths due to inpatient diagnostic errors (~0.2% based on a prior systematic review). Studies of disease-specific error rates were sufficient for meta-analysis (n=6) or at least point estimates (n=6). Causal factors were extensively studied, but too heterogeneously categorized for overall meta-analysis. The causal and risk factor literature was strongest for patient and illness characteristics and relatively weaker on clinician characteristics, fixed systems factors, and dynamic systems factors. Discrepant results were mostly attributable to differences in research methods across studies, including study design, inclusion or exclusion criteria, diagnostic error definitions, and heterogeneity in classifying disease diagnoses and causal factors. Specific gaps identified for each question, with potential remedies, are described in the full report.



Implications and Conclusions

The ED is one of the most challenging clinical settings to practice medicine. That just 5.7 percent of patients would be misdiagnosed, just 2.0 percent would suffer some sort of adverse event as a result, and just 0.3 percent of patients would suffer serious harms from diagnostic error is a testament to the skill and capability of practicing emergency physicians. It should be remembered that not all diagnostic errors are preventable and attempting to prevent some errors may lead to undesirable, unintended consequences that could adversely impact patients. Nevertheless, substantial variability in diagnostic error rates by disease, presenting symptoms, demographic groups, and specific hospitals suggests there remains room for improvement in diagnostic performance that could benefit many patients. Scalable solutions to enhance bedside diagnostic processes are needed, and these should target the most commonly misdiagnosed clinical presentations of key diseases causing serious harms.

Future research should emphasize areas in which data are suboptimal or lacking. For decision making in the United States, overall diagnostic error and harm rates should be confirmed in U.S.-based studies using rigorous, prospective methods. Diagnostic error measurement and reporting should be standardized for both internal and external benchmarking purposes, including public accountability. More research is needed on the burden of diagnostic errors and harms related to diseases with less immediate and severe consequences, pediatric ED diagnostic errors and harms, and the causal contributions of modifiable systems factors amenable to policy intervention such as ED overcrowding, which may increase the risk of diagnostic error). This should also include study of

potential unintended consequences of solutions designed to address these errors, since harms from overuse of diagnostic tests or false positives are also a concern.

Policy changes to consider based on findings from this review include: (1) standardizing measurement and research results reporting to maximize comparability of measures of diagnostic error and misdiagnosis-related harms^{1, 8, 9}; (2) creating a National Diagnostic Performance Dashboard¹⁰ to track performance (analogous to the Dartmouth Atlas Project for utilization of healthcare services¹¹); and (3) using multiple policy levers (e.g., research funding, public accountability, payment reforms)¹ to facilitate the rapid development and deployment of solutions to address this critically important patient safety concern. Resources applied should be commensurate with the measured public health burden, which is likely substantial.



References

1. National Academies of Science Engineering and Medicine. Improving Diagnosis in Health Care. Washington, DC: The National Academies Press; 2015.
<https://www.nap.edu/catalog/21794/improving-diagnosis-in-health-care#rights>.
2. Selbst SM, Friedman MJ, Singh SB. Epidemiology and etiology of malpractice lawsuits involving children in US emergency departments and urgent care centers. *Pediatric emergency care*. 2005 Mar;21(3):165-9. PMID: 15744194.
3. Hussain F, Cooper A, Carson-Stevens A, et al. Diagnostic error in the emergency department: learning from national patient safety incident report analysis. *BMC emergency medicine*. 2019 Dec 4;19(1):77. doi: 10.1186/s12873-019-0289-3. PMID: 31801474.
4. Newman-Toker DE, Schaffer AC, Yu-Moe CW, et al. Serious misdiagnosis-related harms in malpractice claims: The “Big Three” – vascular events, infections, and cancers. *Diagnosis (Berlin, Germany)*. 2019 Aug 27;6(3):227-40. doi: 10.1515/dx-2019-0019. PMID: 31535832.
5. Kachalia A, Gandhi TK, Puopolo AL, et al. Missed and delayed diagnoses in the emergency department: a study of closed malpractice claims from 4 liability insurers. *Annals of emergency medicine*. 2007;49(2):196-205. doi: 10.1016/j.annemergmed.2006.06.035. PMID: 105983200. Language: English. Entry Date: 20080215. Revision Date: 20200708. Publication Type: Journal Article.
6. Brown TW, McCarthy ML, Kelen GD, et al. An epidemiologic study of closed emergency department malpractice claims in a national database of physician malpractice insurers. *Academic emergency medicine : official journal of the Society for Academic Emergency Medicine*. 2010 May;17(5):553-60. doi: 10.1111/j.1553-2712.2010.00729.x. PMID: 20536812.
7. Trautlein JJ, Lambert RL, Miller J. Malpractice in the emergency department—review of 200 cases. *Annals of emergency medicine*. 1984 Sep;13(9 Pt 1):709-11. doi: 10.1016/s0196-0644(84)80733-7. PMID: 6465652.
8. National Quality Forum. Improving Diagnostic Quality and Safety Final Report. 2017.
https://www.qualityforum.org/publications/2017/09/improving_diagnostic_quality_and_safety_final_report.aspxx. Accessed on February 20 2022.

9. National Quality Forum. Reducing Diagnostic Error: Measurement Considerations – Final Report. 2020.
https://www.qualityforum.org/Publications/2020/10/Reducing_Diagnostic_Error__Measurement_Considerations_-_Final_Report.aspx. Accessed on February 20 2022.
10. Mane KK, Rubenstein KB, Nassery N, et al. Diagnostic performance dashboards: tracking diagnostic errors using big data. *BMJ quality & safety*. 2018 Jul;27(7):567-70. doi: 10.1136/bmjqs-2018-007945. PMID: 29550767.
11. Dartmouth Atlas Project. The Dartmouth Atlas of Health Care. 2018.
<https://www.dartmouthatlas.org/>. Accessed on February 20 2022.

Full Report

Newman-Toker DE, Peterson SM, Badihian S, Hassoon A, Nassery N, Parizadeh D, Wilson LM, Jia Y, Omron R, Tharmarajah S, Guerin L, Bastani PB, Fracica EA, Kotwal S, Robinson KA. Diagnostic Errors in the Emergency Department: A Systematic Review. Comparative Effectiveness Review No. 258. (Prepared by the Johns Hopkins University Evidence-based Practice Center under Contract No. 75Q80120D00003.) AHRQ Publication No. 22(23)-EHC043. Rockville, MD: Agency for Healthcare Research and Quality; December 2022. Errata and Addendum, August 2023.
DOI: <https://doi.org/10.23970/AHRQEPCCER258>. Posted final reports are located on the Effective Health Care Program [search page](#).

