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Evidence for Anchoring Bias in Physician Decision-Making

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Conflicts of Interest: None disclosed

Key Points

Questions: Do emergency department (ED) physicians anchor on information found in the “Patient Visit Reason” documented prior to a physician seeing the patient?

Findings: Among patients with congestive heart failure (CHF) presenting to the ED with shortness of breath, physicians were less likely to test such patients for pulmonary embolism (PE) when the Patient Visit Reason mentioned CHF. However, there was no association between mention of CHF and ultimately diagnosed acute PE.

Meaning: Physicians tested patients for PE less when the Patient Visit Reason mentioned CHF, consistent with an anchoring bias that led to delayed workup and diagnosis of PE.

Abstract

Introduction: Cognitive biases are hypothesized to influence physician decision-making, but large-scale evidence consistent with their influence is limited. One such bias is anchoring bias, or the focus on one—often initial—piece of information in making clinical decisions without sufficiently adjusting to later information.

Objective: Using the clinical scenario of patients with congestive heart failure (CHF) presenting to the emergency department (ED) with shortness of breath (SOB), we examined whether physicians were less likely to test such patients for pulmonary embolism (PE) when the “Patient Visit Reason,” documented in triage before physicians see the patient, mentioned CHF.

Design: Cross-sectional study of 2011-2018 national Veterans Affairs (VA) data. Analyses were performed July 2019-January 2023.

Setting: VA EDs

Participants: Patients with CHF presenting with SOB

Exposure: The “Patient Visit Reason” mentions CHF

Main Outcomes and Measures: PE testing (D-dimer, CT scan of chest with contrast, ventilation/perfusion scan, lower-extremity ultrasound), time to PE testing (among those tested for PE), b-type natriuretic peptide (BNP) testing, acute PE diagnosed in the ED, acute PE ultimately diagnosed (within 30 days of ED visit).

Results: Our sample included 108,019 patients with CHF presenting with SOB, 4.1% of whom had a “Patient Visit Reason” that mentioned CHF. Overall, 13.2% of patients received PE testing, on average within 76 minutes, 71.4% received BNP testing, 0.23% were diagnosed with acute PE in the ED, and 1.1% were ultimately diagnosed with acute PE. In adjusted analyses, mention of CHF was associated with a 4.6 percentage-point reduction (95% CI -5.7 to -3.5) in PE testing, 15.5 more minutes (95% CI 5.7 to 25.3) to PE testing, and 6.9 percentage-point (95% CI 4.3 to 9.4) more BNP testing. Mention of CHF was associated with a 0.15 percentage-point lower (-0.23 to -0.08) likelihood of PE diagnosis in the ED, although no significant association between the mention of CHF and ultimately diagnosed PE was observed (0.06 percentage-point difference [95% CI -0.23 to 0.36]).

Conclusions and Relevance: Among patients with CHF presenting with SOB, physicians were less likely to test for PE when the “Patient Visit Reason” documented before they see the patient

mentioned CHF. Physicians may anchor on such initial information in decision-making, in this case associated with delayed workup and diagnosis of PE.

Background

Cognitive biases are hypothesized to influence physician decision-making.^{1,2} One such cognitive bias is anchoring bias, under which physicians focus on one—often initial—piece of information in formulating a diagnosis without sufficiently adjusting to later information.³ It is thought to be one of the most common cognitive biases affecting physician decision-making.^{4,5} Anchoring bias is often accompanied by the framing effect, under which physicians are influenced by the way in which the problem is presented, and by ascertainment bias, under which physicians, once framed, see what they expect to see.³

Literature regarding cognitive biases, however, is largely limited to case vignettes,⁶ small samples of patients,¹ or small-scale experiments.² A handful of studies that have examined the influence of cognitive biases in non-experimental conditions using large databases have found evidence consistent with availability bias (a cognitive bias under which assessments of event probabilities are influenced by the ease with which such events can be recalled).⁷⁻¹⁰ For example, our prior study using the same Veterans Affairs (VA) data found that having a recent patient with a pulmonary embolism (PE) was associated with increased rates of PE testing for subsequent patients.¹⁰ However, despite its hypothesized high prevalence and influence, anchoring bias in complex testing decisions has yet to be examined using large-scale, clinically-rich electronic health record (EHR) data.

In this study, we used national VA EHR data from 2011 to 2018 to examine a common, high-risk clinical scenario: assessing patients in the emergency department (ED) with shortness of breath (SOB) for the risk of pulmonary embolism (PE). We examined information contained in the

patient record field “Patient Visit Reason,” which is documented on ED arrival based on patient report at presentation by a nurse in triage prior to the physician encounter. Among a sample of patients all with congestive heart failure (CHF), we tested the hypothesis that when this “Patient Visit Reason” specifically mentions CHF, as opposed to the more open-ended “shortness of breath” without mention of CHF, physicians anchor on CHF and are less likely to consider PE. First, among patients all with CHF presenting to the ED with SOB, we examined whether the mention of CHF in the visit reason was associated with less testing for PE, a longer time to PE testing, and increased B-type natriuretic peptide (BNP) testing, which is commonly ordered to assess for CHF exacerbation. Next, we examined whether mention of CHF was associated with less diagnosis of acute PE in the ED. Finally, we examined whether mention of CHF was associated with the ultimate diagnosis of acute PE.

Methods

Data, Study Population, and Study Measures

We used national EHR data from the VA Corporate Data Warehouse, which includes patient demographics, vital signs, diagnosis codes, tests ordered, and surgeries performed. We use ED visit data collected in EDIS (Emergency Department Integration Software), which the VA fully implemented in 2011.¹¹ Analyses were performed from July 2019 to January 2023.

We identified patients 30 years or older with diagnosed CHF who visited a VA ED for SOB between 2011 and 2018. Although the data field “Patient Visit Reason” may denote “shortness of breath” or “SOB,” it could also potentially promote anchoring on CHF with a label such as

“SOB/CHF.” We defined the latter as our primary covariate of interest—a binary variable that indicated mention of CHF. We excluded ED visits for patients on hospice or who were comfort measures only. We excluded ED visits for patients with an outpatient prescription fill for an anticoagulant within 30 days prior to ED arrival in order to exclude patients who were possibly being treated for an acute PE or were otherwise on a medication that would make PE a much less likely diagnosis. We also excluded ED visits for patients who also had an outpatient evaluation and management visit on the same day as such outpatient visits may have influenced the ED visit reason.

We focused on PE as a model diagnosis because it is a high-risk diagnosis for which several clinical factors correlated with its risk are observable in EHR data. Specifically, we included 4 of the 7 clinical factors found in the commonly-used Wells’ score for PE⁸ that were observable in our data (prior deep venous thrombosis [DVT] or PE, recent cancer diagnosis, recent surgery, and tachycardia). We included the number of inpatient admissions for CHF exacerbation in the prior year (0 admissions, 1 admission, 2 admissions, 3+ admissions) as a proxy for CHF severity. We also included duration of CHF diagnosis (0-2 years, 2-5 years, 5+ years) because it may be correlated with testing for PE. Other clinical covariates included oxygen saturation less than 90% and the presence of ischemic heart disease or chronic obstructive pulmonary disease (COPD). Other patient covariates included age, sex, race and ethnicity, and do not resuscitate/do not intubate (DNR/DNI) status.

Our first outcome of interest was testing for PE, which was a binary variable defined as any of the following tests: D-dimer, CT scan of the chest with contrast, ventilation/perfusion (V/Q) scan, or lower extremity ultrasound. Our second outcome of interest was, among those tested for

PE, time elapsed in minutes from ED arrival to testing for PE. Our third outcome of interest was a binary variable for B-type natriuretic peptide (BNP). Our fourth outcome of interest was acute PE diagnosed during the ED visit. Finally, to assess whether the mention of CHF was associated with a lower likelihood of an ultimately diagnosed acute PE (that is, an acute PE that was present during the ED visit and diagnosed either during the ED visit or a small period of time after the ED visit), the diagnosis of acute PE within 30 days of the ED visit was an outcome of interest. This outcome, which is inclusive of acute PE diagnosed in the ED, assumes that an acute PE will continue to cause the SOB for which patients presented to the ED until discovered. We interpret finding that the mention of CHF is associated with less diagnosis of acute PE in the ED but not associated with ultimately diagnosed acute PE (inclusive of acute PE diagnosed in the ED) as implying both 1) no ultimate association of mention of CHF with acute PE and 2) delayed diagnosis of acute PE when there is a mention of CHF.

Statistical Analysis

We compared ED visits with a visit reason mentioning CHF to ED visits with a visit reason that did not mention CHF using multivariable regressions with a linear probability model, controlling for the clinical and demographic covariates described above. We also included weekend (versus weekday) fixed effects, month fixed effects, and year fixed effects to adjust for differences in care on the weekends (e.g. staffing), seasonality, and temporal trends. We included physician fixed effects to adjust for within-clinician, time-invariant traits, effectively comparing ED visits to the same physician. We presented adjusted outcomes using marginal standardization, also known as predictive margins, holding other covariates at their mean values. We clustered our standard errors at the hospital level.

All p-values were from 2-sided tests, with statistical significance at the $p < 0.05$ level. Data were prepared using Microsoft SQL Server and analyzed using Stata version 15.1. The VA Greater Los Angeles Healthcare System IRB approved the study.

Results

Characteristics of the Study Population

Our sample included 108,019 patient visits across 104 VA facilities. The average age was 71.9, and 2.5 percent were female (**Table 1**). 4.1 percent had a visit reason that specifically mentioned CHF. 13.2 percent were tested for PE. Among those tested for PE, the average time to test was 75.7 minutes. 71.4 percent received BNP testing. 0.23 percent received a diagnosis of acute PE during the ED visit, and 1.1 percent ultimately received an acute PE diagnosis (inclusive of acute PE diagnosis in the ED) within 30 days. Patient visits with visit reason mentioning CHF (versus not mentioning CHF) had on average a longer duration of CHF and more inpatient admissions for CHF in the prior year. They were more likely to have ischemic heart disease and less likely to have COPD. They were less likely to have a recent diagnosis of malignancy, less likely to have a prior DVT or PE, less likely to have tachycardia, and less likely to have low recorded oxygen saturation.

Unadjusted Results

In unadjusted analyses (**Table 1**), patients in the ED with a “Patient Visit Reason” mentioning CHF were less likely to be tested for PE (8.2 percent versus 13.4 percent; difference -5.2 pp [95% CI, -6.2 to -4.2]) and more likely to receive BNP testing (81.4 percent versus 71.0 percent;

difference 10.4 pp [95% CI, 9.0 to 11.7]). Patients with a mention of CHF were less likely to be diagnosed with acute PE during the ED visit (0.05 percent versus 0.24 percent; difference -0.19 pp [95% CI -0.34 to -0.04]). However, the rates of ultimately diagnosed acute PE between patient visits with mention of CHF compared to visits with no mention of CHF were largely similar (1.0 versus 1.1 percent; difference -0.09 pp [95%, -0.4 to 0.2]).

Adjusted Results

Adjusted for clinical and demographic covariates, PE testing was performed during 8.8 percent of patients visits with a mention of CHF and 13.4 percent of visits with no mention of CHF, a difference of -4.6 percentage points (95% CI, -5.7 to -3.5) (**Table 2**). Among those tested for PE, testing was performed on average 90.4 minutes after ED arrival during visits with a mention of CHF and 74.9 minutes after ED arrival during visits with no mention of CHF, a difference of 15.5 minutes (95% CI, 5.7 to 25.3). BNP testing was performed during 78.0 percent of visits with a mention of CHF and 71.1 percent of visits with no mention of CHF, a difference of 6.9 percentage points (95% CI, 4.3 to 9.4).

Acute PE was diagnosed less frequently in the ED during visits with a mention of CHF (0.08 percent versus 0.23 percent; difference of -0.15 percentage points [95% CI, -0.23 to -0.08]), but we failed to find a difference in the rates of ultimately diagnosed acute PE between these visits compared to visits with no mention of CHF (1.2 versus 1.1 percent; difference 0.06 percentage points [95%, -0.23 to 0.36]) (**Table 2**). Results were largely unchanged, but less precise, when using a smaller, matched sample (**eMethods, eTable1, and eTable2 in the Supplement**).

Results were qualitatively unchanged when estimating using a logistic regression model (**eTable3 in the Supplement**).

Discussion

Using a national sample of over 100,000 VA patients with CHF presenting to the ED with SOB, we found that a “Patient Visit Reason” mentioning CHF was associated with less PE testing, a longer time to PE testing, and more BNP testing. For visits mentioning CHF, acute PE was diagnosed less frequently in the ED. However, there was no significant difference in the rates of ultimately diagnosed acute PE within 30 days of the ED visit. Taken together, these findings suggest that the initial visit label of “CHF,” which may have anchored physicians away from PE, was associated with delayed workup and diagnosis of PE.

A “Patient Visit Reason” that mentions CHF likely does not appear at random. Patients with such visit reasons on average exhibited more severe CHF, longer duration of CHF, and fewer clinical factors correlated with PE risk observable in our data. However, both before and after adjusting for these and other observable differences, visit reasons that mentioned CHF did not appear to contain additional information about ultimate PE incidence. That is, the risk of PE appeared to be the same between visits with mention of CHF and visits with no mention of CHF. However, there were substantial differences in testing between these two groups of visits. In addition, our sensitivity analysis, in which differences in such clinical factors were substantially smaller due to matching (**eTable1 in the Supplement**), produced similar results (**eTable2 in the Supplement**).

There are several possible interpretations of our findings. One possibility is that when the nurse in triage entering the visit reason mentions CHF, physicians anchor on the specific mention of CHF. A second possibility is patient cueing³—that patients whose visit reason mentions CHF are more likely to frame their symptoms as an exacerbation of their CHF both to the nurse entering the visit reason and to the ED physician caring for them. Physicians instead may be influenced by this patient cueing, not by the visit reason (though they are plausibly correlated). We cannot exclude this latter possibility, but if the patient visit reason is instead a proxy for this patient cueing, it also does not appear to be associated with differential PE incidence.

Prior studies that have examined the influence of cognitive biases using large databases have found evidence consistent with availability bias⁷⁻¹⁰ and with left-digit bias, which is a tendency to categorize continuous variables based on the left-most digit.¹² Our prior study using the same VA data found evidence consistent with availability bias.¹⁰ However, the current study is the first to our knowledge that uses large-scale, clinically-rich data to study anchoring bias and the clinical implications of anchoring bias, notably delayed PE diagnosis.

This study has several limitations. First, our findings may be consistent with other cognitive biases, such as the ones discussed above (patient cueing). Second, there may be unobserved clinical confounders not captured in EHR data, such as other clinical factors known to correlate with PE risk (e.g., hemoptysis and clinical signs and symptoms of deep venous thrombosis), other clinical factors that might influence physician decision-making (e.g., bilateral lower extremity edema), and ED triage nurse-specific knowledge (e.g., patient known to have recurrent CHF exacerbations). Third, although we find evidence consistent with anchoring bias contributing to delayed diagnosis of PE, its overall contribution to delayed diagnosis is likely

small relative to other factors. Fourth, we do not know if the differential rate of PE diagnosis in the ED between the two groups of visits led to differences in any other adverse outcomes. Fifth, our results are specific to the VA and may not generalize to non-VA settings or non-VA patient populations. Sixth, we focus on a single clinical scenario in relation to anchoring, so our results may not extend to other clinical scenarios.

In conclusion, among patients with CHF presenting to the ED with SOB, we find that ED physicians were less likely to test for PE when the initial documented reason for visit, prior to the physician's evaluation, specifically mentioned CHF. These results are consistent with physicians anchoring on initial information. Presenting physicians with the patient's general signs and symptoms, rather than specific diagnoses, may mitigate this anchoring. Other interventions include refining knowledge of findings that distinguish between alternative diagnoses for a particular clinical presentation.¹³

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Disclaimer: The views expressed here are those of the authors and do not necessarily represent the views of the U.S. Department of Veterans Affairs or the U.S. government.

Data Sharing Statement: VA data involve protected health information and cannot be shared.

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Table 1: Characteristics of the Study Population

	All ED Visits Examined (n=108,019)	Visit Reason Mentions CHF (n=4,392)	Visit Reason Does Not Mention CHF (103,627)	Difference (95% CI)
Visit reason mentions CHF	4.1	1	0	-
Age (years)	71.9	72.0	71.9	0.05 (-0.3 to 0.4)
30-49 (%)	1.6	2.1	1.6	-
50-59 (%)	10.4	10.8	10.4	
60-69 (%)	36.0	36.4	36.0	
70-79 (%)	26.5	24.2	26.6	
80-89 (%)	19.9	19.9	19.9	
90+ (%)	5.5	6.7	5.4	
Female (%)	2.5	2.0	2.6	-0.5 (-1.0 to -0.03)
Race				
American Indian or Alaska Native (%)	0.7	0.7	0.7	-
Asian (%)	0.9	0.9	0.9	
Black (%)	25.7	25.3	25.7	
Hispanic (%)	5.2	5.0	5.2	
Other race or ethnicity (%)	4.1	5.0	4.1	
White (%)	63.3	63.1	63.3	
Malignancy within 6 months (%)	15.9	12.8	16.0	-3.1 (-4.3 to -2.0)
Past deep venous thrombosis or pulmonary embolism (%)	12.5	11.1	12.6	-1.5 (-2.5 to -0.5)
Surgery within 4 weeks (%)	3.0	2.5	3.0	-0.5 (-1.0 to 0.00003)
Heart rate > 100 (%)	20.9	13.7	21.2	-7.6 (-8.8 to -6.3)
Oxygen saturation < 90% (%)	12.5	7.1	12.7	-5.7 (-6.7 to -4.7)
Ischemic heart disease (%)	71.3	73.2	71.3	1.9 (0.6 to 3.3)
Chronic obstructive pulmonary disease (%)	68.4	51.7	69.1	-17.4 (-18.8 to -16.0)
Duration of CHF	3.8	4.0	3.8	0.3 (0.2 to 0.3)
0-2 years (%)	42.0	38.1	42.1	-
2-5 years (%)	24.5	24.8	24.5	
5+ years (%)	33.5	37.0	33.4	
Number of inpatient admissions for CHF	0.5	0.9	0.5	0.4 (0.4 to 0.4)
0 admissions (%)	73.8	56.4	74.5	-
1 admission (%)	15.4	23.3	15.0	
2 admissions (%)	5.7	9.9	5.5	
3+ admissions (%)	5.1	10.3	4.9	
DNR/DNI	13.9	12.6	13.9	-1.3 (-2.3 to -0.2)
PE testing	13.2	8.2	13.4	-5.2 (-6.2 to -4.2)
Time to PE testing (minutes)	75.7	83.9	75.6	8.3 (-0.3 to 16.9)
BNP testing	71.4	81.4	71.0	10.4 (9.0 to 11.7)
Acute PE diagnosed during ED visit	0.23	0.05	0.24	-0.19 (-0.34 to -0.04)
Acute PE ultimately diagnosed within 30 days of ED visit	1.1	1.0	1.1	-0.09 (-0.41 to 0.23)

Notes: Author's calculation using VA data from 2011-2018. CHF is congestive heart failure. DNR/DNI is do not resuscitate/do not intubate. PE is pulmonary embolism. BNP is b-type natriuretic peptide. Time to PE testing is among those who received PE testing. To improve the specificity of the outcomes of acute PE diagnosed during the ED visit and of acute PE ultimately diagnosed within 30 days of ED visit, in analyses examining these outcomes, we excluded patients with an acute PE diagnosis prior to the ED visit (that is, to avoid a prior diagnosis of acute PE being carried forward in the electronic health record and being coded in the study as a new acute PE). Among patient visits with a mention of CHF, 2 had an acute PE diagnosed during the ED visit and 43 had an acute PE ultimately diagnosed within 30 days of the ED visit. Among patient visits with no mention of CHF, 231 had an acute PE diagnosed during the ED visit and 1,081 had an acute PE ultimately diagnosed within 30 days of the ED visit.

Table 2: Differences in Outcomes for Patients with a Visit Reason that Mentions Versus Does Not Mention Congestive Heart Failure

	Visit Reason Mentions CHF	Visit Reason does not Mention CHF	Difference (95% CI)
Testing for Pulmonary Embolism (%)	8.8 (7.8 to 9.9)	13.4 (13.3 to 13.4)	-4.6 (-5.7 to -3.5)
Time to Testing for Pulmonary Embolism (minutes)	90.4 (80.9 to 99.9)	74.9 (74.7 to 75.1)	15.5 (5.7 to 25.3)
BNP Testing (%)	78.0 (75.6 to 80.4)	71.1 (71.0 to 71.2)	6.9 (4.3 to 9.4)
Pulmonary Embolism Diagnosis in the ED (%)	0.08 (0.009 to 0.15)	0.23 (0.23 to 0.24)	-0.15 (-0.23 to -0.08)
Pulmonary Embolism Diagnosis within 30 Days of ED Visit (%)	1.2 (0.9 to 1.4)	1.1 (1.1 to 1.1)	0.06 (-0.23 to 0.36)

Notes: Author's calculation using VA data from 2011-2018. Adjusted probabilities were calculated using marginal standardization from linear probability models of 1) testing for pulmonary embolism (PE) (D-dimer, CT scan of the chest with contrast, ventilation/perfusion scan, or lower extremity ultrasound), 2) time to testing for PE (for those who received testing for PE), 3) B-type natriuretic peptide (BNP) testing, 4) PE diagnosed during the ED visit, and 5) PE diagnosed within 30 days of the ED visit, as a function of visit reason mentioning congestive heart failure (CHF) (versus not mentioning CHF); physician fixed effects were included to compare differences in testing by the same physician, controlling also for duration of CHF, number of inpatient admissions for CHF in the prior year, malignancy, past deep venous thrombosis/PE, recent surgery, tachycardia, oxygen saturation below 90, past history of ischemic heart disease, past history of chronic obstructive pulmonary disease, do not resuscitate/do not intubate status, age, female, race and ethnicity, year, month, and weekend. Standard errors were clustered at the hospital level. 95% confidence intervals in parentheses.