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Relationships Between EHR-Based Audit Log Data and Physician Burnout and Clinical Practice Process Measures

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Abstract

Objective: To explore the relationship of electronic health record (EHR)–based audit log data with physician burnout and clinical practice process measures.

Methods: From September 4 to October 7, 2019, we surveyed physicians in a larger academic medical department and matched responses to August 1 through October 31, 2019, EHR-based audit log data. Multivariable regression analysis evaluated the relationship between log data and burnout and the interrelationship between log data and turnaround time for In Basket messages and percentage of encounters closed within 24 hours.

Results: Of the 537 physicians surveyed, 413 (77%) responded. On multivariable analysis, number of In Basket messages received per day (each additional message: odds ratio, 1.04 [95% CI, 1.02 to 1.07]; $P<.001$) and time spent in the EHR outside scheduled patient care (each additional hour: odds ratio, 1.01 [95% CI, 1.00 to 1.02]; $P=.04$) were associated with burnout. Time spent doing In Basket work (each additional minute: parameter estimate, −0.11 [95% CI, −0.19 to −0.03]; $P=.01$) and in the EHR outside scheduled patient care (each additional hour: parameter estimate, 0.04 [95% CI, 0.01 to 0.06]; $P=.002$) were associated with turnaround time (days per message) for In Basket messages. None of the variables explored were independently associated with percentage of encounters closed within 24 hours.

Conclusion: Electronic health record–based audit log data of workload relate to odds of burnout and responsiveness to patient-related inquiries and results. Further study is needed to determine whether interventions that reduce the number of and time spent doing In Basket messages or time spent in the EHR outside scheduled patient care reduce physician burnout and improve clinical practice process measures.

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Physician well-being has an impact on the patient's experience. Professional burnout, a consequence of chronic, unmitigated work stress,[1] is associated with medical errors, malpractice litigation, impaired professionalism, lower commitment to patient care, and reduced patient satisfaction.[2,3] In addition, as the severity of burnout increases among physicians, so does their intent to reduce their clinical hours or to leave their current job.[2] Previous studies have reported that physicians with burnout are twice as likely as physicians without burnout to leave their organization during the next 2 years.[4-6] Such reductions in clinical effort and turnover negatively affect patients' access to care as well as continuity of care. Long-term patient-physician relationships are associated not only with higher patient satisfaction but also with better health care outcomes and lower costs.[7,8]

Leaders in medicine have called for efforts to improve the patient experience, to optimize health care outcomes, and to reduce health care expenditures to include system-level approaches to mitigate work

stress and to reduce burnout.[2,9-12] A critical part of such efforts—and a key recommendation from the National Academy of Medicine—is routine measurement and monitoring of physician burnout and potential contributory factors.[2] Although pragmatic strategies can be employed to reduce responder burden and to guide institutional action,[13] an upstream approach could be a useful complementary strategy that could signal work units at risk of high levels of burnout if prompt action is not taken, with potential to alter trajectory and to mitigate risk of burnout consequences. One well-recognized contributor to burnout is workload, which can be tracked, at least partially, through electronic health record (EHR)–based audit log data.[14,15] Electronic health record–based audit log data (eg, time spent in the EHR, number of In Basket messages received) have been proposed as a metric to be included in system improvement efforts intended to reduce work load or to improve work efficiency.[16,17] National organizations, such as the American Medical Association, are setting the expectation that health care organizations monitor and respond to EHR-based audit log data in their efforts to improve physician well-being and to reduce burnout.[18]

Previous studies have reported relationships between EHR-based audit log data (ie, total In Basket volume, patient call volumes, and time spent entering notes) and symptoms of burnout among physicians.[19-22] Most of these studies aggregated physicians with other health care professionals, included only primary care physicians, used a measure of burnout likely to underestimate the prevalence of burnout, did not link survey data with EHR-based audit log data, or did not adjust analysis for personal or professional characteristics that relate to risk of burnout.[19-24] In addition, no previous studies have explored interrelationships between EHR-based audit log data variables that could potentially provide insight into efficiency or reflect other clinical practice process measures to augment traditional practice analytics usually leveraged to identify patient experience and practice improvement opportunities. For example, turnaround time for In Basket messages and percentage of clinic encounters completed within 24 hours (of the appointment) are EHR-based audit log data reflecting timeliness of response to patient inquiries and test results and clinical notes being electronically available to patients, other health care workers, and the billing office. Such information may provide insights into areas of the practice to be improved to optimize the patient experience, team-based care, and timely collection of revenue.

The aim of our study was to evaluate the relationship of EHR-based audit log data of workload with occupational burnout and to explore the interrelationship between various EHR-based audit log data and responsiveness to patient-related inquiries and results and timeliness of completed outpatient documentation. The overarching goal is to explore whether EHR-based audit log data, in their current form and function, could serve as leading indicators for physician burnout and clinical practice process measures that identify practice improvement opportunities.

METHODS

Participants

All physicians in the Department of Medicine, Rochester, Minnesota, were asked to complete the annual Program on Physician Well-Being survey between September 4 and October 7, 2019. The Department of Medicine has 11 divisions ranging in size from 7 to 97 physicians: endocrinology, gastroenterology, general internal medicine (a referral-based, non–primary care practice that includes executive health), hematology, hospital medicine, infectious diseases, nephrology and hypertension, preventive medicine, primary care (community-based, general internal medicine continuity practices in Rochester, Minnesota, and Mayo Clinic Health System campuses in Wisconsin and Minnesota), pulmonary and critical care, and rheumatology. The invitation email informed individuals that participation was voluntary and that responses were

confidential. Responders who worked in hospital internal medicine exclusively were not included in this analysis. The Mayo Clinic institutional review board deemed this study exempt.

Electronic Health Record Workload Variables

Electronic health record–based audit log data were obtained from the Epic Signal tool (Epic Systems Corporation, 1999-2021). We selected the subset of data for evaluation and analysis from all the available metadata in audit logs based on literature, insights from the KLAS Arch Collaborative,[25] and our collective expertise (Table 1). For each physician, we obtained these data points from August through October 2019. This was 8 months after the completion of an organization-wide EHR implementation initiative and 2 months after the first upgrade and optimization effort. Most physicians had 15 months of experience with the EHR, with the maximum physician experience with the Mayo Clinic EHR being 25 months.

Clinical Practice Process Measures

To reflect responsiveness to patient-related inquiries and results, we selected turnaround time (average days per message) for In Basket messages (sum of turnaround time for the following types of In Basket messages: patient calls, patient advice requests, prescription refills, results messages, and result notes) from the EHR-based audit log data measures (Table 1). As a metric of timeliness of completed outpatient documentation, we chose percentage of closed office encounters the same day (ie, note was signed the same day the patient was seen in the office). We also obtained these data points from August through October 2019 for each physician.

Survey

The survey included basic demographic characteristics (age, sex), average weekly work hours, and 2 single measures from the Maslach Burnout Inventory, used under license with Mind Garden, Inc, previously demonstrated in samples of more than 10,000 physicians to stratify risk of burnout with areas under the receiver operating characteristic curve of 0.94 for the single item of emotional exhaustion and 0.93 for the single item of depersonalization.[26,27] Each measure has a 7-item frequency response option ranging from never to every day. The positive predictive values of the single-item thresholds for high levels of emotional exhaustion and depersonalization (ie, once a week or more) are 88.2% and 89.6%, with positive likelihood ratios of 14.9 and 23.4, respectively.[27] Overall burnout was defined by a high score on the emotional exhaustion or depersonalization item, as has been done in multiple prior studies.[28-30] Survey responses were linked to EHR-based audit log data, and all identifiers were stripped before analysis.

Statistical Analyses

For analysis purposes, we created 4 variables:

1. Time in the EHR outside scheduled patient care (a sum of time outside scheduled hours and time on unscheduled days) to reflect total time physicians spent in the EHR when not engaged in direct face-to-face care[22];
2. Total non-visit care (NVC) In Basket messages (sum of patient calls, patient advice requests, and prescription refills);
3. Total results management In Basket messages (results messages and result notes); and
4. Total NVC plus result management In Basket result messages as these are the most common types of in-box messages (there are >100 types of In Basket messages).

We calculated basic summary statistics and explored relationships between dependent and independent variables by using Fisher exact test (for categorical variables) or Kruskal-Wallis test (for continuous variables), examining relationships overall and by primary care vs non–primary care specialties. All tests were 2 sided, with a type I error rate of .05. Collinearity diagnostics were performed, and the results did not

TABLE 1. Electronic Health Record–Based Log Audit Data Variables

	Definition
Workload measures	
Patient appointments per day	Numerator: Number of appointments in the reporting period Denominator: Sum of scheduled half-days (0.5-4 hours of scheduled time in clinic) and full days (>4 hours of scheduled time in clinic) in the reporting period
No. of In Basket messages received per day (all types)	Numerator: Total messages received within the reporting period Denominator: Total number of days that the providers logged in and worked during the reporting period
No. of In Basket messages related to non-visit care	The following specific types of In Basket messages: patient calls, patient advice requests, and prescription refills
No. of In Basket messages related to results	The following specific types of In Basket messages: results messages, result notes (messages generated by a health care professional to another staff to direct results management)
In Basket minutes per day	Numerator: Total number of minutes spent per physician in an In Basket activity or navigator section within the reporting period Denominator: Total number of days that the physician logged in and worked during the reporting period
Time outside scheduled hours	Numerator: Number of minutes spent in the system outside of scheduled hours based on Cadence data with a 30-minute buffer before the first appointment and after the last appointment Denominator: Number of scheduled days in the reporting period where time was spent in the system
Time outside of 7 AM to 7 PM	Numerator: Number of minutes spent in the system outside 7 AM to 7 PM on scheduled days Denominator: Number of scheduled days in the reporting period where time was spent in the system outside 7 AM to 7 PM
Pajama time	Numerator: Number of minutes spent in charting activities outside 7 AM to 5:30 PM on weekdays and outside scheduled hours on weekends Denominator: Number of scheduled days in the reporting period where time was spent in the system
Time on unscheduled days	Numerator: Number of minutes spent in the system on days with no scheduled patients Denominator: Number of unscheduled days in the reporting period where time was spent in the system
Clinical practice process measures	
Turnaround time for In Basket messages	Numerator: Sum of the number of days it took for the physician to mark all messages of this type as done Denominator: Total number of messages of this type
Percentage of closed office encounters same day	Numerator: Number of appointments that were closed the same day as the appointment date Denominator: Number of appointments the physician had in the reporting period

support impactful collinearity. We then conducted 3 separate multivariable analyses to evaluate the relationship between EHR workload variables and burnout, turnaround time for In Basket messages, and percentage of office encounters closed the same day. The multivariable models included age, sex, specialty (primary care vs not), appointments per day (for each additional appointment), number of In Basket messages received per day, In Basket minutes per day (for each additional minute), and calculated measure of total time in the EHR outside of scheduled patient care (for each additional hour). Given large differences in In Basket messages received between primary care and non–primary care physicians, we reran the models for turnaround time for In Basket messages separately for primary care and non–primary care physicians.

RESULTS

In aggregate, 413 of 533 physicians (77.5%) responded to the survey. Of these responders, 394 had EHR-based audit log data available from August through October 2019 and were included in the analysis. Demographic and professional characteristics of participants are shown in Table 2. Overall, 36.6% (137/374) were female, 19.5% (77/394) worked in primary care, and self-reported mean weekly work hours were 56.9. Within this cohort, 38.7% (151/392) had high emotional exhaustion, 21.8% (85/392) had high depersonalization, and 40.0% (156/392) had overall burnout.

TABLE 2. Characteristics of Responding Physicians

Variable	No. (%) or Mean (SD)
Age, years	
<30	3 (0.8)
31-40	101 (26.7)
41-50	104 (27.5)
51-60	97 (25.7)
≥61	73 (19.3)
Missing	16
Sex	
Male	230 (61.5)
Female	137 (36.6)
Other	7 (1.9)
Missing	20
Specialty	
Allergy	5 (1.3)
Endocrine	25 (6.3)
Gastroenterology	50 (12.7)
General internal medicine[a]	74 (18.8)
Hematology	40 (10.2)
Infectious disease	21 (5.3)
Nephrology and hypertension	29 (7.4)
Preventive medicine, occupational health, and aerospace medicine	14 (3.6)
Primary care[b]	77 (19.5)
Pulmonary and critical care medicine	46 (11.7)
Rheumatology	13 (3.3)
Missing	0
Average work hours per week	56.9 (13.8)
Burnout	
High emotional exhaustion	151 (38.7)
High depersonalization	85 (21.8)
Overall burnout	156 (40.0)

[a]A referral-based, non–primary care practice that includes executive health.

[b]Community-based, general internal medicine continuity practices in Rochester, Minnesota, and Mayo Clinic Health System campuses in Wisconsin and Minnesota.

Electronic health record workload variables and patient experience measures for the 394 physicians are shown in Table 3 overall and by primary care vs non–primary care specialties. The mean number of In Basket messages received per day was 26.0 (SD 17.2). On average, physicians had 4 In Basket messages for each appointment per scheduled day in clinic. Overall, physicians spent 13.9 (SD 9.8) minutes per day completing In Basket work, 36.2 (SD 24.6) minutes per day in the EHR beyond face-to-face time with patients on clinic days (ie, time outside of scheduled hours), and an additional 39.9 (SD 29.6) minutes per day in the EHR on days not seeing patients in clinic (ie, time on unscheduled days). These EHR workload variables had large ranges, and on average primary care physicians had more In Basket messages (Supplemental Figure, available online at http://www.mayoclinicproceedings.org) and spent more time in the EHR outside time allocated for direct patient care (Table 3).

Overall, mean turnaround time for In Basket messages was 3.5 (SD 4.9) days per message; however, responsiveness to patient inquiries was around 3 days, with prescription requests being completed within 1 day on average. Typically, patients were informed of new test results in an average of 4 days. Despite having higher volumes of In Basket messages, on average primary care physicians had shorter turnaround times on most measures. Approximately two-thirds (68.6%) of clinic notes were completed within 24 hours.

Electronic Health Record Workload Measures and Burnout

On average, physicians with burnout received more In Basket messages, had more In Basket messages per appointment per scheduled day in clinic, and spent more time each day completing In Basket messages (Table 4). Greater numbers of NVC encounter messages, in particular patient calls, and both types of result management messages were associated with burnout. Physicians with burnout spent more time in the EHR on days not scheduled to see patients and had more total time in the EHR outside scheduled patient care.

On multivariable analysis controlling for sex, age, specialty, appointments per day, and time spent in the In Basket per day, more In Basket messages received per day (for each additional message: odds ratio, 1.04 [95% CI, 1.02 to 1.07]; $P<.001$) and total time spent in the EHR

TABLE 3. Electronic Health Record–Based Audit Log Data Among Survey Responders From August Through October 2019[a]

	Overall (N=394)		Primary care (n=77)	Non–primary care (n=317)	*P* value
	Mean (SD)	Range	Mean (SD)	Mean (SD)	
EHR workload variables					
Appointments per day[b]	7.6 (4.3)	0.2-58.0	8.7 (2.9)	7.3 (4.6)	<.001
No. of In Basket messages received per day	26.0 (17.2)	0.4-99.3	44.1 (22.0)	21.5 (12.3)	<.001
No. of messages per month (below categories)	444.5 (327.9)	3.0-1919.7	794.0 (381.3)	359.6 (248.5)	<.001
NVC encounter messages per month	130.0 (121.4)	0.3-595.7	303.6 (135.0)	87.7 (69.1)	<.001
Patient calls	62.4 (52.7)	0.3-351.3	124.3 (63.6)	47.4 (36.4)	<.001
Patient advice requests	34.7 (34.3)	0.0-217.0	61.8 (48.2)	27.9 (25.8)	<.001
Prescription refills	35.5 (53.1)	0.0-267.3	119.0 (62.6)	13.8 (16.2)	<.001
Results management messages per month	122.1 (89.1)	0.0-577.0	174.9 (75.0)	109.2 (87.6)	<.001
Results message	117.8 (85.6)	0.0-564.7	158.2 (67.5)	107.9 (86.7)	<.001
Result notes message	5.3 (8.8)	0.0-69.7	16.9 (11.8)	1.7 (2.0)	<.001
Total In Basket messages per appointment per scheduled day	4.0 (3.1)	0.1-37.3	5.2 (2.5)	3.7 (3.2)	<.001
In Basket minutes per day	13.9 (9.8)	0.3-74.1	24.9 (10.5)	11.2 (7.5)	<.001
Time outside scheduled hours, minutes per day	36.2 (24.6)	1.9-155.9	44.3 (30.0)	33.9 (22.4)	.009
Time outside of 7 AM to 7 PM, minutes per day	17.5 (18.5)	0.1-205.9	18.7 (16.2)	17.1 (19.1)	.25
Pajama time, minutes per day	12.2 (15.7)	0.0-106.0	13.2 (15.3)	11.9 (15.8)	.12
Time on unscheduled days, minutes per day	39.9 (29.6)	0.9-184.9	54.7 (35.7)	35.7 (26.2)	<.001
Total time in the EHR outside scheduled patient care, total hours across 3 months	30.3 (26.1)	0.8-208	43.5 (29.7)	26.6 (23.8)	<.001
EHR patient experience variables					
Turnaround time (below In Basket message types), days[c]	3.5 (4.9)	0.3-40.3	2.0 (4.3)	3.9 (5.0)	<.001
Turnaround time NVC encounter messages, days	3.0 (4.8)	0.1-54.1	1.6 (4.1)	3.4 (4.9)	<.001
Patient calls average TAT/message	3.4 (5.0)	0.1-42.9	1.8 (4.7)	3.8 (5.0)	<.001
Patient advice requests average TAT/message	3.6 (9.2)	0.0-112.1	3.8 (15.6)	3.5 (6.7)	<.001
Prescription authorizations average TAT/message	0.8 (1.7)	0.0-20.8	0.3 (0.3)	0.9 (1.9)	<.001
Turnaround time results management messages, days	4.0 (5.7)	0.0-47.3	2.5 (3.5)	4.4 (6.1)	.002
Results average TAT/message, days	4.0 (5.8)	0.0-47.6	2.5 (3.5)	4.4 (6.1)	.001
Result notes average TAT/message, days	3.8 (9.8)	0.0-132.0	2.6 (2.5)	4.2 (11.1)	.006
Percentage of closed office encounters the same day	68.6 (31.5)	0.0-100.0	67.3 (31.4)	69.0 (31.5)	.70

[a]EHR, electronic health record; NVC, non-visit care; TAT, turnaround time for In Basket messages.
[b]Average of number of scheduled appointments divided by number of full days or half-days scheduled to see patients in August through October 2019.
[c]Average turnaround time for non-visit care encounter and results management messages combined.

outside scheduled patient care (for each additional hour: odds ratio, 1.01 [95% CI, 1.00 to 1.02]; *P*=.04) were independently associated with higher odds of burnout (Table 5).

Electronic Health Record Workload Measures and Clinical Practice Process Measures

On average, physicians who received more In Basket messages (all types) and spent more time completing In Basket work had longer turnaround times for patient-related inquires and results (Table 4). The more time physicians spent in the EHR on days scheduled and not scheduled to work in the clinic, the faster their turnaround time was for In Basket messages. On multivariable analysis controlling for sex, age, specialty, appointments per day, and number of In Basket messages received per day, physicians who spent more time doing In Basket work took more days to respond to patient-related inquires and results (each additional minute: parameter estimate, −0.11 [95% CI, −0.19 to −0.03]; *P*=.01). Physicians who spent more time in the EHR outside scheduled

patient care responded in fewer days to In Basket messages (for each additional hour: parameter estimate, 0.04 [95% CI, 0.01 to 0.06]; P=.002).

Because of the substantial differences in In Basket volume for primary care and non−primary care physicians, we examined differences in turnaround time for messages by specialty (Supplemental Table 1, available online at http://www.mayoclinicproceedings.org). For primary care physicians, more In Basket messages per patient appointment per scheduled day and more time spent completing In Basket tasks were associated with slower turnaround times. The relationship between time spent completing In Basket tasks and slower turnaround time persisted on multivariable analysis controlling for other factors (for each additional minute: parameter estimate, −0.11 [95% CI, −0.21 to −0.01]; P=.03; Supplemental Table 2, available online at http://www.mayoclinicproceedings.org). Among physicians in non−primary care, a greater volume of In Basket messages and in particular of patient calls was associated with slower turnaround time, whereas more time in the EHR was associated with faster turnaround time. On multivariable analysis, total time in the EHR outside scheduled patient care was independently associated with faster turnaround time (parameter estimate, 0.04 [95% CI, 0.02 to 0.07]; P=.003).

Physicians who received more In Basket messages and spent more time completing In Basket messages had fewer office encounters closed the same day (Table 4). The more time physicians spent charting after hours in the EHR (ie, pajama time), completing tasks in the EHR on days not scheduled to see patients, and working in the EHR outside of scheduled patient care, the fewer encounters were closed within 24 hours. On multivariable analysis, none of the explored variables were independently associated with percentage of office encounters closed the same day (Table 5).

DISCUSSION

In this study of physicians in a large academic medical department, volume of In Basket messages, time spent doing In Basket work, and total time spent in the EHR outside scheduled patient care were independently associated with burnout and turnaround time for In Basket messages after adjustment for physician sex, age, specialty, appointments per day, and work hours. Further study is needed to determine whether tracking and responding to these measures ultimately reduce physician burnout and improve clinical practice processes.

Among this cohort of physicians, each additional In Basket message received per day was associated with a 4% higher odds of burnout. The volume of In Basket messages received per day ranged widely, with primary care physicians receiving, on average, twice as many messages as non−primary care physicians. Nearly a quarter of these messages stemmed from patients calls that often necessitate a call back to the patient, work not captured in EHR audit log data. Recent studies have reported that physicians are receiving more In Basket messages and spending more time in the EHR now relative to prepandemic levels.[31,32] Correspondingly, a national study of US physicians approximately 21 months into the pandemic revealed a dramatic increase in the prevalence of burnout.[33] Together these results imply that system-level approaches to reduce physician burnout should include new reimbursement models that enable replacement of traditional face-to-face clinic visits with blocked time during the clinical workday for In Basket work and new approaches to reduce the volume of In Basket messages received by physicians. New team-based workflows are assumed to be a solution to this problem. However, this has not been rigorously tested. Strategies are also needed that assess the efficiency of different team-based models in terms of physician workload, response time, and patient satisfaction.

Consistent with previous research,[19] we also found that a particular type of In Basket message that records patient calls to which physicians need to reply was associated with increased odds of burnout. We further

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demonstrate that higher patient call volumes are also associated with slower responsiveness time to patient inquiries and results, possibly reflecting a prioritization of returning patient calls to completing other In Basket tasks, particularly among non—primary care physicians. Time spent returning patient calls is additional work often unaccounted for by health care organizations and traditionally not reimbursed, leaving it as an add-on activity after a busy clinical day.

More time logged doing In Basket work related to burnout, slower turnaround time for In Basket messages, and fewer clinical encounters completed day of appointment. The relationship between more time recorded doing In Basket work and slower turnaround time for In Basket messages persisted on multivariable analysis after controlling for sex, age, specialty, appointments per day, volume of In Basket messages received, and total time in the EHR outside scheduled patient care. However, when examined separately by specialty, this finding persisted only for primary care physicians on multivariable analysis. Reasons for this warrant further study and may stem from differences in triage in patient-generated In Basket messages, task distribution across team members, and other factors.

Total time physicians spent in the EHR when not engaged in direct face-to-face care averaged 30 hours during the 3-month period (approximately 10 hours per month or 600 minutes per month). This calculated measure outside scheduled patient care may more completely estimate total time physicians spend in the EHR outside of direct patient care as it considers time in the EHR on clinic and nonclinic days and is not limited to certain activities (eg, pajama time estimates time spent in charting activities per day scheduled to care for patients). On average, US physicians spend more time per workday and after hours in the EHR than non-US physicians,[34] suggesting that completing EHR-related tasks outside scheduled patient care time to this extent is not a necessary consequence of clinical care with currently available health information technologies.

On multivariable analysis, we found an independent dose-response relationship between each additional minute per day of being in the EHR outside scheduled patient care time and greater odds of burnout. We also found that the more time physicians spent in the EHR outside scheduled patient care time, the faster they completed In Basket tasks. However, when examined separately by specialty, the relationship between time in the EHR and turnaround time for In Basket messages persisted only among non—primary care physicians after controlling for other factors. This may be due to differences in how time is spent in the EHR outside scheduled patient care time by specialty.

This study has several limitations. This single-institution study was conducted within the Department of Medicine. The findings may not be generalizable to other specialties or nonacademic settings. The study was cross-sectional, and thus the direction of the observed relationships cannot be determined. In addition, the study included a limited number of factors likely to have an impact on work stress, turnaround time to In Basket messages, and note completion. There could also be factors moderating or mediating effect on the relationships explored. We explored interaction effects between burnout, EHR time, and measures of efficiency and did not identify consistent patterns or any interaction effects that substantially changed overall model outcomes. Vendor-available variables have several drawbacks. For example, In Basket messages received per day and time spent in the In Basket average the total messages received and time spent over the total number of days physicians log into the EHR, regardless of whether they are scheduled to care for patients, potentially underestimating the workload. In addition, the time log stops accumulating measurements with each pause in system use lasting more than 5 seconds (eg, moving the mouse, clicking, scrolling, and making keystrokes) and does not include time spent in the EHR using a mobile application (eg, Haiku or Canto). Time completing In Basket work is likely to be

TABLE 4. Relationship Between EHR Workload Variables and Burnout, Turnaround Time, and Office Encounters Closed the Same Day[a]

	Burnout			Turnaround time for In Basket messages[b]		Mean % office encounters closed the same day[c]	
	Burnout, mean (SD)	No burnout, mean (SD)	*P* value	GLM parameter estimate (95% CI)	*P* value	GLM parameter estimate (95% CI)	*P* value
Appointments per day[d]	7.9 (5.4)	7.4 (3.5)	.36	0.01 (−0.10 to 0.12)	.86	−0.39 (−1.12 to 0.34)	.29
No. of In Basket messages received per day (all types)	30.6 (19.5)	23.0 (14.9)	<.001	−0.05 (−0.08 to −0.02)	<.001	−0.27 (−0.45 to −0.09)	.004
No. of In Basket messages per month (below categories)	531.1 (378.4)	390.8 (277.8)	<.001	−0.00 (−0.00 to −0.00)	<.001	−0.01 (−0.02 to −0.00)	.004
NVC encounter messages per month	153.7 (139.2)	116.0 (106.0)	.01	−0.01 (−0.01 to −0.00)	<.001	−0.01 (−0.04 to 0.01)	.33
Patient calls	74.7 (62.7)	55.1 (43.5)	.006	−0.02 (−0.03 to −0.01)	<.001	−0.02 (−0.08 to 0.04)	.44
Patient advice requests	36.9 (34.3)	33.6 (34.4)	.07	−0.03 (−0.04 to −0.01)	<.001	−0.03 (−0.13 to 0.06)	.46
Prescription refills	44.9 (65.6)	29.7 (42.1)	.12	−0.02 (−0.02 to −0.01)	.001	−0.03 (−0.09 to 0.03)	.32
Results management messages per month	147.7 (99.0)	105.7 (78.4)	<.001	−0.01 (−0.01 to −0.00)	.007	0.01 (−0.02 to 0.05)	.54
Results message	142.1 (94.9)	102.1 (75.5)	<.001	−0.01 (−0.01 to −0.00)	.014	0.01 (−0.02 to 0.05)	.46
Result notes message	6.6 (10.2)	4.4 (7.5)	.03	−0.11 (−0.17 to −0.05)	<.001	−0.22 (−0.60 to 0.16)	.26
Total In Basket messages per appointment per scheduled day	4.6 (3.9)	3.5 (2.4)	<.001	−0.21 (−0.37 to −0.06)	.008	−1.71 (−2.72 to −0.71)	<.001
In Basket minutes per day	15.7 (10.0)	12.7 (9.6)	<.001	−0.10 (−0.14 to −0.05)	<.001	−0.51 (−0.82 to −0.19)	.002
Time outside scheduled hours, minutes per day	38.9 (27.0)	34.4 (23.0)	.12	0.02 (−0.00 to 0.04)	.09	−0.12 (−0.25 to 0.01)	.07
Time outside of 7 AM to 7 PM, minutes per day	18.5 (23.42)	16.4 (13.9)	.76	0.06 (0.03-0.08)	<.001	−0.16 (−0.34 to 0.02)	.08
Pajama time, minutes per day	13.6 (17.6)	11.2 (14.2)	.34	0.06 (0.02-0.09)	<.001	−0.31 (−0.51 to −0.10)	.003
Time on unscheduled days, minutes per day	47.1 (34.9)	34.8 (24.1)	<.001	0.03 (0.01-0.04)	.001	−0.14 (−0.25 to −0.03)	.01
Total hours in the EHR outside scheduled patient care, for each additional hour[e]	34.6 (29.4)	27.5 (23.4)	.005	0.01 (−0.01 to 0.03)	.15	−0.16 (−0.28 to −0.04)	.012

[a]EHR, electronic health record; GLM, generalized linear model; NVC, non-visit care;
[b]A negative number indicates slower average turnaround time for In Basket messages.
[c]A negative number indicates fewer charts closed the same day.
[d]Average of number of scheduled appointments divided by number of full days or half-days scheduled to see patients in August through October 2019.
[e]A calculated number representing sum of time outside scheduled hours and time on unscheduled days to reflect total time physicians spent in the EHR when not engaged in direct face-to-face care.

underestimated as the time does not include time spent reviewing other aspects of the chart (eg, chart review, medications) needed to answer the message. The study did not consider patient complexity, differences in cognitive load associated with various EHR-related tasks, physician savviness with the EHR, maturity of triage of In Basket messages by other care team members, or other factors influencing user experience or other system-related factors affecting work-related stress.[35] Electronic health record–based audit log data obtained from the Epic Signal tool in 2019 are limited to clinical work conducted in the outpatient setting, and many of the physicians in this cohort are in specialties with considerable hospital and procedural practices, affecting the metrics on time in the EHR. Tracking and responding to EHR-based audit log data will likely need to be complementary to other approaches to successfully affect the physician and patient experience.[36] Future integration of data from procedure-based platforms (eg, Provation for gastroenterology, Solus Endoscopy suit for pulmonary medicine) as well as other unmeasured efforts (voice recording software, eg, M Modal, Nuance) into a metadata interface could allow more comprehensive information about work effort. Last, Epic Signal data are limited to those who are actively practicing and delivering direct patient care on a minimum number of days.

TABLE 5. Multivariable Analysis of EHR[a] Workload Variables and Burnout, Turnaround Time, and Office Encounters Closed the Same Day

	Burnout			Turnaround time for In Basket messages[b]			Mean % office encounters closed the same day[c]		
	Odds ratio (95% CI)	*P* value	Overall *P* value	Parameter estimate (95% CI)	*P* value	Overall *P* value	Parameter estimate (95% CI)	*P* value	Overall *P* value
Sex (vs male)			.76			.05			.33
Female	1.20 (0.72-2.02)	.49		1.37 (0.27-2.46)	.02		−4.45 (−11.89 to 2.99)	.24	
Other	0.86 (0.15-4.79)	.86		0.25 (−3.12 to 3.61)	.89		−12.36 (−35.26 to 10.53)	.29	
Age, years (vs <40)			.43			.53			.86
41-50	1.17 (0.63-2.18)	.61		−0.17 (−1.48 to 1.13)	.79		−3.09 (−11.94 to 5.76)	.49	
51-60	0.86 (0.45-1.64)	.64		0.64 (−0.70 to 1.98)	.35		−3.61 (−12.71 to 5.50)	.44	
61+	0.65 (0.32- 1.33)	.24		0.67 (−0.79 to 2.13)	.37		−2.67 (−12.59 to 7.25)	.60	
Primary care vs not	0.60 (0.30-1.22)		.16	−1.59 (−3.05 to −0.13)		.03	9.32 (−0.63 to 19.27)		.07
Appointments per day, for each additional appointment	0.95 (0.86-1.04)		.24	0.12 (−0.06 to 0.30)		.19	0.08 (−1.13 to 1.29)		.90
No. of In Basket messages received per day	1.04 (1.02-1.07)		<.001	0.002 (−0.04 to 0.05)		.91	−0.27 (−0.56 to 0.02)		.06
In Basket minutes per day (for each additional minute)	0.98 (0.94-1.02)		.37	−0.11 (−0.19 to −0.03)		.01	−0.29 (−0.85 to 0.27)		.31
Total time in the EHR outside scheduled patient care (for each additional hour)	1.01 (1.00-1.02)		.04	0.04 (0.01-0.06)		.002	−0.10 (−0.25 to 0.05)		.18

[b]A negative number indicates slower average turnaround time for In Basket messages.

[c]A negative number indicates fewer charts closed the same day.

[a]EHR, electronic health record.

As such, this may exclude low-volume physicians and select for higher volume physicians who are at increased risk for burnout. Alternatively, this may exclude erroneous events, null measurements, and false logins. Therefore, whereas using vendor-defined limits does introduce selection bias, doing so limits data corruption and creates consistencies across studies and organizations that may facilitate progress.

CONCLUSION

This study suggests that the volume of In Basket messages, the time spent doing In Basket work, and the calculated measure total time spent in the EHR outside scheduled patient care relate to risk of burnout and markers of the patient experience. Given the relationship between burnout and quality of care, turnover, and suicidal ideation risk, health system leaders should consider tracking and addressing factors contributing to high In Basket volume and time physicians spend in the EHR outside scheduled patient care time. Future studies are needed to explore whether these vendor-defined or vendor-derived EHR-based audit log data can serve as useful targets for proactive identification of subgroups of physicians at risk for having excessive work-related stress and whether acting on these data ultimately reduces burnout and improves patient satisfaction and outcomes. In addition, it may also be worth exploring whether EHR-based audit log data may be useful as part of future models that identify work units with high engagement and efficiency. With identification of those work units, internal team dynamics, strategies, role delineations, and tool configurations could be shared and emulated throughout an organization for the betterment of all.

POTENTIAL COMPETING INTERESTS

Dr Dyrbye is co-inventor of the Well-being Index instruments (outside submitted work). Mayo Clinic holds the copyright for these instruments and has licensed them for use outside of Mayo Clinic. Dr Dyrbye receives a portion of any royalties paid to Mayo Clinic. Dr Dyrbye receives honoraria for lectures and other presentations related to health care professional well-being and health care trainee well-being. Dr O'Horo has received grants from Nference, Inc and the MITRE corporation as well as personal consulting fees from Bates College outside of the submitted work.

SUPPLEMENTAL ONLINE MATERIAL

Supplemental material can be found online at http://www.mayoclinicproceedings.org. Supplemental material attached to journal articles has not been edited, and the authors take responsibility for the accuracy of all data.

Abbreviations and Acronyms: **EHR**, electronic health record; **NVC**, non-visit care

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