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Evidence for Anchoring Bias During Physician Decision-Making

Dan P. Ly, MD, PhD, MPP; Paul G. Shekelle, MD, PhD; Zirui Song, MD, PhD

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 a single—often initial—piece of information when making clinical decisions without sufficiently adjusting to later information.

OBJECTIVE To examine whether physicians were less likely to test patients with congestive heart failure (CHF) presenting to the emergency department (ED) with shortness of breath (SOB) for pulmonary embolism (PE) when the patient visit reason section, documented in triage before physicians see the patient, mentioned CHF.

DESIGN, SETTING, AND PARTICIPANTS In this cross-sectional study of 2011 to 2018 national Veterans Affairs data, patients with CHF presenting with SOB in Veterans Affairs EDs were included in the analysis. Analyses were performed from July 2019 to January 2023.

EXPOSURE The patient visit reason section, documented in triage before physicians see the patient, mentions CHF.

MAIN OUTCOMES AND MEASURES The main outcomes were testing for PE (D-dimer, computed tomography scan of the chest with contrast, ventilation/perfusion scan, lower-extremity ultrasonography), time to PE testing (among those tested for PE), B-type natriuretic peptide (BNP) testing, acute PE diagnosed in the ED, and acute PE ultimately diagnosed (within 30 days of ED visit).

RESULTS The present sample included 108 019 patients (mean [SD] age, 71.9 [10.8] years; 2.5% female) with CHF presenting with SOB, 4.1% of whom had mention of CHF in the patient visit reason section of the triage documentation. 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 (pp) reduction (95% CI, −5.7 to −3.5 pp) in PE testing, 15.5 more minutes (95% CI, 5.7-25.3 minutes) to PE testing, and 6.9 pp (95% CI, 4.3-9.4 pp) more BNP testing. Mention of CHF was associated with a 0.15 pp lower (95% CI, −0.23 to −0.08 pp) likelihood of PE diagnosis in the ED, although no significant association between the mention of CHF and ultimately diagnosed PE was observed (0.06 pp difference; 95% CI, −0.23 to 0.36 pp).

CONCLUSIONS AND RELEVANCE In this cross-sectional study among patients with CHF presenting with SOB, physicians were less likely to test for PE when the patient visit reason that was documented before they saw the patient mentioned CHF. Physicians may anchor on such initial information in decision-making, which in this case was associated with delayed workup and diagnosis of PE.

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Supplemental content

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Cognitive biases are hypothesized to influence physician decision-making.[1,2] One such cognitive bias is anchoring bias, under which physicians focus on a single—often initial—piece of information when 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 how 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 outcome of cognitive biases in nonexperimental 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 PE. We examined information contained in the patient visit reason section, which is documented on ED arrival based on the patient report at presentation to the ED by a nurse in triage before 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 SOB without mention of CHF, physicians anchor on CHF and are less likely to consider PE. First, among patients 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 the mention of CHF was associated with less diagnosis of acute PE in the ED. Finally, we examined whether the mention of CHF was associated with the ultimate diagnosis of acute PE.

Key Points

Question Do emergency department physicians anchor on information found in the patient visit reason section documented before a physician sees the patient?

Findings In this cross-sectional study among 108 019 patients with congestive heart failure (CHF) presenting to the emergency department 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 the mention of CHF and ultimately diagnosed acute PE.

Meaning Physicians tested patients for PE less when the patient visit reason section mentioned CHF, consistent with an anchoring bias that led to delayed workup and diagnosis of PE.

Methods

Data, Study Population, and Study Measures

In this cross-sectional study, 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 used ED visit data collected in the Emergency Department Integration Software (EDIS) (Department of Veterans Affairs), which the VA fully implemented in 2011.[11] The VA Greater Los Angeles Healthcare System institutional review board approved the study. Informed consent was waived because the data were deidentified. This study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline. Analyses were performed from July 2019 to January 2023.

We identified patients aged 30 years or older with diagnosed CHF who visited a VA ED for SOB between 2011 and 2018. Although the patient visit reason section may read "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 the present study's primary covariate of interest—a binary variable that indicates mention of CHF. We excluded ED visits for patients in hospice or who were comfort measures only. We excluded ED visits for patients with an outpatient prescription fill for an anticoagulant within 30 days before ED arrival 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 PE[8] that were observable in the present data (prior deep venous thrombosis 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 the 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 of less than 90% and the presence of ischemic heart disease or chronic obstructive pulmonary disease. Other patient covariates included age, sex, race and ethnicity, and do not resuscitate/do not intubate status.

The 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 scan, or lower extremity ultrasonography. The second outcome of interest was, among those tested for PE, time

elapsed in minutes from ED arrival to testing for PE. The third outcome of interest was a binary variable for BNP testing. The 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 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. 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 before the ED visit (that is, to avoid a prior diagnosis of acute PE being carried forward in the EHR and being coded in the study as a new acute PE).

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 previously. We also included weekend (vs weekday) fixed effects, month fixed effects, and year fixed effects to adjust for differences in care on the weekends (eg, 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 the standard errors at the hospital level.

All *P*-value tests were 2-sided with statistical significance set at $P < .05$. Data were prepared using Microsoft SQL Server Management Studio 18.12.1 and analyzed using Stata statistical software, version 17.0 (StataCorp).

Results

Characteristics of the Study Population

The present sample included 108 019 patient visits across 104 VA facilities. The mean (SD) age was 71.9 (10.8) years, and 2.5% were female (**Table 1**). A total of 4.1% had a visit reason that specifically mentioned CHF, and 13.2% were tested for PE. Among those tested for PE, the average time to test was 75.7 minutes. A total of 71.4% received BNP testing, and 0.23% received a diagnosis of acute PE during the ED visit. A total of 1.1% ultimately received an acute PE diagnosis (inclusive of acute PE diagnosis in the ED) within 30 days. Patient visits with visit reason mentioning CHF (vs 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 chronic obstructive pulmonary disease. They were less likely to have a recent diagnosis of malignant neoplasm, less likely to have a prior deep venous thrombosis 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% vs 13.4%; difference, −5.2 percentage points [pp]; 95% CI, −6.2 to −4.2 pp) and more likely to receive BNP testing (81.4% vs 71.0%; difference, 10.4 pp; 95% CI, 9.0-11.7 pp). For absolute event rates among patient visits (n = 4219) with a mention of CHF and no acute PE diagnosis before the ED visit, 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 (n = 97 699) with no mention of CHF and no acute PE diagnosis prior to the ED visit, 231 had an acute PE diagnosed during the ED visit, and 1081 had an acute PE ultimately diagnosed within 30 days of the ED visit. Patients with a mention of CHF were less likely to be diagnosed with acute PE during the ED visit (0.05 % vs 0.24 %; difference, −0.19 pp; 95% CI, −0.34 to −0.04 pp). However, the rates of ultimately diagnosed acute PE between patient visits with mention of CHF compared with visits with no mention of CHF were largely similar (1.0% vs 1.1%; difference, −0.09 pp; 95% CI, −0.4 to 0.2 pp).

Adjusted Results

Adjusted for clinical and demographic covariates, PE testing was performed during 8.8% of patients visits with a mention of CHF and 13.4% of visits with no mention of CHF, a difference of −4.6 pp (95% CI, −5.7 to −3.5 pp) (**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, 5.7-25.3 minutes). Testing with BNP was performed during 78.0% of visits with a mention of CHF and 71.1% of visits with no mention of CHF, a difference of 6.9 pp (95% CI, 4.3-9.4 pp).

Acute PE was diagnosed less frequently in the ED during visits with a mention of CHF (0.08% vs 0.23%; difference of −0.15 pp; 95% CI, −0.23 to −0.08 pp), but we failed to find a difference in the rates of ultimately diagnosed acute PE between these visits compared with visits with no mention of CHF (1.2% vs 1.1%; difference, 0.06 pp; 95% CI, −0.23 to 0.36 pp) (Table 2). Results were largely unchanged but less precise when using a smaller, matched sample (eMethods, eTable 1, and eTable 2 in Supplement 1). Results were qualitatively unchanged when estimating using a logistic regression model (eTable 3 in Supplement 1).

Discussion

In this cross-sectional study using a national sample of more than 100 000 VA patients with CHF presenting to the ED

Table 1. Characteristics of the Study Population[a]

Characteristic	All ED visits examined, % (n = 108 019)	Visit reason mentions CHF, % (n = 4392)	Visit reason does not mention CHF, % (n = 103 627)	Difference, % (95% CI)
Visit reason mentions CHF	4.1	100	0	NA
Mean age, y	71.9	72.0	71.9	0.05 (−0.3 to 0.4)
30-49	1.6	2.1	1.6	NA
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)
Male	97.5	98.0	97.4	0.5 (0.03 to 1.0)
Race and ethnicity				
American Indian or Alaska Native	0.7	0.7	0.7	NA
Asian	0.9	0.9	0.9	
Black	25.7	25.3	25.7	
Hispanic	5.2	5.0	5.2	
White	63.3	63.1	63.3	
Other[b]	4.1	5.0	4.1	
Malignant neoplasm within 6 mo	15.9	12.8	16.0	−3.1 (−4.3 to −2.0)
Past deep venous thrombosis or PE	12.5	11.1	12.6	−1.5 (−2.5 to −0.5)
Surgery within 4 wk	3.0	2.5	3.0	−0.5 (−1.0 to 0.00003)
Heart rate >100 bpm	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, y	3.8	4.0	3.8	0.3 (0.2 to 0.3)
0-2	42.0	38.1	42.1	NA
2-5	24.5	24.8	24.5	
≥5	33.5	37.0	33.4	
No. of inpatient admissions for CHF	0.5	0.9	0.5	0.4 (0.4 to 0.4)
0	73.8	56.4	74.5	NA
1	15.4	23.3	15.0	
2	5.7	9.9	5.5	
≥3	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, min	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 d of ED visit	1.1	1.0	1.1	−0.09 (−0.41 to 0.23)

Abbreviations: BNP, B-type natriuretic peptide; CHF, congestive heart failure; DNR/DNI, do not resuscitate/do not intubate; ED, emergency department; NA, not applicable; PE, pulmonary embolism.

[a] Author's calculation using Veterans Affairs data from 2011 to 2018. Time to PE testing was 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 d of ED visit, in analyses examining these outcomes, we excluded patients with an acute PE diagnosis before 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 d of the ED visit. Among patient visits with no mention of CHF, 231 had an acute PE diagnosed during the ED visit and 1081 had an acute PE ultimately diagnosed within 30 d of the ED visit.

[b] Other race and ethnicity refers to when race and ethnicity was missing, declined to answer by patient, or unknown by patient.

with SOB, we found that a documented 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 the

Table 2. Differences in Outcomes for Patients With a Visit Reason That Mentions vs Does Not Mention Congestive Heart Failure (CHF)[a]

Variable	Visit reason mentions CHF (95% CI)	Visit reason does not mention CHF (95% CI)	Difference (95% CI)
Testing for PE, %	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 PE, min	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)
PE 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)
PE diagnosis within 30 d of ED visit, %	1.2 (0.9 to 1.4)	1.1 (1.1 to 1.1)	0.06 (−0.23 to 0.36)

Abbreviations: BNP, B-type natriuretic peptide; ED, emergency department; PE, pulmonary embolism.

[a] Author's calculation using Veterans Affairs data from 2011 to 2018. Adjusted probabilities were calculated using marginal standardization from linear probability models of (1) testing for PE (D-dimer, computed tomography scan of the chest with contrast, ventilation/perfusion scan, or lower extremity ultrasonography), (2) time to testing for PE (for those who received testing for PE), (3) BNP testing, (4) PE diagnosed during the ED visit, and (5) PE diagnosed within 30 d of the ED visit, as a function of visit reason mentioning CHF (vs 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 y, malignant neoplasm, past deep venous thrombosis/PE, recent surgery, tachycardia, oxygen saturation below 90%, history of ischemic heart disease, history of chronic obstructive pulmonary disease, do not resuscitate/do not intubate status, age, female, race and ethnicity, y, mo, and weekend. Standard errors were clustered at the hospital level.

present study's 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 a mention of CHF and visits with no mention of CHF. However, there were substantial differences in testing between these 2 groups of visits. In addition, the sensitivity analysis, in which differences in such clinical factors were substantially smaller due to matching (eTable 1 in Supplement 1), produced similar results (eTable 2 in Supplement 1).

There are several possible interpretations of the present 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 cueing[3]—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 bias[7-10] 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.

Limitations

First, the present findings may be consistent with other cognitive biases, such as the ones discussed previously (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 (eg, hemoptysis and clinical signs and symptoms of deep venous thrombosis), other clinical factors that might influence physician decision-making (eg, bilateral lower extremity edema), and ED triage nurse-specific knowledge (eg, 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 2 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 concerning anchoring, so the present study's results may not extend to other clinical scenarios.

Conclusions

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 reason for visit, documented before 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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