Association of Diagnostic Discrepancy with Length of Stay and Mortality in Congestive Heart Failure Patients Admitted to the Emergency Department

Joseph Finkelstein, MD, PhD,[1] Wanting Cui, MA,[1] Jeffrey P Ferraro, PhD,[2] Kensaku Kawamoto, MD, PhD[1]

[1]Department of Biomedical Informatics, [2]Department of Medicine, School of Medicine, University of Utah, Salt Lake City, UT

Abstract

The goal of this study was to analyze diagnostic discrepancies between emergency department (ED) and hospital discharge diagnoses in patients with congestive heart failure admitted to the ED. Using a synthetic dataset from the Department of Veterans Affairs, the patients' primary diagnoses were compared at two levels: diagnostic category and body system. With 12,621 patients and 24,235 admission cases, the study found a 58% mismatch rate at the category level, which was reduced to 30% at the body system level. Diagnostic categories associated with higher levels of mismatch included aplastic anemia, pneumonia, and bacterial infections. In contrast, diagnostic categories associated with lower levels of mismatch included alcohol-related disorders, COVID-19, cardiac dysrhythmias, and gastrointestinal hemorrhage. Further investigation revealed that diagnostic mismatches are associated with longer hospital stays and higher mortality rates. These findings highlight the importance of reducing diagnostic uncertainty, particularly in specific diagnostic categories and body systems, to improve patient care following ED admission.

Introduction

In the context of the Emergency Department (ED), a diagnostic discrepancy is defined as a discrepancy between hospital discharge and ED diagnoses [1]. Diagnostic discrepancy is a well-described phenomenon in healthcare [2-3], and it is common, especially in patients hospitalized via the ED [4-5]. According to previous reports, diagnostic error rates in patients admitted to the ED vary between 0.6% and 64% [6-8]. The variation in the reported error rates, at least in part, is explained by differences in how the diagnostic error was defined, and whether primary diagnosis, all diagnoses, missed diagnosis, or unintentionally delayed diagnosis were used in calculating diagnostic discrepancy [8–11]. Diagnostic discrepancy in the ED may result in serious patient harm and, in certain instances [4], may be associated with heightened morbidity and mortality [12]. Diagnostic discrepancies can have significant implications, both for patients and healthcare providers, such as delayed treatment, increased healthcare costs, patient anxiety, distress and continued suffering, decreased patient trust, inappropriate treatment, overuse of resources, unnecessary or excessive referrals and consultations, negative impact on clinical decision-making, and unnecessary treatments [13-16]. The Comparative Effectiveness Review of Diagnostic Errors in the ED published in 2022 by the Agency for Healthcare Research and Quality (AHRQ) concluded that diagnostic discrepancies in the ED represent a significant patient safety challenge and that future research should emphasize areas in which data are suboptimal or lacking [17]. A systematic analysis of diagnostic discrepancies in patients with congestive heart failure admitted to the ED has not been performed. The goal of this study was to address this gap.

Methods

The dataset used in the study was a synthetic dataset containing heart failure veteran patients generated by the US Department of Veterans Affairs. The Synthetic Data Lake (SDL) is designed to balance data utility and patient privacy by maintaining the original dataset's structure and variable types while implementing privacy safeguards. Before the synthesis process, basic de-identification steps are taken, such as removing direct identifiers like names and addresses and limiting the SDL to a random sample of the original patients. However, there are some limitations when utilizing the synthetic data lake as a substitute for the original data. First, specific date values are not retained, but the SDL captures temporal relationships, such as time intervals between diagnosis and the duration of hospital admissions. Second, data elements with hierarchical structures, such as diagnoses and medications, are provided at a less detailed level, with medications represented by their active ingredient (ATC5) and diagnoses categorized under ICD-10 sub-groups.

We identified cases of hospital admission following emergency department (ED) visits by calculating the time difference between the discharge date/time from the ED and the subsequent inpatient admission date/time. Only records where the inpatient visit occurred either on the same day or one day after the ED discharge date were retained for analysis. To meet the selection criteria, patients were required to be adults at the time of their ER visit. Additionally, ER diagnoses that pertained to symptoms or injuries (based on CCSR classification as described below) were excluded from the analysis to ensure a more specific and relevant dataset for further investigation.

Once the research cohort was established, additional information was mapped for each case. This included patients' demographic information, hospital length of stay, and survival information. In this analysis, each medical visit was associated with a maximum of two diagnoses, namely the primary and secondary diagnoses. All diagnoses were in ICD-10 subgroups. We then further categorized all diagnoses using the Clinical Classifications Software Refined (CCSR) for the ICD-10-CM diagnosis data dictionary from AHRQ [18]. It mapped ICD-10 codes into over 530 clinical categories across 22 body systems.

Our objective was to compare the primary diagnosis at the ED with the primary discharge diagnosis of the inpatient visit, conducting a one-to-one comparison. This comparison assessed diagnostic discrepancies at two levels: the diagnostic category level and the broader body system level. We separated the cases into two subsets: we defined a 'match' case if the primary diagnosis in the ED was within the same level as the primary discharge diagnosis during inpatient care. Conversely, a 'no match' case occurred when the primary diagnosis in the ED was not within the same level as the primary discharge diagnosis during inpatient care. We counted the number of cases for each subgroup and performed descriptive statistics. We further calculated the average length of stay and death rate at discharge for each subgroup and performed statistical testing using the Mann–Whitney U test for continuous variables and the chi-squared test for categorical variables.

Results

There were 12,621 patients and 24,235 cases in the analytic dataset. The average age of patients was 71.39±10.81 years old. Approximately 3% (n = 429) of patients were female, while 97% (n = 12,192) of patients were male. In terms of racial distribution, White patients made up the majority at 71% (n = 8,986), followed by Black or African American patients at 23% (n = 2,842), with the remaining 6% representing patients of other races. In terms of ethnicity, 4% (n = 561) of patients were identified as Hispanic or Latino, while 90% (n = 11,412) of patients were not Hispanic or Latino, and the remaining 6% patients had missing information.

We calculated descriptive statistics on the diagnostic mismatch rate. As shown in Table 1, there were around 58% of mismatches based on the categorical level. The mismatches were reduced to 30.3% when using the body system level. 10,110 cases were matched at the category level, whereas 14,125 cases were mismatched at this level. In contrast, at the body system level, 16,903 cases were labeled as matched and 7,332 cases were labeled as not matched.

Table 1. Number of match and mismatch cases.

	Category		Body System	
	# Records	% Records	# Records	% Records
Match	10110	41.7%	16903	69.7%
No match	14125	58.3%	7332	30.3%

Table 2 shows the top 20 most frequent ED primary diagnostic categories. Predominantly, patients visiting the ED were diagnosed with heart failure, followed by nonspecific chest and chronic obstructive pulmonary disease and bronchiectasis. The diagnostic categories with higher levels of mismatch were aplastic anemia, pneumonia, bacterial infections, and fluid and electrolyte disorders. In contrast, the diagnostic categories of alcohol-related disorders, COVID-19, cardiac dysrhythmias, gastrointestinal hemorrhage, and other specified diseases of veins and lymphatics had lower levels of mismatch.

Table 2. Summary statistics of top 20 most frequent ED primary diagnostic categories.

Diagnostics categories	Number of emergency visits	Distribution	Number of Mismatches	Mismatch percent
Heart failure	3579	14.8%	2398	67.0%
Nonspecific chest pain	3233	13.3%	2155	66.7%
Chronic obstructive pulmonary disease and bronchiectasis	1612	6.7%	835	51.8%
Cardiac dysrhythmias	1292	5.3%	416	32.2%
Pneumonia (except that caused by tuberculosis)	1068	4.4%	881	82.5%
Other specified diseases of veins and lymphatics	979	4.0%	386	39.4%
Respiratory failure; insufficiency; arrest	895	3.7%	459	51.3%
Acute and unspecified renal failure	757	3.1%	393	51.9%
Fluid and electrolyte disorders	756	3.1%	542	71.7%
Acute myocardial infarction	578	2.4%	242	41.9%
Alcohol-related disorders	571	2.4%	82	14.4%
Coronary atherosclerosis and other heart disease	547	2.3%	335	61.2%
Urinary tract infections	531	2.2%	282	53.1%
Aplastic anemia	512	2.1%	434	84.8%
Gastrointestinal hemorrhage	446	1.8%	159	35.7%
Hypotension	443	1.8%	251	56.7%
Septicemia	316	1.3%	134	42.4%
Diabetes mellitus with complication	288	1.2%	120	41.7%
Bacterial infections	271	1.1%	218	80.4%
COVID-19	248	1.0%	41	16.5%

In terms of body system (Table 3), around 49% of patients went to the emergency department for diseases of the circulatory system, which was consistent with category level diagnoses. There was an 18% mismatch rate, which was relatively low. Secondly, 17% of patients in the emergency department were diagnosed with diseases of the respiratory system, and the mismatch rate was 36% for this body system, which was higher than the overall mismatch rate. Thirdly, 8% of patients were diagnosed with diseases of the genitourinary system, and its mismatch rate was 45%, which was higher than the overall mismatch rate. In addition, there were 5% of patients who were diagnosed with diseases of the endocrine system and mental disorders respectively. The mismatch rate for diseases of the endocrine system was high at 59%, whereas the mismatch rate for mental disorders was low at 10%.

Table 3. Summary statistics of primary ED diagnoses in body systems.

Body Systems	Number of emergency visits	Distribution	Number of Mismatches	Mismatch percent
Diseases of blood and blood-forming organs (BLD)	701	2.9%	339	48.4%
Diseases of circulatory system (CIR)	11808	48.7%	2173	18.4%
Dental diseases (DEN)	25	0.1%	19	76.0%
Diseases of digestive system (DIG)	998	4.1%	225	22.5%
Diseases of the ear and mastoid process (EAR)	6	0.0%	5	83.3%

Diseases of endocrine system (END)	1164	4.8%	684	58.8%
Diseases of eye and adnexa (EYE)	21	0.1%	18	85.7%
Factors influencing health status and contact with health services (FAC)	473	2.0%	465	98.3%
Diseases of genitourinary system (GEN)	1875	7.7%	839	44.7%
Infectious and parasitic diseases (INF)	936	3.9%	360	38.5%
Mental, behavioral and neurodevelopmental disorders (MBD)	1130	4.7%	112	9.9%
Diseases of musculoskeletal system and connective tissue (MUS)	357	1.5%	282	79.0%
Neoplasms (NEO)	125	0.5%	62	49.6%
Diseases of nervous system (NVS)	311	1.3%	159	51.1%
Diseases of respiratory system (RSP)	4194	17.3%	1504	35.9%
Diseases of skin and subcutaneous tissue (SKN)	106	0.4%	81	76.4%

We further investigated how diagnostic mismatch affected patients' hospital length of stay (LOS) and mortality rate. According to Table 4, the overall average LOS was 4.35 days. On a category level, the average LOS for the match group was 3.68 days and the average LOS for the mismatch group was 4.7 days. On a body system level, the average LOS for the match group was 3.72 days and the average LOS for the mismatch group was 5.56 days. There was a significantly longer length of stay for the mismatch group in both the category level mismatch and the body system level mismatch.

Table 4. Summary statistics of LOS by mismatch status.

Category						
	mean	std	25%	50%	75%	P-Value
No match	4.70	7.98	1	2	6	<0.001
Match	3.68	7.66	1	2	4	
Body System						
No match	5.56	9.39	1	3	6	<0.001
Match	3.72	7.02	1	2	4	

There were 2.2% of patients who died during the hospital stay. Based on Table 5, on the category level, the mortality rate of the match group was 1.36%, whereas the mortality rate of the mismatch group was 2.80%. On the body system level, the mortality rate of the match group was 1.46%, whereas the mortality rate of the mismatch group was 3.91%. The differences in LOS and mortality between "match" and "no-match" groups were statistically significant.

Table 5. Summary statistics of mortality rate by mismatch.

	Category			Body System		
	# Death	% Death	P-Value	# Death	% Death	P-Value
No match	396	2.80%	<0.001	287	3.91%	<0.001
Match	137	1.36%		246	1.46%	

We further analyzed patients' discharge diagnoses through the mismatch rate, LOS and mortality rate (Table 6). Around 11% of primary inpatient diagnoses were hypertension with complications and secondary hypertension (n = 2,694), followed by 7.6% for heart failure (n = 1,839) and 6.5% for respiratory failure, insufficiency, or arrest (n = 1,573). Diagnostic categories with a high mismatch rate were hypertension with complications and secondary hypertension (94.9%), bacterial infection (87.3%), septicemia (82.9%), and coronary atherosclerosis and other heart disease (80.5%). Diagnostic categories with low mismatch rates were other specified diseases of veins and lymphatics (17.8%), nonspecific chest pain (21.1%), and alcohol-related disorders (29.1%), which were consistent with the ED diagnoses. In addition, diagnoses in respiratory failure, septicemia and COVID-19 resulted in both longer hospital admission and higher percentage of death. Diagnoses in alcohol-related disorders and diabetes mellitus with complications resulted in longer hospital admission, but a relatively low percentage of death.

Table 6. Summary statistics of top 20 most frequent inpatient primary diagnostic categories.

Diagnostic categories	Mismatch percent	LOS		Death	
		mean	std	# Death	% Death
Hypertension with complications and secondary hypertension	94.9%	4.00	5.17	35	1.3%
Heart failure	35.8%	4.32	7.33	36	2.0%
Respiratory failure; insufficiency; arrest	72.3%	5.40	8.04	107	6.8%
Nonspecific chest pain	21.1%	1.40	9.00	0	0.0%
Cardiac dysrhythmias	31.0%	3.19	6.02	8	0.6%
Chronic obstructive pulmonary disease and bronchiectasis	38.8%	3.27	13.43	9	0.7%
Coronary atherosclerosis and other heart disease	80.5%	2.58	5.96	8	0.7%
Septicemia	82.9%	6.88	7.97	94	8.9%
Acute myocardial infarction	61.2%	3.88	5.03	23	2.7%
Other specified diseases of veins and lymphatics	17.8%	3.90	9.82	1	0.1%
Acute and unspecified renal failure	48.4%	3.71	5.87	10	1.4%
Alcohol-related disorders	29.1%	5.45	9.99	1	0.1%
Diabetes mellitus with complication	69.6%	5.43	7.39	4	0.7%
Gastrointestinal hemorrhage	38.1%	3.67	4.63	7	1.5%
Urinary tract infections	43.4%	3.75	5.54	2	0.5%
Hypotension	54.4%	2.43	3.49	2	0.5%
Bacterial infections	87.3%	4.52	5.69	7	1.7%
Pneumonia (except that caused by tuberculosis)	51.9%	3.12	3.41	1	0.3%
COVID-19	45.8%	7.01	7.91	45	11.8%
Fluid and electrolyte disorders	41.2%	2.19	3.01	2	0.5%

Discussion

The study focused on the analysis of heart failure patients, aiming to understand diagnostic discrepancies between emergency department (ED) and inpatient diagnoses and their impact on patient outcomes. Several key findings emerged from the investigation, shedding light on the nature of these discrepancies and their implications.
There were a significant number of diagnostic discrepancies between ED and inpatient diagnoses. At the diagnostic category level, these discrepancies were observed in approximately 58% of cases, and even at the broader body system level, there was still a 30% mismatch rate. In the diagnostic category level, the diagnostic categories associated with higher levels of mismatch included aplastic anemia, pneumonia, bacterial infections, and fluid and electrolyte disorders. In contrast, diagnostic categories related to alcohol-related disorders, COVID-19, cardiac dysrhythmias, gastrointestinal hemorrhage, and specified diseases of veins and lymphatics had lower levels of mismatch. When examining diagnostic discrepancies at the body system level, diseases of the circulatory system, a common reason for ED visits in the patient cohort under investigation, had a relatively low mismatch rate. Conversely, diseases of the respiratory system and genitourinary system had higher mismatch rates.

In addition, we assessed how diagnostic discrepancies impacted patient outcomes. We observed that patients in the mismatched group, whether at the categorical or body system level, experienced significantly longer hospital stays compared to those in the matched group. This finding underscored the potential challenges associated with diagnostic uncertainty [19], which may lead to prolonged hospitalization and increased healthcare resource utilization.

Furthermore, the analysis showed that diagnostic discrepancies can influence mortality rates. There was a significantly higher mortality rate for the mismatched group than for the matched group on both the categorical and body system levels. Diagnoses such as respiratory failure, septicemia, and COVID-19, which have high mismatch rates, were associated with both extended hospital admissions and higher percentages of patient deaths. In contrast, diagnoses like alcohol-related disorders and diabetes mellitus with complications, which result in longer hospital stays, exhibited relatively lower mortality rates.

However, there were some limitations to the study. Firstly, the dataset was specifically curated for heart failure patients, predominantly consisting of older adult and male patients. This demographic composition may limit the generalizability of the findings to the broader population, as older patients tend to exhibit longer hospital stays and higher mortality rates. Therefore, caution should be exercised when extrapolating the results to a more diverse patient population, including younger individuals and females. Secondly, the dataset provided at most two diagnoses for each medical visit, which was fewer than what is typically available in real-world healthcare settings. Based on our previous experience with real-world data extracted from electronic medical records, an average of four diagnoses for ED visits and eight diagnoses for inpatient visits is typical for this population [20-21]. This limitation implied that the full spectrum of diagnoses may not be captured and would potentially result in a different observed rate of diagnostic mismatch. The mismatched rate could potentially change if all diagnoses were compared. Lastly, the synthetic nature of the dataset precluded the derivation of detailed medical histories and the calculation of a comorbidity index, which could provide deeper insights into various contributing factors.

In future studies, we will apply similar methods to other datasets, such as TriNetX and All of Us, that represent diverse patient subgroups and medical conditions on a population level [22]. Data from electronic health records (EHR) and malpractice claims may be another valuable resource for modeling diagnostic uncertainty in real world settings [23-24]. The comparative analysis could provide additional information on variations in diagnostic consistency across different healthcare contexts. We will also build predictive models to identify cases of potential misdiagnoses for enhancing clinical decision-making and patient care. Clinical decision support embedded into EHR AND based on machine learning algorithms for differential diagnostics has a potential to reduce diagnostic uncertainty in the future [25]. These investigations could provide a more comprehensive understanding of diagnostic discrepancies in healthcare settings and contribute to improvements in patient outcomes and healthcare delivery.

Conclusion

In conclusion, this study provided valuable insights into diagnostic discrepancies between ED and inpatient diagnoses among heart failure veteran patients. It highlighted the need for improved diagnostic consistency, particularly in certain diagnostic categories and body systems, to enhance patient care and optimize healthcare resource utilization. It is a useful and valid preliminary study that could provide insights into strategies to reduce diagnostic discrepancies and their associated adverse outcomes in clinical practice, ultimately improving the quality of care provided to patients with heart failure and other medical conditions.

References

1. Hautz WE, Kämmer JE, Hautz SC, Sauter TC, Zwaan L, Exadaktylos AK, et al. Diagnostic error increases mortality and length of hospital stay in patients presenting through the emergency room. Scand J Trauma Resusc Emerg Med. 2019;27(1):1–12.
2. Tipsmark LS, Obel B, Andersson T, Søgaard R. Organisational determinants and consequences of diagnostic discrepancy in two large patient groups in the emergency departments: a national study of consecutive episodes between 2008 and 2016. BMC Emerg Med. 2021;21(1):145.

3. Bartlett EE. Physicians' cognitive errors and their liability consequences. J Healthc Risk Manag. 1998;18(4):62–9.
4. Hussain F, Cooper A, Carson-Stevens A, et al. Diagnostic error in the emergency department: learning from national patient safety incident report analysis. BMC Emerg Med. 2019;19(1):77.
5. Avelino-Silva TJ, Steinman MA. Diagnostic discrepancies between emergency department admissions and hospital discharges among older adults: secondary analysis on a population-based survey. Sao Paulo Med J. 2020; 138(5):359-67.
6. Peng A, Rohacek M, Ackermann S, Ilsemann-Karakoumis J, Ghanim L, Messmer AS, et al. The proportion of correct diagnoses is low in emergency patients with nonspecific complaints presenting to the emergency department. Swiss Med Wkly. 2015;145(March):1–9.
7. Berner ES, Graber ML. Overconfidence as a Cause of Diagnostic Error in Medicine. Am J Med. 2008;121(5 SUPPL):2–23.
8. Chellis M, Olson J, Augustine J, Hamilton G. Evaluation of missed diagnoses for patients admitted from the emergency department. Acad Emerg Med. 2001;8(2):125–30.
9. Graber ML, Franklin N, Gordon R. Diagnostic error in internal medicine. Arch Intern Med. 2005;165(13):1493–9.
10. Moonen PJ, Mercelina L, Boer W, Fret T. Diagnostic error in the emergency department: follow up of patients with minor trauma in the outpatient clinic. Scand J Trauma Resusc Emerg Med. 2017;25(1):1–7.
11. Hautz WE. When I say … diagnostic error. Med Educ. 2018;52(9):896–7.
12. Abe T, Tokuda Y, Shiraishi A, et al. In-hospital mortality associated with the misdiagnosis or unidentified site of infection at admission. Crit Care. 2019;23(1):202.
13. 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.
14. 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.
15. 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.
16. 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.
17. Newman-Toker DE, Peterson SM, Badihian S, et al. 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.
18. Shaka H, Edigin E. A Revised Comorbidity Model for Administrative Databases Using Clinical Classifications Software Refined Variables. Cureus. 2021 Dec 14;13(12):e20407.
19. Alam R, Cheraghi-Sohi S, Panagioti M, Esmail A, Campbell S, Panagopoulou E. Managing diagnostic uncertainty in primary care: a systematic critical review. BMC Fam Pract. 2017 Aug 7;18(1):79.
20. Lyu J, Cui W, Finkelstein J. Assessing Disparities in COVID-19 Testing Using National COVID Cohort Collaborative. Stud Health Technol Inform. 2022 Jun 29;295:316-319.
21. Lyu J, Cui W, Finkelstein J. Using Big Data to Identify Impact of Asthma on Mortality in Patients with COVID-19. Stud Health Technol Inform. 2022 May 25;294:352-356.
22. Huo X, Finkelstein J. Analyzing Diagnostic Discrepancies in Emergency Department Using the TriNetX Big Data. 2023 IEEE International Conference on Bioinformatics and Biomedicine (BIBM), 2023, pp. 4896-4898.
23. Cui W, Cabrera M, Finkelstein J. Latent COVID-19 Clusters in Patients with Chronic Respiratory Conditions. Stud Health Technol Inform. 2020 Nov 23;275:32-36.
24. Cui W, Finkelstein J. Using Big Data Analytics to Identify Dentists with Frequent Future Malpractice Claims. Stud Health Technol Inform. 2020 Jun 16;270:489-493.
25. Kawamoto K, Finkelstein J, Del Fiol G. Implementing Machine Learning in the Electronic Health Record: Checklist of Essential Considerations. Mayo Clin Proc. 2023 Mar;98(3):366-369.