Associations Between Hospitalist Shift Busyness, Diagnostic Confidence, and Resource Utilization: A Pilot Study

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Objectives: Hospitalized patients are at risk for diagnostic errors. Hospitalists caring for these patients are often multitasking when overseeing patient care. We aimed to measure hospitalist workload and understand its influences on diagnostic performance in a real-world clinical setting.

Methods: We conducted a single-center, prospective, pilot observational study of hospitalists admitting new patients to the hospital. Hospitalists completed an abridged Mindful Attention Awareness Tool and a survey about diagnostic confidence at shift completion. Data on differential diagnoses and resource utilization (e.g., laboratory, imaging tests ordered, and consultations) were collected from the medical record. The number of admissions and paging volume per shift were used as separate proxies for shift busyness. Data were analyzed using linear mixed effects models (continuous outcomes) or mixed effects logistic regression (dichotomous outcomes).

Results: Of the 53 hospitalists approached, 47 (89%) agreed to participate; complete data were available for 37 unique hospitalists who admitted 160 unique patients. Increases in admissions (odds ratio, 1.99; 95% confidence interval [CI], 1.04 to 3.82; $P = 0.04$) and pages (odds ratio, 1.11; 95% CI, 1.02 to 1.21; $P = 0.01$) were associated with increased odds of hospitalists finding it "difficult to focus on what is happening in the present." Increased pages was associated with a decrease in the number of listed differential diagnoses (coefficient, −0.02; 95% CI, −0.04 to −0.003; $P = 0.02$).

Conclusions: Evaluation of hospitalist busyness and its associations with factors that may influence diagnosis in a real-world environment was feasible and demonstrated important implications on physician focus and differential diagnosis.

Key Words: diagnosis, differential, diagnostic techniques and procedures, hospitalists

(*J Patient Saf* 2023;19: 447–452)

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The authors disclose no conflict of interest.

This project was supported by grant number P30HS024385 from the Agency for Healthcare Research and Quality. The funding source played no role in study design, data acquisition, analyses, or decision to report these data. A.B.G is supported by funding from the Gordon and Betty Moore Foundation. M.T.G. receives funding support from the Agency for Healthcare Research and Quality and the Department of Veterans Affairs. V.I.C. is supported by funding from the Agency for Healthcare Research and Quality (1 R18 HS025891-01).

All authors have accepted responsibility for the entire content of this manuscript and approved its submission.

Informed consent was obtained from all individuals included in this study.

Research involving human subjects complied with all relevant national regulations and institutional policies, is in accordance with the tenets of the Helsinki Declaration (as revised in 2013), and has been approved by the authors' institutional review board (University of Michigan HUM00145793).

Data are available from the authors upon reasonable request.

Diagnostic errors are among one of the most prevalent and hazardous problems in healthcare, particularly in the inpatient setting.[1–3] A hospitalized patient with an acute, high-risk condition is particularly vulnerable to the effects of diagnostic error[3] for several reasons. First, hospitalists (general internists who care for hospitalized patients in the U.S. healthcare system) simultaneously oversee care for several patients that vary widely in terms of clinical presentations and acuity of illness. In the inpatient arena, hospitalists must therefore not only be adept in evaluation but also be agile so as to easily transition across disease states and evolving patient circumstances. Second, for many such physicians, clinical care begins with little prior knowledge or information about the patient, placing emphasis on diagnostic reasoning and early, appropriate testing. Diagnostic uncertainty and errors in reasoning or failure to order timely tests may thus have substantial deleterious impact on patient outcomes. Finally, hospitalists are subject to myriad external factors (e.g., time constraints, asynchronous messaging, use of electronic health systems to retrieve and input data, and distractions that emanate from the hospital environment), leading to a high degree of cognitive load.[4–7] Despite these truths, there are limited data on how these factors relate to patient care in inpatient settings and associated outcomes.

In fields outside medicine, an association between work or cognitive load and risk factors is known to exist. For example, participants in driving simulators experienced decreased reaction times and longer stop times in scenarios requiring higher cognitive load.[8] Similarly, most airline incidents or crashes occur during periods of high cognitive load, such as takeoff or landing, when attention to key parameters such as speed and altitude is needed.[9] To date, attempts to understand physician workload and its impact on performance have occurred primarily in artificial, simulation-based settings. Thus, appropriate measures of physician work or cognitive load or the influence of such measures on key indicators that may be associated with diagnostic error remain unknown.

Therefore, in this pilot study, we evaluated the extent to which physician workload was associated with diagnostic processes including diagnostic confidence, resource utilization, and differential diagnosis. We hypothesized that as subjective and objective workload increased, a physician would be less confident in their diagnostic reasoning. We inferred that lower diagnostic confidence, in turn, would relate to fewer diagnoses listed and greater resource utilization (e.g., tests and consultations).

SUBJECTS AND METHODS

Settings and Participants

Between September 2018 and June 2019, we conducted a prospective, observational pilot study of hospitalists as they were providing direct clinical care to patients within a large, academic, tertiary care medical center. Participants (hospitalists) provided written informed consent and were recruited by a trained research assistant at the beginning of an admitting shift. During this shift, a typical hospitalist receives electronic communications in the form of pages concerning all admissions of adult, general medicine patients from the emergency department (ED), evaluates prospective admissions by reviewing pertinent data, receives verbal handoff from the ED provider, evaluates the patient in person, places admitting orders, completes documentation including the admission history and physical, and prepares to hand off the patient to the oncoming physician (i.e., sign-out). In addition, hospitalists often triage prospective admissions to other providers (e.g., resident physicians) and services (e.g., cardiology) within the hospital. We specifically targeted admitting shifts (as opposed to shifts during which physicians cared for patients previously admitted to the hospital) because the diagnostic process is disproportionately weighted toward the time of admission when physicians do not have the benefit of time or the ability to evaluate treatment effect while generating or refining their differential diagnoses. Participants were recruited consecutively, Monday through Friday, based on existing clinical schedules in their workplace.

Data Collection Methods and Processes

Data were collected by a research assistant, who was present from shift onset (1:00 P.M.) until shift completion or 9:00 P.M., whichever was earlier. At the completion of each shift (or at 9:00 P.M.), participants completed a paper survey in which they were asked to rate the following statements related to their attention awareness, adapted from the Mindful Attention Awareness Scale (MAAS)[10]: (1) I find it difficult to stay focused on what's happening in the present; (2) I rush through activities without being aware of what I am doing; (3) It seems I am "running on automatic" without being aware of what I am doing; and (4) Today I was able to keep my thoughts focused on my work tasks. A 6-point Likert scale (a score of 1 indicated "almost always" and a score of 6 indicated "almost never") were used for each statement.

In addition, participants were surveyed for their perceived confidence (using a 10-point Likert scale) in the accuracy of the primary diagnosis they made for each admitted patient (a score of 1 indicated they were least confident whereas a score of 10 indicated they were most confident). Survey results were transferred into an electronic database. Subsequently, 3 members of the research staff reviewed the electronic health record of each admitted patient and abstracted the following elements directly into an electronic repository: number and type of laboratory tests and imaging studies ordered in the ED, by consultants and by the admitting hospitalist (i.e., the study participant); the number of consults requested by the ED and by the admitting hospitalist; the number of diagnoses listed in the admitting hospitalist's initial differential diagnosis; and admission and discharge diagnoses. Intermittent, random data audits were performed to ensure the accurate transfer of data from both the paper survey and the electronic health record to the electronic repository.

To gauge how busy a physician may have been during a shift, our primary predictor variables were (1) the number of admissions and (2) the volume of pages received by participants using institutional health information technology data. While the study team recognized that the number of admissions and number of pages are an incomplete representation of shift busyness, this approach provided a reproducible and quantifiable representation of the workload that had internal and face validity. Resource utilization was defined as a count of the total number of laboratory tests, imaging studies, and consults requested throughout the patient's course from ED presentation through hospital admission. Chart review of disease categories and spectrum of illness for admitted patients was conducted (A.B.G.). Patients who were either directly admitted with a known diagnosis or those transferred from another unit within the hospital (e.g., intensive care unit to the general care floor) were excluded.

Outcomes

The primary outcomes of interest were the responses to the MAAS questions by admitting physicians. Secondary outcomes included diagnostic confidence, resource utilization, and the number of diagnoses in the physician differential.

Statistical Analyses

Descriptive statistics (medians and interquartile ranges for continuous variables and frequencies and percentages for categorical variables) were used to summarize data. Mixed models were used to account for repeated measures at the physician level (because a single physician may have seen multiple patients in a single shift and/or participated during multiple shifts). For our primary analyses, mixed effects logistic regression models were used to assess associations with the end-of-shift MAAS questions. For our secondary analyses, linear mixed effects models, using maximum likelihood estimation methods, were used to assess associations between our primary indicators of shift busyness (number of admissions and number of pages) and (1) diagnostic confidence, (2) resource utilization (sum of all laboratory tests, consults, and imaging ordered), and (3) number of diagnoses in physician differential. Linear mixed effect models were also used to assess the association between diagnostic confidence and resource utilization.

For models examining effects of shift busyness on attention awareness, odds ratios (ORs) were estimated for survey scores corresponding to the 2 most extreme negative survey responses from the 4 subjective MAAS questions (almost always or very frequently for questions 1–3; very infrequently or almost never for question 4). For models examining the effects of shift busyness on diagnostic confidence and on resource utilization, fixed effects were estimated for: (1) the total number of admissions; and (2) the total number of pages. For models examining the effects of diagnostic confidence on resource utilization, fixed effects were estimated for the diagnostic confidence rating.

For all models, random intercept components were included for participants to account for clustering at the physician level. All models were also adjusted with fixed components for gender, race, and shift duration (measured in total minutes). Odds ratios or fixed effect coefficient estimates, 95% confidence intervals (CIs), and P values were estimated. An α level of 0.05 was used to determine statistical significance of the fixed effect coefficient of interest for all models. Predictive margins and 95% CIs were graphed to illustrate observed associations. All analyses were conducted in Stata MP 14.1 (StataCorp, College Station, Tex).

Ethical and Regulatory Oversight

This study was reviewed and approved by the institutional review board at the University of Michigan Health System (HUM00145793).

RESULTS

Physician, Shift, and Patient Characteristics

A total of 53 physicians were approached for study participation; 47 agreed to participate and completed surveys. Of these 47 physicians, patient chart data were available for 44 physicians. Of these 44 physicians, 3 were removed from the sample as they admitted only patients that were ineligible for the study (i.e., direct admits, planned treatment, or transfer patients). An additional 4 physicians were removed from the sample because of missing data elements (2 physicians were missing paging data, 1 physician

TABLE 1. Participating Physician Characteristics (N = 37)

Characteristic	No. (%) or Median (IQR)
Male	19 (51.4%)
Race/ethnicity	
White	21 (56.8%)
Asian	15 (40.5%)
Hispanic	1 (2.7%)
Shifts worked during study	2 shifts (1–3)
Shift duration	420 minutes (375–438)
Admissions per shift	2 admissions (1–2)
Pages per shift	24 pages (18–32)
Diagnostic confidence*	8 (7–9)
Total orders (laboratory tests + consults + imaging)	7 (5–10)
Laboratory tests	5 (3–8)
Consults	0 (0–1)
Imaging	2 (1–3)
Diagnoses in physician differential	2 (1–3)

*Diagnostic confidence rated on a scale of 1 to 10, with 10 representing highest degree of confidence.

was missing race data, and 1 physician was missing shift duration data). The final sample was composed of 37 physicians, who admitted 160 unique, eligible patients. Select physician characteristics are presented in Table 1. The range of number of admissions per shift was 1 to 4, with a median of 2 (interquartile range [IQR], 1–2). The range of number of pages per shift was 8 to 60, with a median of 24 (IQR, 18–32). Median diagnostic confidence was 8 (IQR, 7–9). The median number of total orders (laboratory tests + consults + imaging studies ordered) per patient during the admission shift was 7 (IQR, 5–10). The median number of diagnoses in the physician differential was 2 (IQR, 1–3).

The 37 participating physicians answered survey questions assessing attention awareness across 83 unique shift days. A total of 12 physicians (32.4%) reported very frequently or almost always finding it "difficult to stay focused on what's happening in the present" during at least one shift. A total of 3 (8.1%) reported very frequently or almost always "rushing through activities without being aware of what I am doing" and 3 (8.1%) very frequently or almost always seemed to be "running on automatic without being aware of what I am doing" during at least one shift. A total of 7 (18.9%) reported very infrequently or almost never being "able to keep my thoughts focused on my work tasks" during at least one shift.

All 160 patients were admitted through the ED and (at the time of admission) most often had diagnoses related to infectious diseases (n = 28, 17.5%), the gastrointestinal system (n = 27, 16.9%), the pulmonary system (n = 22, 13.8%), or the cardiovascular system (n = 21, 13.1%). The median length of hospital stay was 5 days (IQR, 2–7 days).

Shift Busyness and Attention Awareness

Associations between: (1) number of admissions; and (2) number of pages and attention awareness are presented in Table 2. The number of admissions and number of pages were each associated with very frequently or almost always finding it difficult to stay focused on what is happening in the present (OR, 1.99; 95% CI, 1.04–3.82; $P = 0.04$ and OR, 1.11; 95% CI, 1.02–1.21; $P = 0.01$, respectively). There were no associations detected between our primary indicators of shift busyness and the other MAAS questions.

Diagnostic Associations

Diagnostic associations from our secondary analyses are presented in Table 3. We observed an inverse association between diagnostic confidence and resource utilization (coefficient −0.36; 95% CI, −0.69 to −0.03; $P = 0.03$). That is, for every 1-unit increase in diagnostic confidence, the mean number of total orders decreased by 0.36 (Fig. 1). The association was primarily driven by a decrease in laboratory test ordering as confidence increased (diagnostic confidence coefficient −0.33; 95% CI, −0.60 to −0.06; $P = 0.02$). When analyzed separately, no significant associations between diagnostic confidence and ordering of consults ($P = 0.06$) or imaging ($P = 0.16$) were observed.

No associations between admissions (coefficient −0.07; 95% CI, −0.40 to 0.25; $P = 0.67$; Fig. 2A) or pages (coefficient −0.02; 95% CI, −0.06 to 0.09; $P = 0.18$; Fig. 2B) and diagnostic confidence were observed. Similarly, no associations between admissions (coefficient −0.37; 95% CI, −1.01 to 0.28; $P = 0.27$; Fig. 2C) or pages (coefficient 0.01; 95% CI, −0.06 to 0.09; $P = 0.74$; Fig. 2D) and resource utilization (total orders: laboratory tests + consults + imaging) were observed. Although we did not observe an association between number of admissions and number of diagnoses in physicians' differential (coefficient −0.06; 95% CI, −0.24 to 0.12; $P = 0.49$; Fig. 2E), we did observe a decrease in the number of diagnoses listed in the physician

TABLE 2. Associations Between Shift Busyness* and Attention Awareness

Dependent Variable	Predictor Variable	Adjusted† OR (95% CI, *P*)
Very frequently or almost always finding it "difficult to stay focused on what's happening in the present"	No. pages	1.11 (1.02 to 1.21, $P = 0.01$)
	No. admissions	1.99 (1.04 to 3.82, $P = 0.04$)
Very frequently or almost always rushing through activities without being aware of what I am doing	No. pages	1.08 (0.93 to 1.26, $P = 0.31$)
	No. admissions	6.45 (0.30 to 139.73, $P = 0.24$)
Very frequently or almost always 'running on automatic' without being aware of what I am doing	No. pages	1.07 (0.94 to 1.22, $P = 0.29$)
	No. admissions	3.91 (0.87 to 17.57, $P = 0.08$)
Very infrequently or almost never able to keep my thoughts focused on my work tasks today	No. pages	1.05 (0.97 to 1.14, $P = 0.24$)
	No. admissions	1.32 (0.56 to 3.12, $P = 0.53$)

*Number of pages and number of admissions per shift used as proxies of shift busyness (primary predictor variables) in separate models.

†All models fit using mixed logistic regression with a random component for physician. All models also adjusted for fixed effects for gender, race, and shift duration.

TABLE 3. Associations Between Diagnostic Confidence, Shift Busyness*, and Resource Utilization

Dependent Variable	Predictor Variable	Adjusted† Fixed Effect Coefficient for Predictor Variable (95% CI, *P*)
Total orders (laboratory test + consults + imaging)	Diagnostic confidence	−0.36 (−0.69 to −0.03, *P* = 0.03)
Laboratory tests	Diagnostic confidence	−0.33 (−0.60 to −0.06, *P* = 0.02)
Consults	Diagnostic confidence	0.06 (−0.002 to 0.12, *P* = 0.06)
Imaging	Diagnostic confidence	−0.09 (−0.21 to 0.03, *P* = 0.16)
Diagnostic confidence	No. pages	−0.02 (−0.06 to 0.01, *P* = 0.18)
	No. admissions	−0.07 (−0.40 to 0.25, *P* = 0.67)
Total orders (laboratory test + consults + imaging)	No. pages	0.01(−0.06 to 0.09, *P* = 0.74)
	No. admissions	−0.37(−1.01 to 0.28, *P* = 0.27)
Laboratory tests	No. pages	−0.0003 (−0.06 to 0.06, *P* = 0.99)
	No. admissions	−0.06 (−0.60 to 0.48, *P* = 0.84)
Consults	No. pages	0.01(−0.0005 to 0.03, *P* = 0.06)
	No. admissions	−0.12 (−0.24 to 0.01, *P* = 0.06)
Imaging	No. pages	0.00007 (−0.03 to 0.03, *P* = 0.99)
	No. admissions	−0.18 (−0.42 to 0.05, *P* = 0.13)
Diagnoses in physician differential	No. pages	−0.02 (−0.04 to −0.003, *P* = 0.02)
	No. admissions	−0.06 (−0.24 to 0.12, *P* = 0.49)

*Number of pages and number of admissions per shift used as proxies of shift busyness (primary predictor variable) in separate models.

†All models fit using mixed logistic regression with a random component for physician. All models also adjusted for fixed effects for gender, race, and shift duration.

differential as pages increased (coefficient −0.02; 95% CI, −0.04 to −0.003; *P* = 0.02; Fig. 2F).

DISCUSSION

In this pilot study of 37 hospitalist physicians who admitted 160 patients to inpatient settings, we found that shift busyness (as measured by number of admissions and number of pages) had positive associations with several measures of workload. For example, the higher the number of admissions or pages received, the greater the association between physician-reported difficulty in staying focused. We also observed that the more pages a physician received, the fewer differential diagnoses they listed. On the other hand, we observed that physician busyness (either admissions or paging volume) was not associated with self-reported diagnostic confidence or resource utilization. However, the more confident a physician was, the fewer laboratory tests they ordered. Although preliminary and in need of confirmation, these findings are novel and suggest that patient load, cognitive processing, and tasks can be measured, assessed, and potentially used as markers for real-world evaluation of diagnostic errors.

Our pilot study suggests that measuring workload and assessing impact on outcomes is feasible, especially when limited to metrics that are quantifiable using electronic sources of information. Clinicians were willing to participate in the study and most completed postshift surveys regarding their diagnostic processes. Data on the number of admissions and number of pages per shift were readily available. Whereas most evaluations identify diagnostic error substantially after its occurrence,[11] and many studies aimed at identifying contributions to error occur outside the clinical environment (e.g., simulated settings), our study highlights the potential to identify factors that may be associated with error in near real time and in a real-world environment. Though still requiring additional validation, using numbers of admission and paging volume as markers of busyness has face validity: it makes clinical sense (one would expect busyness to increase as pages and admissions increase), and correspondingly, it did correlate with reported deficits in attention awareness. There are undoubtedly other factors that contribute to physician busyness. For example, patient acuity and complexity, time of day, and physician experience may have an important impact on busyness and should be considered in a composite metric encompassing this aspect. Ideally, these busyness factors could be combined into a single "index" or score, for ease of use. Having a clinically applicable marker that could potentially be addressed in near real time would be a significant leap forward in the quest to reduce diagnostic errors.

There are limitations to our study. First, as above, the evaluation of admission and paging volume alone fails to capture other contributors to shift busyness such as time for patient triage or patient complexity. Importantly, we did not assess diagnostic accuracy in our study and thus were unable to link diagnostic confidence, busyness, or healthcare utilization to patient outcomes. Further work to include and quantify these variables may result in a better-honed metric. In addition, the number of patient admissions were undercounted, as patients directly admitted with a known

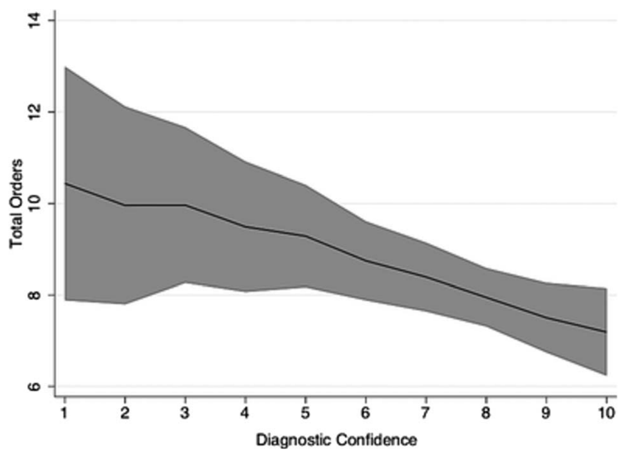

FIGURE 1. The effect of diagnostic confidence on total ordering (laboratory tests + consults + imaging) (predictive margins with 95% CIs).

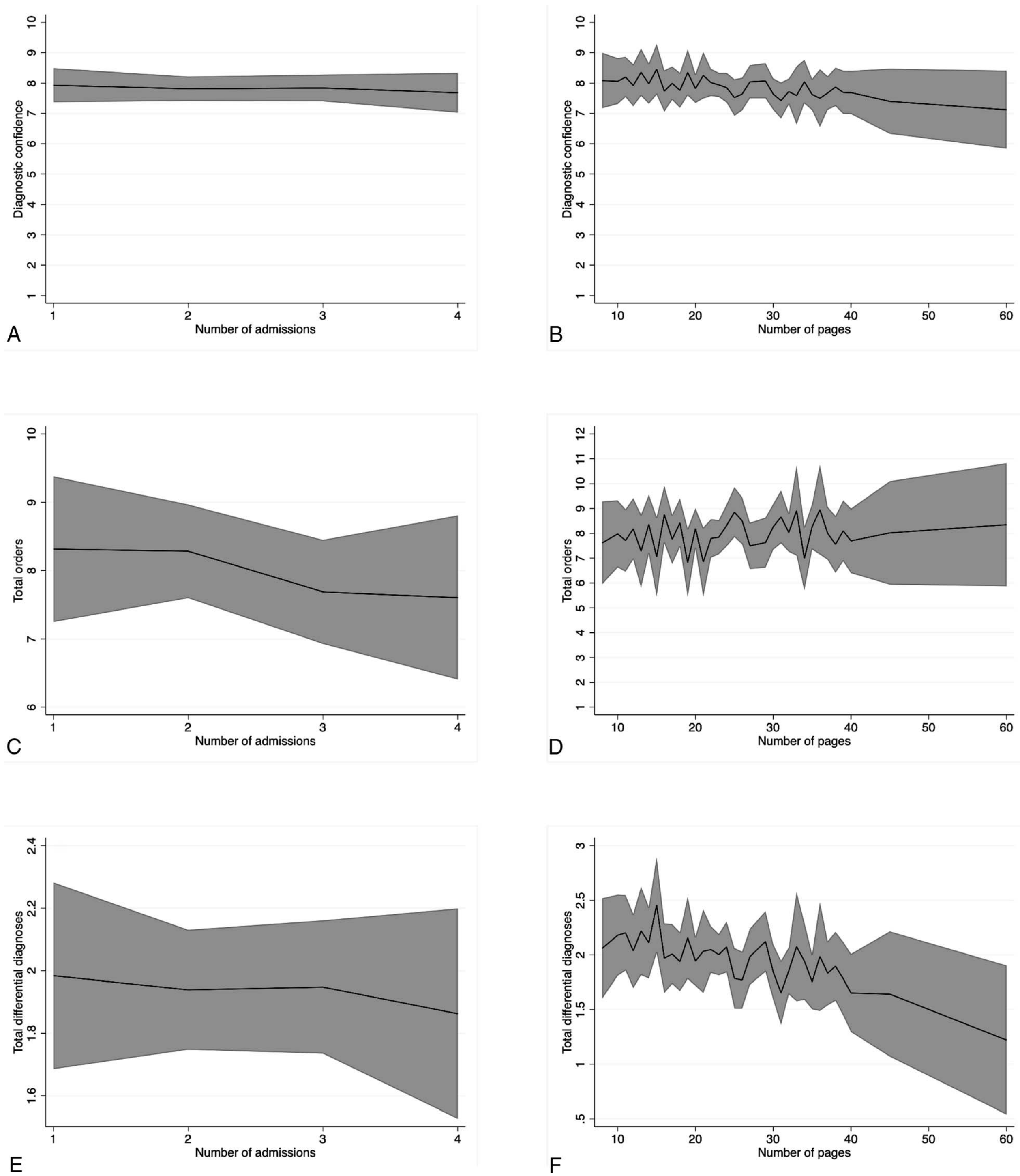

FIGURE 2. The effect of shift busyness on secondary outcomes (predictive margins with 95% CIs). All data are presented with predictive margins with 95% CIs: (A) the effect of number of admissions on diagnostic confidence, (B) the effect of number of pages on diagnostic confidence, (C) the effect of number of admissions on total ordering (laboratory tests + consults + imaging), (D) the effect of number of pages on total ordering (laboratory tests + consults + imaging), (E) the effect of number of admissions on number of diagnoses in the differential, and (F) the effect of number of pages on number of diagnoses in the differential.

diagnosis or transferred from another unit were excluded from the study (as the goal of this study was to evaluate undifferentiated patients). Distribution of these excluded patients was unlikely to be uniform (as admission volume varies from day to day), and thus their exclusion may have biased our results toward the null.

Despite these limitations, our study has several strengths. First, to our knowledge, ours is the first study to attempt to quantify and link physician workload using subjective markers on diagnostic performance and objective process indicators in real-world settings. Our results, though preliminary, have important implications for the field as this type of quantification may serve as a bellwether in the prevention of diagnostic errors. Second, we noted that resource utilization, specifically laboratory test ordering, declined with increasing diagnostic confidence. Vignette-based studies have previously demonstrated a similar correlation.[12] The same study also demonstrated that clinician diagnostic confidence was not associated with diagnostic accuracy.[12] That raises the question of whether clinical hubris, or a "leaner" diagnostic workup may fuel diagnostic errors? Third, we observed that shift busyness resulting from high paging volume was associated with a less expansive differential diagnosis. As prior studies have suggested that the absence of a differential diagnosis or failure to consider a diagnosis is associated with diagnostic error, this observation has important implications in linking real-world markers to patient safety.[13,14]

CONCLUSIONS

A unique study prospectively evaluating the relationship between shift busyness metrics, diagnostic confidence, and resource utilization was feasible and demonstrated several important associations. Incorporation of additional factors contributing to busyness and linking them to direct patient outcomes seems warranted.

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