



Missed Serious Neurologic Conditions in Emergency Department Patients Discharged With Nonspecific Diagnoses of Headache or Back Pain

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Study objective: Serious neurologic conditions can be missed on initial emergency department (ED) visit and discharge diagnosis oftentimes remains a nonspecific symptom. We aim to examine the incidence of potential harm from serious neurologic conditions in ED patients discharged with a nonspecific diagnosis of headache or back pain, identify specific missed conditions, and determine risk factors for potential misdiagnosis-related harm.

Methods: This was a retrospective analysis using the population-based data of 6 US states from the State Emergency Department Databases and State Inpatient Databases from 2006 through 2012. We identified adults (≥ 18 years) discharged from the ED with a diagnosis of atraumatic headache or back pain. The primary outcome was a composite of return ED visit and hospitalization for primary diagnosis of a serious neurologic condition or in-hospital death within 30 days of ED discharge.

Results: There were 2,101,081 ED discharges with a nonspecific diagnosis of headache and 1,381,614 discharges with a nonspecific diagnosis of back pain. Overall, 0.5% of the headache patients and 0.2% of back pain patients had a primary outcome. The most common missed condition for headache was ischemic stroke (18.1%). The most common missed condition for back pain was intraspinal abscess (41%). In both populations, advanced age, male sex, non-Hispanic white, and comorbidities (eg, neurologic disorders, HIV/AIDS, malignancy) were associated with higher odds of outcome.

Conclusion: A small proportion of ED patients discharged with nonspecific diagnoses of headache or back pain returned with a serious neurologic condition or in-hospital death within 30 days. [Ann Emerg Med. 2019;74:549-561.]

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0196-0644/\$-see front matter

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<https://doi.org/10.1016/j.annemergmed.2019.01.020>

INTRODUCTION

Background

Misdiagnosis of life-threatening conditions represents a significant public health problem because it leads to both financial burdens and increased morbidity and mortality.¹⁻⁴ In a recent large observational study of US adult patients, the diagnostic error rate in the outpatient setting was approximately 5% and affected 12 million patients per year.⁵ In the emergency department (ED), the likelihood varies widely by diagnosis and ranges from 0.6% to 35%.⁶⁻¹² Many diagnostic errors are associated with the potential for moderate to severe harm.¹³ Previous studies on closed ED malpractice claims have demonstrated that most errors are the result of a failure to make a diagnosis.^{14,15} The National Academy of Medicine has issued a call to action to reduce misdiagnosis in medicine, citing it as a public health imperative.¹

Importance

The misdiagnosis of neurologic emergencies is of particular interest to frontline providers, given the time-sensitive nature of many treatment modalities, which, if delayed even by minutes to hours, can result in serious permanent neurologic dysfunction or death. Early recognition and intervention decreases morbidity and mortality for serious conditions, including stroke, cauda equina syndrome, and epidural abscesses.¹⁶⁻²⁴ Thus, timely diagnosis of these conditions is paramount. Although a few studies have examined specific missed neurologic diagnoses,²⁵⁻²⁷ the incidence, diagnosis, and risk factors for potential misdiagnosis-related harm of serious neurologic conditions in ED patients remain largely unclear.

Goals of This Investigation

To address this knowledge gap, we analyzed a population-based sample of ED patients discharged with a

Editor's Capsule Summary*What is already known on this topic*

Failure to diagnose a serious medical condition in the emergency department (ED) can cause morbidity and mortality.

What question this study addressed

Among ED patients discharged with nonspecific diagnoses of headache or back pain, how many return within 30 days with a serious neurologic condition or in-hospital death?

What this study adds to our knowledge

Among 2,101,081 ED patients discharged with headache, 10,374 (0.5%) returned and had a serious condition, the most frequent being cerebrovascular occlusion. Among 1,381,614 ED patients discharged with back pain, 2,850 (0.2%) returned and had a serious condition, the most frequent being intraspinal abscess.

How this is relevant to clinical practice

The absolute rate of serious neurologic conditions missed at the initial ED visit is very low, and it is unknown whether clinicians can reduce this rate further.

nonspecific diagnosis of headache or back pain to describe the likelihood of ED revisit for a serious neurologic condition or in-hospital death for these patients and different subpopulations. We also identified the specific missed conditions and determined factors associated with the potential misdiagnosis-related harm.

MATERIALS AND METHODS**Study Design and Setting**

We conducted a retrospective analysis using data from the Healthcare Cost and Utilization Project State Emergency Department Databases and State Inpatient Databases.²⁸ The Healthcare Cost and Utilization Project is a family of health care databases developed through a federal-state-industry partnership and sponsored by the Agency for Healthcare Research and Quality. The databases contain the largest collection of longitudinal hospital care data in the United States with all-payer, encounter-level information. The State Emergency Department Databases and State Inpatient Databases are a component of the Healthcare Cost and Utilization Project. The State Emergency Department Databases capture all

treat-and-release and transfer ED visits from short-term, acute care, nonfederal hospitals in participating states. The State Inpatient Databases capture all ED visits that result in admissions and inpatient discharges from short-term, acute care, nonfederal, general, and other specialty hospitals. Using all of them, we identified all ED visits regardless of disposition and all hospitalizations regardless of source. Additional details about the State Emergency Department Databases and State Inpatient Databases can be found elsewhere.²⁹ Composition and completeness of data files may vary from state to state. For the present analysis, we focused on 6 states (California, Florida, Iowa, Nebraska, New York, and Utah) from January 1, 2006, through December 31, 2012. We selected these states for their high data quality and geographic diversity, and chiefly because their data contain unique encrypted identifiers that enable follow-up of specific individuals across years. The institutional review board of Massachusetts General Hospital approved this study.

Selection of Participants

Using the ED visit data from the 6 states, we included all ED patients (≥ 18 years) discharged (ie, treat and release) to home or a nonacute facility with a primary discharge diagnosis of nonspecific headache as defined by the following *International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)* diagnosis codes for headache: tension headache (307.81), migraine (346), and headache, acute headache, and head pain (784.0). For back pain, the following diagnoses and *ICD-9-CM* codes were included: lumbar disc herniation (722.1); nonspecific disc herniation (722.2); back pain including thoracic pain, lumbar back pain, or sciatica (724); thoracic strain (847.1); lumbar strain (847.2); and back strain (847.9).^{30,31} We excluded patients with trauma, those who left the hospital against medical advice, those who were transferred to another acute care facility, those who died at the index ED visit, and out-of-state residents. Similar to previous research on revisits and readmissions,^{32,33} additional ED discharges for headache or back pain within a 30-day period from the index ED visit were not considered, whereas subsequent ED visits occurring after 30 days were counted as an index ED visit if they met the inclusion criteria.

Methods of Measurement

The State Emergency Department Databases and State Inpatient Databases include information on patient characteristics, including demographics (age, sex, and race/ethnicity), primary insurance, estimated household income that is estimated from the patient's zip code, urban-rural

status, and *ICD-9-CM* diagnosis.³⁴ In addition, the databases also contain information about each of the 29 Elixhauser comorbidity measures that are derived from *ICD-9-CM* codes.^{35,36} Quartile classifications of estimated median household income of residents in the patient's zip code were examined. Urban-rural status of the patient residence was defined according to the National Center for Health Statistics.³⁷

To identify potential misdiagnosis-related harm of serious neurologic conditions in our population, we used the Symptom-Disease Pair Analysis of Diagnostic Error framework. We used a look-forward approach, which takes a common symptom (eg, headache, back pain) and identifies important diseases that might be missed in patients presenting with those symptoms.³⁸ The framework has the advantage of using hard clinical outcomes, thereby minimizing subjectivity, and has been used to identify misdiagnosis of neurologic emergencies.^{10,25}

Outcome Measures

The primary outcome measure was a composite of return ED visit and hospitalization for the primary diagnosis of a serious neurologic condition (Table 1) or in-hospital death within 30 days of the index ED discharge. We chose these diagnoses because they are associated with a high admission rate and high inpatient mortality, and if the diagnosis is delayed, they can have devastating consequences for the patient.³⁹⁻⁴² The secondary outcome measures were a composite of these outcome measures for the periods within 3 and 7 days from the index ED discharge. In using return ED visits as a marker of misdiagnosis, 2 assumptions must be considered: the same process that led to the primary outcome was present during the index visit, and if the process was present on the index visit, it was misdiagnosed.

Additionally, we used patients with the following nonneurologic chief complaints as a control group for comparison: cough, chest pain, abdominal pain, localized superficial swelling, mass, or lump. We chose these diagnoses because they are typically not related to the specified neurologic diagnoses, and we calculated the composite event rate of outcomes for these cases.

Primary Data Analysis

For each of the patient groups (ie, patients discharged with a diagnosis of headache and those discharged with a diagnosis of back pain), we first computed the incidence of outcomes in the overall population and subpopulations (eg, age, sex, race/ethnicity groups). We also examined the difference in the incidence of outcomes by patient subpopulations, using the χ^2 test. Additionally, to examine

the factors associated with the risk of each outcome, we constructed a multivariable logistic regression model including patient's age, sex, race or ethnicity, primary insurance, quartiles for household income, urban-rural status, Elixhauser comorbidity measures, state, discharge season, and year. We handled all variables as categorical ones and used a case-complete analysis because there were few missing data. Because we aimed to determine the risk factors of ED revisits and not test the hypothesis of any specific association, we did not include any interaction terms in the model. We analyzed data with a random-effect model to account for patient clustering within the hospital.

Next, we examined the 10 most frequent causes of the serious neurologic conditions by using the primary *ICD-9-CM* diagnosis code of the return ED visits and hospitalizations. To help data presentation and interpretation, we also consolidated the diagnoses (>14,000 *ICD-9-CM* diagnosis codes) into 285 mutually exclusive diagnostic categories, using the Agency for Healthcare Research and Quality Clinical Classifications Software,⁴³ as done previously.^{32,44,45} All analyses were conducted with Stata (version 14.1; StataCorp, College Station, TX).

RESULTS

Characteristics of Study Subjects

Among the 143 million adult ED visits in the 6 states from 2006 through 2012, we identified 2,101,081 ED patients discharged with a nonspecific diagnosis of headache and 1,381,614 discharged with a nonspecific diagnosis of back pain who were at risk for serious neurologic conditions. Patient characteristics are summarized in Table E1, available online at <http://www.annemergmed.com>. For patients with a diagnosis of headache, the median age was 39 years (interquartile range 29 to 50 years), 75% were women, and 48% were non-Hispanic white. For patients with a diagnosis of back pain, the median age was 44 years (interquartile range 33 to 55 years), 57% were women, and 52% were non-Hispanic white.

Main Results

Overall, for patients with a nonspecific diagnosis of headache, 0.5% (n=10,374) had the primary outcome (ie, a composite of serious neurologic condition or in-hospital death) within 30 days after the index ED discharge (Table 2). For patients with a nonspecific diagnosis of back pain, 0.2% (n=2,850) had a composite of serious neurologic condition or in-hospital death within 30 days after the index ED discharge (Table 3).

Table 1. Missed serious neurologic conditions in patients discharged from the ED, according to initial presentation.

Serious Neurologic Conditions	ICD-9-CM Code
Patients with headache	
Malignant neoplasm of cranial nerves	192.0
Malignant neoplasm of cerebral meninges	192.1
Malignant neoplasm of other specified sites of nervous system	192.8
Malignant neoplasm of nervous system, part unspecified	192.9
Bacterial meningitis	320.xx
Encephalitis myelitis and encephalomyelitis	323.x
Intracranial and intraspinal abscess	324.x
Phlebitis and thrombophlebitis of intracranial venous sinuses	325
Late effects of intracranial abscess or pyogenic infection	326
Benign intracranial hypertension	348.2
Compression of brain	348.4
Cerebral edema	348.5
Acute angle-closure glaucoma	365.22
Malignant essential hypertension	401.0
Subarachnoid hemorrhage	430
Intracerebral hemorrhage	431
Other and unspecified intracranial hemorrhage	432.x
Occlusion and stenosis of precerebral arteries	433.xx
Occlusion of cerebral arteries	434.xx
Transient cerebral ischemia	435.x
Acute but ill-defined cerebrovascular disease	436
Other and ill-defined cerebrovascular disease	437.x
Dissection of carotid artery	443.21
Dissection of vertebral artery	443.24
Giant cell arteritis	446.5
Mild or unspecified preeclampsia	642.4
Severe preeclampsia	642.5
Toxic effect of carbon monoxide	986
Patients with back pain	
Malignant neoplasm of spinal cord	192.2
Malignant neoplasm of spinal meninges	192.3
Malignant neoplasm of other specified sites of nervous system	192.8
Malignant neoplasm of nervous system, part unspecified	192.9
Benign neoplasm of spinal cord	225.3
Benign neoplasm of spinal meninges	225.4
Benign neoplasm of other specified sites of nervous system	225.8
Benign neoplasm of nervous system, part unspecified	225.9
Encephalitis myelitis and encephalomyelitis	323.xx

Table 1. Continued.

Serious Neurologic Conditions	ICD-9-CM Code
Intraspinal abscess	324.1
Intracranial and intraspinal abscess of unspecified site	324.9
Other diseases of spinal cord	336.x
Paraplegia	344.1
Monoplegia of lower limb	344.3x
Cauda equina syndrome	344.6x
Paralysis, unspecified	344.9
Thoracic or lumbar spondylosis with myelopathy	721.4x
Anterior spinal artery occlusion	433.8

ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification.

For patients with a nonspecific diagnosis of headache, 0.2% (n=3,749) had an outcome within 3 days and 0.3% (n=5,687) had an outcome within 7 days after discharge (Tables E3 and E4, respectively, available online at <http://www.annemergmed.com>). The frequency of outcome was highest between days 1 and 3 after discharge, with a gradual decline thereafter (Figure, A). For patients with a nonspecific diagnosis of back pain, less than 0.1% (n=659) had an outcome within 3 days and less than 0.1% (n=1,210) had an outcome within 7 days after discharge (Tables E5 and E6, respectively, available online at <http://www.annemergmed.com>). The frequency of outcome was highest between days 1 and 3 after discharge, with a gradual decline thereafter (Figure, B). For the control group, the composite incidence of outcomes at 30 days for the headache-related missed neurologic emergencies was as follows for each nonneurologic complaint: 0.18% for cough, 0.14% for chest pain, 0.14% for abdominal pain, and 0.12% for localized soft tissue complaint. For back-pain-related missed neurologic emergencies, the incidence at 30 days was as follows: 0.11% for cough, 0.06% for chest pain, 0.08% for abdominal pain, and 0.08% for localized soft tissue complaint. The full results for the control group are displayed in Table 4.

Table 2 demonstrates the risks of serious neurologic event and in-hospital death for ED patients discharged with a diagnosis of headache. Compared with the youngest patient group (18 to 39 years), the oldest group (≥ 85 years) was more likely to have a high risk of having an outcome within 30 days (0.3% versus 2.0%) after discharge. Table E6, available online at <http://www.annemergmed.com>, summarizes the multivariable associations of patient characteristics with the risk of outcome by follow-up period (ie, 3, 7, and 30 days).

Advanced age, male sex, non-Hispanic white, several comorbidities (eg, vasculitis, hypertension, neurologic disorders, HIV/AIDS, malignancy), and diagnosis of nonmigraine headache at the index ED discharge were associated with a significantly higher incidence of outcome across the follow-up periods. For example, compared with younger patients (18 to 39 years), older patients (≥ 85 years) had a significantly higher incidence of outcome within 30 days after ED discharge (odds ratio 3.46; 95% confidence interval 3.03 to 3.94) (Table E6, available online at <http://www.annemergmed.com>). The most frequent cause of serious neurologic condition within 30 days after discharge was ischemic stroke (18.1%). The top 10 diagnoses are displayed in Table 5.

Table 3 demonstrates the risks of serious neurologic event for ED patients discharged with a diagnosis of back pain. Compared with the youngest patient group, the oldest group had a higher likelihood of outcome within 30 days (0.1% versus 1.0%). In the multivariable models (Table E7, available online at <http://www.annemergmed.com>), advanced age, male sex, non-Hispanic white, and several comorbidities (eg, neurologic disorders, HIV/AIDS, malignancies, substance abuse) were associated with significantly higher incidences of outcome across the follow-up periods. Overall, the most frequent cause of serious neurologic condition within 30 days after discharge was intraspinal abscess (44%). The top 10 diagnoses are displayed in Table 6.

LIMITATIONS

The study has several potential limitations. First, there are inherent limitations related to the use of administrative data, such as errors in recording diagnoses and therefore misclassification of encounters. The ability of the Healthcare Cost and Utilization Project database to verify the identity of individuals varies by state, year, and age, among other factors. Furthermore, the database fails to capture events for patients who present to a hospital in a different state during the follow-up period and out-of-hospital deaths. Thus, event rates are likely underestimated. Although errors are possible, Healthcare Cost and Utilization Project data are highly accurate, rigorously tested, and widely used to estimate diagnoses and visit frequency.^{25,38,46} For example, the use of ICD-9-CM codes to identify acute ischemic stroke has been validated and is known to have a high positive predictive value (94%).⁴⁷ Second, we identified the outcomes as measured by ED visits or hospitalizations and in-hospital death. However, even if some patients later presented to urgent care or other ambulatory care sites, they would have ultimately required

in-hospital management. Third, the assumptions one needs to consider in using return ED visits as a marker of misdiagnosis may overestimate this rate. However, this methodology has been well described in the literature and used in previous investigations on diagnostic error.^{35,48} Fourth, although our study evaluated correlation between patient factors and outcomes, retrospective studies cannot confirm causality. It is possible that patients returned for a nonneurologic condition that led to an adverse outcome. The study objective, however, was to describe the likelihood of revisit for a serious neurologic condition or death in the setting of a real population and current ED practice. Fifth, our population-based study is potentially limited by not being a random sample of the US population. However, the data from these 6 geographically dispersed states include all ED visits and hospitalizations for approximately 26% of the US population,⁴⁹ thereby supporting the generalizability of the findings.

DISCUSSION

By using population-based data of greater than 3 million ED patients discharged with a nonspecific atraumatic diagnosis of headache or back pain, we found that a small proportion returned with a serious neurologic condition or died in-hospital. The most common missed diagnosis resulting in potential harm in patients with headache was ischemic stroke, whereas the most common diagnosis in those with back pain was intraspinal abscess (which includes epidural abscess). By determining the primary and secondary outcomes, we aimed to estimate the rate of potential diagnosis-related harm that occurred during the index visit.⁵⁰ Our findings suggest that the rate of potential diagnosis-related harm is greater than 2 times higher for headache compared with back pain. Risk factors include older age, male sex, non-Hispanic white, and certain comorbidities, including neurologic disorders, HIV/AIDS, and malignancies for both headache and back pain, as well as drug abuse for back pain.

One should remember when interpreting our findings that although the rate of potential misdiagnosis-related harm of the serious neurologic conditions we considered is likely relatively high,^{8,51} the absolute risk of potential harm for a common, nonspecific symptom presentation is relatively low⁵² because the majority of cases are not due to dangerous diseases and because not all missed diagnoses result in harm to patients. Headache and back pain are common complaints in the ED: 2%³⁹ and 3%⁵³ of chief complaints, respectively. Therefore, although the observed rate in our study was low, the absolute number of potential adverse diagnostic outcomes was substantial.

Table 2. Frequency of serious neurologic event and in-hospital death within 30 days after ED discharge with diagnosis of headache, overall and stratified by patient characteristics in California, Florida, Iowa, Nebraska, New York, and Utah, 2006 to 2012.

	Index ED Visit, n	Overall		
		Inhospital Death or Serious Neurologic Events Within 30 Days After ED Discharge, No. (%)	Inhospital Death Within 30 Days After ED Discharge, No. (%)	Serious Neurologic Events Within 30 Days After ED Discharge, No. (%)
Overall	2,101,081	10,374 (0.5)	1,266 (0.06)	9,389 (0.4)
Age, y				
18–39	1,070,726	2,761 (0.3)	219 (<0.1)	2,585 (0.2)
40–64	855,045	4,961 (0.6)	616 (0.1)	4,496 (0.5)
65–84	150,481	2,167 (1.4)	310 (0.2)	1,925 (1.3)
≥85	24,829	485 (2.0)	121 (0.5)	383 (1.5)
Sex				
Men	527,051	3,191 (0.6)	505 (0.1)	2,769 (0.5)
Women	1,566,134	7,152 (0.5)	752 (<0.1)	6,595 (0.4)
Race				
Non-Hispanic white	1,015,261	5,442 (0.5)	656 (0.1)	4,927 (0.5)
Non-Hispanic black	391,544	1,957 (0.5)	221 (0.1)	1,794 (0.5)
Hispanic	425,401	1,808 (0.4)	231 (0.1)	1,624 (0.4)
Asian	135,130	659 (0.5)	87 (0.1)	591 (0.4)
Other	133,745	508 (0.4)	71 (0.1)	453 (0.3)
Payer				
Medicare	279,462	3,049 (1.1)	504 (0.2)	2,639 (0.9)
Medicaid	447,664	1,883 (0.4)	239 (0.1)	1,684 (0.4)
Private	906,784	3,905 (0.4)	349 (<0.1)	3,655 (0.4)
Self-pay	356,856	1,073 (0.3)	121 (<0.1)	987 (0.3)
Other	106,439	451 (0.4)	49 (<0.1)	414 (0.4)
Median household income state quartile for patient zip code				
1 (lowest quartile)	671,287	3,241 (0.5)	406 (0.1)	2,928 (0.4)
2	552,614	2,812 (0.5)	348 (0.1)	2,546 (0.5)
3	479,804	2,321 (0.5)	298 (0.1)	2,086 (0.4)
4 (highest quartile)	362,379	1,841 (0.5)	191 (0.1)	1,691 (0.5)
Type of headache at the index ED visit				
Nonmigraine	1,489,964	8,823 (0.6)	1,077 (0.1)	7,990 (0.5)
Migraine	611,117	1,551 (0.3)	189 (<0.1)	1,399 (0.2)
No. of comorbidities				
0	1,520,617	5,440 (0.4)	583 (<0.1)	4,993 (0.3)
1–2	535,317	4,260 (0.8)	535 (0.1)	3,855 (0.7)
3–4	42,583	623 (1.5)	132 (0.3)	506 (1.2)
≥5	2,564	51 (2.0)	16 (0.6)	35 (1.4)
Patient residence				
Metropolitan	1,906,720	9,439 (0.5)	1,158 (0.1)	8,541 (0.4)
Nonmetropolitan	194,014	934 (0.5)	108 (0.1)	847 (0.4)

Among patients with a diagnosis of headache, 0.5% (10,374 patients) had an outcome within 30 days after ED discharge, and among those with a diagnosis of back pain, 0.2% (2,850 patients) had an outcome at 30 days.

Both of these rates are higher than those in the control cases. When extrapolated to the national level, our numbers translate to approximately 40,000 patients with potentially adverse diagnostic outcomes for headache

Table 2. Continued.

	Index ED Visit, n	Overall		
		Inhospital Death or Serious Neurologic Events Within 30 Days After ED Discharge, No. (%)	Inhospital Death Within 30 Days After ED Discharge, No. (%)	Serious Neurologic Events Within 30 Days After ED Discharge, No. (%)
Discharge quarter				
Jan-Mar	584,930	2,841 (0.5)	357 (0.1)	2,554 (0.4)
Apr-Jun	600,161	3,012 (0.5)	382 (0.1)	2,720 (0.5)
Jul-Sep	634,458	3,203 (0.5)	396 (0.1)	2,895 (0.5)
Oct-Dec	281,532	1,318 (0.5)	131 (<0.1)	1,220 (0.4)

Data are presented as n (%) unless otherwise specified.
ED, emergency department.

and approximately 17,000 for back pain in the United States annually.⁵⁴

For frontline clinicians (eg, emergency physicians, neurologists), professional organizations, researchers, and hospitals, these numbers are important to consider. On the individual patient level, the testing threshold and in turn acceptable miss rate for the specific condition, frequency of the condition, patient age, remaining potential years of life, incremental cost of potential harm for additional tests, and whether an accurate diagnosis made on the index visit could have prevented downstream adverse consequences are all factors the clinician must weigh. In addition to the direct patient harm and long-term consequences associated with missed or delayed diagnosis of strokes, intraspinal abscesses, and other serious neurologic conditions, misdiagnosis also leads to substantial health care costs and litigation. For instance, the aggregate costs to the US health care system are estimated to be \$100 to \$500 billion annually.⁵⁵ Individual payouts in malpractice claims related to diagnostic errors average \$295,000 per case.⁵⁶ Thus, although our observed misdiagnosis rate was relatively low, the potential costs (both financial and human effect) to the patient, family, clinician, and health care system may be substantial.

Our study extends earlier reports of neurologic misdiagnoses in large populations by demonstrating not only the incidence of potential adverse diagnostic outcomes of serious neurologic conditions but also their specific diagnoses and patient risk factors in population-based data. In a single-center analysis, Atzema et al⁴⁸ examined return ED visits within 30 days of discharged ED patients with peripheral vertigo and found a misdiagnosis rate of 0.2% for acute stroke, which is comparable to our observed calculation for missed neurologic conditions in patients with headache and back pain. In a cross-sectional study during a 1-year period, Newman-Toker et al²⁵ also examined 30-day return ED

visits and found that 15% of strokes were initially misdiagnosed (the denominator was the number of strokes, a look-back approach). Among those missed cases, headache and dizziness were the most common presenting symptoms. In contrast, the observed 30-day return rate of 0.5% for headache in our study was lower. The difference is attributable, at least in part, to the difference in study design and populations. Indeed, Newman-Toker et al²⁵ applied a look-back approach only to patients with stroke. The difference in these 2 approaches (look-forward versus look-back method) is illustrated by the analogy of the needle in the haystack. In our look-forward approach, we examined the haystack to identify the needles that were missed, whereas a look-back approach examines the pile of needles to identify how many of those needles were missed on the first visit. Each approach highlights the problem from a very different perspective. Our look-forward approach more closely parallels real-time decisionmaking, normal ED work flow, and the fact that most patients either do not receive a misdiagnosis or their misdiagnoses are of problems that do not result in death or the need for acute hospitalization.

The reasons for misdiagnosis are likely multifactorial. Previous studies on the misdiagnosis of neurologic emergencies have described cognitive errors, knowledge gaps, and systems-based errors as contributing factors.^{11,40,57,58} In a recent meta-analysis of 15,721 patients with acute cerebrovascular events, Tarnutzer et al⁸ found that misdiagnosis was more frequent for patients presenting with milder, transient, and nonspecific symptoms such as headache and dizziness. These atypical presentations are more prone to cognitive biases and failed heuristics for the physician, and therefore it is important for frontline providers to be aware of them. Croskerry^{59,60} also described several cognitive “debiasing” techniques, including metacognition, or reflecting on the thought

Table 3. Frequency of serious neurologic event and in-hospital death within 30 days after ED discharge with diagnosis of back pain, overall and stratified by patient characteristics in California, Florida, Iowa, Nebraska, New York, and Utah, 2006 to 2012.

	Index ED Visit, n	Overall		
		Inhospital Death or Serious Neurologic Events Within 30 Days After ED Discharge, No. (%)	Inhospital Death Within 30 Days After ED Discharge, No. (%)	Serious Neurologic Events Within 30 Days After ED Discharge, No. (%)
Overall	1,381,614	2,850 (0.2)	1,824 (0.1)	1,040 (0.1)
Age, y				
18–39	530,844	345 (0.1)	113 (<0.1)	233 (<0.1)
40–64	666,264	1,296 (0.2)	679 (0.1)	627 (0.1)
65–84	155,446	917 (0.6)	758 (0.5)	161 (0.1)
≥85	29,060	292 (1.0)	274 (0.9)	19 (0.1)
Sex				
Men	592,288	1,510 (0.3)	934 (0.2)	588 (0.1)
Women	783,329	1,324 (0.2)	878 (0.1)	448 (0.1)
Race				
Non-Hispanic white	724,213	1,805 (0.2)	1,174 (0.2)	638 (0.1)
Non-Hispanic black	247,768	331 (0.1)	217 (0.1)	115 (<0.1)
Hispanic	251,847	387 (0.2)	228 (0.1)	162 (0.1)
Asian	84,791	150 (0.2)	91 (0.1)	61 (0.1)
Other	72,995	177 (0.2)	114 (0.2)	64 (0.1)
Payer				
Medicare	250,566	1,303 (0.5)	1,042 (0.4)	266 (0.1)
Medicaid	281,800	434 (0.2)	244 (0.1)	194 (0.1)
Private	455,849	689 (0.2)	352 (0.1)	340 (0.1)
Self-pay	269,014	285 (0.1)	130 (<0.1)	156 (0.1)
Other	122,093	136 (0.1)	55 (<0.1)	82 (0.1)
Median household income state quartile for patient zip code				
1 (lowest quartile)	463,217	844 (0.2)	527 (0.1)	321 (0.1)
2	366,481	761 (0.2)	479 (0.1)	286 (0.1)
3	311,600	694 (0.2)	455 (0.1)	242 (0.1)
4 (highest quartile)	216,466	509 (0.2)	337 (0.2)	175 (0.1)
No. of comorbidities				
0	1,051,347	1,531 (0.1)	836 (0.1)	704 (0.1)
1–2	300,720	1,046 (0.3)	755 (0.3)	294 (0.1)
3–4	27,698	239 (0.9)	201 (0.7)	39 (0.1)
≥5	1,849	34 (1.8)	32 (1.7)	≤10*
Patient residence				
Metropolitan	1,248,249	2,577 (0.2)	1,640 (0.1)	949 (0.1)
Nonmetropolitan	133,143	273 (0.2)	184 (0.1)	91 (0.1)
Discharge quarter				
Jan–Mar	383,554	849 (0.2)	561 (0.1)	290 (0.1)
Apr–Jun	398,257	839 (0.2)	516 (0.1)	327 (0.1)
Jul–Sep	418,272	786 (0.2)	502 (0.1)	289 (0.1)
Oct–Dec	181,531	376 (0.2)	245 (0.1)	134 (0.1)

Data are presented as n (%) unless otherwise specified.

ED, emergency department.

*Reported according to the Healthcare Cost and Utilization Project data use agreement.

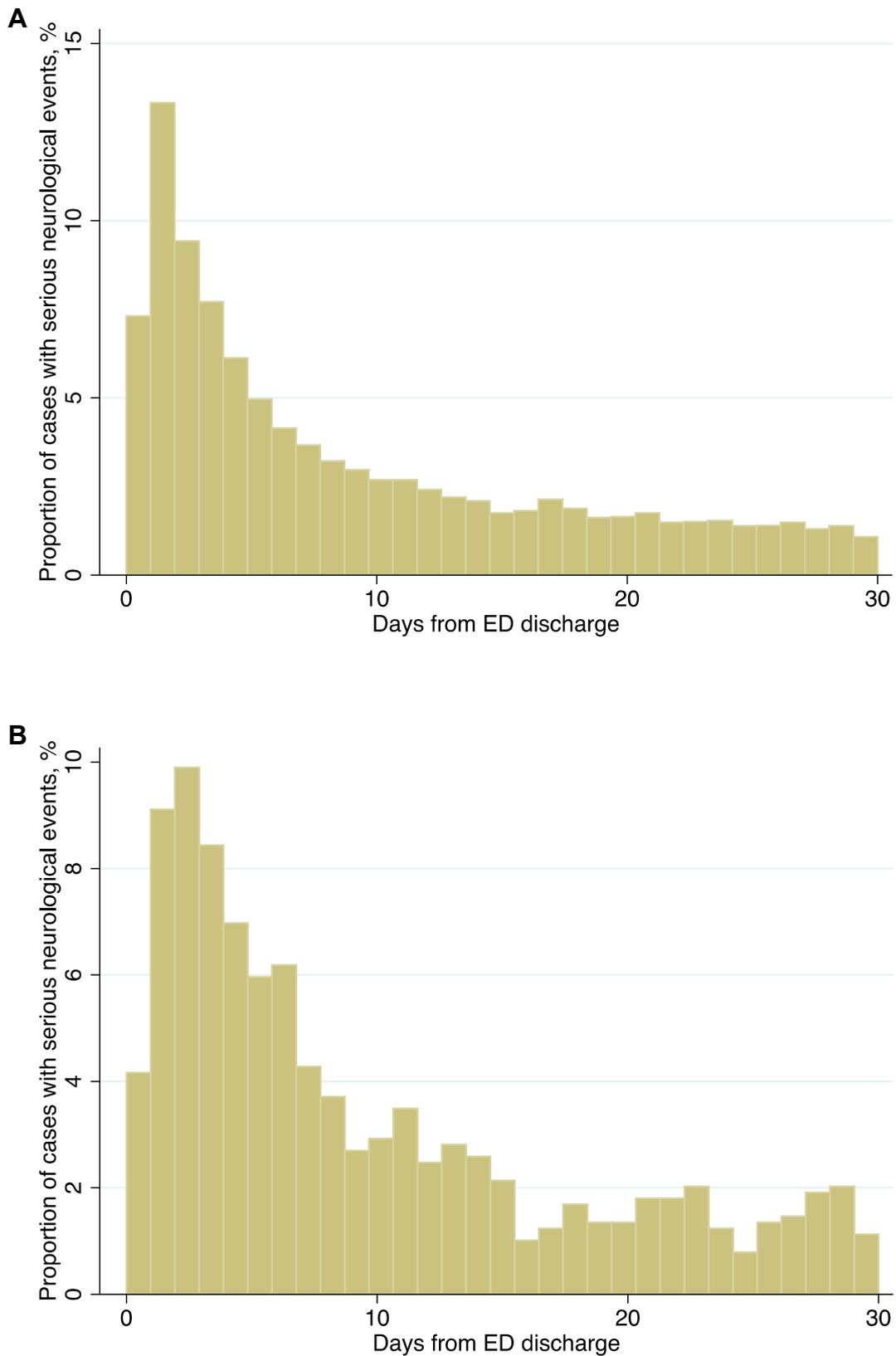


Figure. Proportion of ED revisit or hospitalization for serious neurologic event or in-hospital death within 30 days after index ED discharge with diagnosis for headache or back pain, by day. A, ED patients discharged with a nonspecific diagnosis of headache. B, ED patients discharged with a nonspecific diagnosis of back pain.

Table 4. Composite event rate of outcomes for headache or back pain in patients who visited the ED for other conditions.

Among Cough (n=1,442,479), Event Rate, %, (95% CI)	Among Chest Pain (n=8,299,338), Event Rate, %, (95% CI)	Among Abdominal Pain (n=736,158), Event Rate, %, (95% CI)	Among Localized Superficial Swelling, Mass, or Lump (n=73,630), Event Rate, %, (95% CI)
For headache outcomes			
Within 3 days	0.04 (0.03–0.04)	0.03 (0.02–0.03)	0.02 (0.01–0.03)
Within 7 day	0.07 (0.07–0.07)	0.05 (0.05–0.05)	0.04 (0.03–0.05)
Within 30 day	0.18 (0.17–0.19)	0.14 (0.14–0.14)	0.12 (0.010–0.15)
For back pain outcomes			
Within 3 day	0.02 (0.02–0.03)	0.01 (0.01–0.01)	0.01 (0.01–0.01)
Within 7 day	0.04 (0.04–0.05)	0.02 (0.02–0.02)	0.03 (0.02–0.04)
Within 30 day	0.11 (0.10–0.11)	0.06 (0.06–0.07)	0.08 (0.06–0.10)

CI, confidence intervals.

process, as ways to prevent this type of error. Educating clinicians on these processes may help prevent such misses. In addition, lack of understanding of the limitations of imaging on the part of clinicians may contribute to misdiagnosis.⁴¹ Current modern-generation computed

tomography scanners, the most frequent default initial imaging test in the ED, still misses early-presenting acute ischemic strokes⁶¹ and later-presenting subarachnoid hemorrhage.⁶² Furthermore, even magnetic resonance imaging (MRI) with diffusion-weighted imaging will miss

Table 5. Ranked reasons for neurologically serious events after ED discharge with diagnosis of headache, by follow-up period.

Average Rank		Proportion, % (Rank)		
		Within 3 Days	Within 7 Days	Within 30 Days
ICD-9-CM diagnosis				
1	Cerebral artery occlusion, unspecified with cerebral infarction	19.6 (1)	18.9 (1)	18.1 (1)
2	Subarachnoid hemorrhage	12.3 (2)	10.6 (2)	7.7 (4)
3	Unspecified transient cerebral ischemia	8.7 (3)	9.3 (3)	11.9 (2)
4	Benign intracranial hypertension	7.5 (4)	9.3 (4)	10.7 (3)
5	Malignant essential hypertension	5.2 (6)	5.9 (5)	6.4 (5)
6	Cerebral aneurysm, nonruptured	5.2 (6)	5.1 (6)	6.1 (6)
7	Intracerebral hemorrhage	5.5 (5)	5.1 (7)	4.3 (7)
8	Subdural hemorrhage	4.6 (8)	4.5 (8)	4.0 (8)
9	Giant cell arteritis	2.7 (10)	3.2 (9)	3.0 (9)
10	Cerebral embolism with cerebral infarction	2.9 (9)	2.6 (10)	2.5 (11)
CCS diagnosis group				
1	Acute cerebrovascular disease	51.0 (1)	47.2 (1)	41.0 (1)
2	Other nervous system disorders	11.1 (2)	13.2 (2)	14.7 (2)
3	Transient cerebral ischemia	9.4 (3)	10.0 (3)	12.9 (3)
4	Hypertension with complications and secondary hypertension	6.7 (4)	7.7 (4)	8.2 (4)
5	Other and ill-defined cerebrovascular disease	6.7 (4)	6.8 (5)	7.8 (5)
6	Other circulatory disease	2.7 (7)	3.2 (7)	3.0 (7)
7	Meningitis (except by TB or STDs)	3.1 (6)	3.8 (6)	2.2 (8)
8	Aortic, peripheral, and visceral artery aneurysms	1.7 (8)	1.7 (8)	1.6 (9)
9	Occlusion or stenosis of precerebral arteries	1.3 (10)	1.6 (9)	3.1 (6)
10	Hypertension complicating pregnancy, childbirth, and the puerperium	1.6 (9)	1.5 (10)	1.5 (10)

ICD-9-CM, International Classification of Diseases 9th Revision Clinical Modification; CCS, Clinical Classifications Software; TB, tuberculosis; STD, sexually transmitted disease.

Table 6. Ranked reasons for neurologically serious events after ED discharge with diagnosis of back pain, by follow-up period.

Average Rank		Proportion, % (Rank)		
		Within 3 Days	Within 7 Days	Within 30 Days
ICD-9-CM diagnosis				
1	Intraspinal abscess	45.6 (1)	46.4 (1)	44.0 (1)
2	Cauda equina syndrome without mention of neurogenic cause	14.6 (2)	13.3 (2)	11.9 (2)
3	Spondylosis with myelopathy, lumbar region	7.8 (3)	7.6 (3)	9.3 (3)
4	Unspecified disease of spinal cord	3.6 (5)	6.3 (4)	7.1 (4)
5	Paraplegia	3.6 (6)	2.7 (7)	3.3 (6)
6	Vascular myelopathies	3.2 (7)	2.9 (5)	2.1 (9)
7	Other causes of myelitis	3.6 (4)	2.7 (6)	2.0 (10)
8	Benign neoplasm of spinal meninges	2.1 (10)	2.5 (9)	3.7 (5)
9	Intracranial and intraspinal abscess of unspecified site	2.5 (9)	2.5 (10)	2.3 (8)
10	Benign neoplasm of spinal cord	1.8 (13)	2.5 (8)	3.2 (7)
CCS diagnosis group				
1	Other CNS infection and poliomyelitis	48.0 (1)	48.9 (1)	46.2 (1)
2	Paralysis	19.9 (2)	17.4 (2)	16.9 (2)
3	Other hereditary and degenerative nervous system conditions	8.5 (3)	11.3 (3)	11.3 (3)
4	Spondylosis, intervertebral disc disorders, back problems	8.2 (4)	8.8 (4)	11.3 (4)
5	Other and unspecified benign neoplasm	3.9 (6)	5.1 (5)	7.0 (5)
6	Encephalitis (except by TB or STDs)	5.7 (5)	4.1 (6)	3.4 (6)
7	Other nervous system disorders	3.2 (7)	2.5 (7)	2.3 (7)
8	Cancer of brain and nervous system	2.5 (8)	2.0 (8)	1.8 (8)
9	NA*			
10	NA*			

ICD-9-CM, International Classification of Diseases 9th Revision Clinical Modification; CCS, clinical classification software; CNS, central nervous system; TB, tuberculosis; STD, sexually transmitted diseases.

*All reasons were categorized into 8 CCS categories.

nearly 7% of acute ischemic strokes, especially those in the posterior circulation.⁶³ A negative test result does not always rule out serious neurologic pathology, such as subarachnoid hemorrhage as time from the hemorrhage elapses^{64,65} and early stroke,⁶⁶ which were the most common missed diagnoses observed in our study population discharged with headache. For patients with back pain, although the majority of complaints are due to benign causes, the diagnosis of serious neurologic conditions (eg, intraspinal abscesses, cauda equina syndrome) requires MRI. This imaging modality is not always readily accessible in some ED practice settings, thus highlighting the tension between favorable patient outcomes and resource overuse.^{40,42,67} Checklists⁶⁸ and health information technology^{69,70} have been used to decrease error in a variety of clinical settings. The use of these tools to identify risk factors (eg, substance abuse in patients with back pain) or computer-assisted forced questions (eg, is the headache of abrupt onset?) could avoid overtesting while helping clinicians better distinguish

patients with nonspecific symptoms who may require an extensive ED evaluation.

In summary, using the population-based data of almost 3.5 million ED patients discharged with nonspecific diagnoses of headache or back pain, we found that only a small proportion returned with a serious neurologic condition or died in-hospital after ED discharge. The most common potentially missed diagnosis for patients with atraumatic headache was ischemic stroke, whereas that for back pain was intraspinal abscess. We also found that advanced age, male sex, non-Hispanic white, and certain comorbidities were risk factors for this outcome. For emergency physicians, our findings suggest that although the incidence is well below what has been previously shown, there are still a substantial number of patients who may receive a misdiagnosis. Our findings also underscore the importance of continued efforts to improve education on the diagnosis of neurologic emergencies and address systems-based issues (eg, computer-based forced functions asking about risk factors for serious causes of headache and

back pain, boilerplate language in imaging results highlighting their limitations), which may in turn prevent misdiagnoses.

Supervising editor: Clifton Callaway, MD, PhD. Specific detailed information about possible conflict of interest for individual editors is available at <https://www.annemergmed.com/editors>.

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Author contributions: NMD, JAE, and KH conceived the study and designed the analysis. TG and CAC provided statistical advice on study design. TG analyzed the data. NMD drafted the article, and all authors contributed substantially to its revision. NMD takes responsibility for the paper as a whole.

All authors attest to meeting the four [ICMJE.org](http://www.icmje.org) authorship criteria: (1) Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; AND (2) Drafting the work or revising it critically for important intellectual content; AND (3) Final approval of the version to be published; AND (4) Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Funding and support: By *Annals* policy, all authors are required to disclose any and all commercial, financial, and other relationships in any way related to the subject of this article as per ICMJE conflict of interest guidelines (see www.icmje.org). The authors have stated that no such relationships exist.

Publication dates: Received for publication July 11, 2018. Revision received December 8, 2018. Accepted for publication January 4, 2019.

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