Received: 19 May 2024 | Revised: 29 August 2024 | Accepted: 13 September 2024

DOI: 10.1002/aet2.11028

AEM Education and Training

ORIGINAL CONTRIBUTION

PGY-2 emergency medicine residents are more efficient when paired with an early clinical medical student

Nicole Liang[1] | Corlin M. Jewell MD[2] | Dann J. Hekman MS[2] | Christopher Shank MA[2] | Benjamin H. Schnapp MD, Med[2]

[1]University of Wisconsin School of Medicine and Public Health, Madison, Wisconsin, USA

[2]BerbeeWalsh Department of Emergency Medicine, University of Wisconsin School of Medicine and Public Health, Madison, Wisconsin, USA

Correspondence
Corlin M. Jewell, BerbeeWalsh Department of Emergency Medicine, University of Wisconsin, 800 University Bay Drive, Madison, WI 53705, USA.
Email: cmjewell@medicine.wisc.edu

Abstract

Objectives: There is a concern that provide increased extraneous cognitive load when paired with residents on shift. However, this may be offset by the decrease in extraneous load they may provide to the residents they are paired with by offloading basic patient care tasks. We hypothesized that these forces may not be balanced.

Methods: We conducted a retrospective observational analysis of PGY-2 emergency medicine residents and junior medical students at a single academic emergency department (ED) in the Midwest. A series of efficiency metrics (relative value unit [RVUs], patients per hour [PPH], time to note completion, and resident assignment to disposition [RATD]) as well as one quality metric (number of return ED visits; "bouncebacks") were compared for resident shifts in which a student was paired with the resident as well those in which no student was paired utilizing a regression model.

Results: A total of 1844 records met the inclusion criteria (214 shifts with a paired medical student and 1630 without). After covariates were adjusted for, medical student shift status was a statistically significant predictor of increases in PPH ($p<0.0001$) and RVUs ($p=0.0161$) but was not significantly associated with RATD ($p=0.6941$), log-time to note completion ($p=0.1604$), or bounceback status ($p=0.9840$). Shifts where residents were paired with medical students were predicted to see an additional 1.131 (95% confidence interval [CI] 0.660–1.602) PPH and produce an additional 1.923 RVUs (95% CI 1.130–3.273) per shift relative to shifts without medical students.

Conclusions: When junior medical students were paired with a PGY-2 resident on ED shifts, there was a significant increase in the PPH and RVUs generated when compared with shifts in which no medical student was paired with them.

Presented at the WACEP 2024 Spring Symposium & 32nd Annual EM Research Forum, Brookfield, WI, March 2024.

Supervising Editor: Wendy C. Coates

INTRODUCTION

Efficiency in an academic emergency department (ED) is a multifaceted concept encompassing patient flow, timely decision making, effective teamwork, balancing learner supervision and autonomy, and resource utilization.[1,2] As ED volumes and boarding increase,[3] the challenge of accomplishing these tasks to provide safe and timely care to patients also increases. However, the need to provide students in the learning environment with experiential learning remains critically important.[4] When residents work alongside students in the ED to provide a teaching experience, there is a concern that the residents' clinical efficiency could be negatively affected.[5] Cognitive load theory (CLT) suggests that there are limitations to the amount of information that individuals can process in their working memory at any given time.[6] Students have the potential to increase extraneous cognitive load on the residents due to the need for teaching and guidance while on shift. On the other hand, it is also possible that students could decrease the extraneous cognitive load by performing or assisting with patient care tasks that the resident would otherwise have to perform themselves. To optimize the balance between germane load (where learning occurs) and efficient patient care, it is important that the extraneous load added by the students' presence on shift is balanced by their ability to assist with patient care.[6,7] One previous study has shown that when fourth-year medical students (M4s) are added to the clinical environment, there is no change or even a slight decrease in certain measures of departmental efficiency, such as increased patient length of stay (LOS) and time to disposition decision.[8] Another study looked at patient encounters initiated by second- and third-year emergency medicine (EM) residents (PGY-2 and PGY-3) assigned to medical student precepting shifts and found that “door to disposition time” was increased when the two were paired.[9]

To date, the existing literature has not explored the effects of pairing up residents with more junior members of the medical team—PGY-2s completing their initial core clinical clerkships (at our institution, students enter their core clinical clerkships at Month 19 of the curriculum). The aim of our study is to further explore the impact of junior medical students working with residents in the ED and how this partnership can affect efficiency measured by patients seen per hour (PPH), relative value units (RVUs) generated, and patient LOS.[10,11] Based on previous literature, our hypothesis is that any additional work associated with having a student on shift, such as teaching activities, is not offset by the student's ability to help with important aspects of patient care (e.g., updating patients, calling consultants), especially considering the more limited clinical experience these students have while rotating in our department.

METHODS

Study site

The study was conducted at a single 3-year EM residency program that was associated with a Level 1 trauma, stroke, and STEMI center at an urban academic ED located in the midwestern United States. Each residency class consisted of 12 residents until the entering class of 2021 when the complement was increased to 13 residents. The ED sees over 51,000 adult patient visits per year. Our results were reported according to the STROBE guidelines.[10]

Study design and population

This retrospective analysis utilized data extracted from the electronic health record (EHR) system (Epic) from January 1, 2020, through July 30, 2023. Of note, no students were present in the ED between late March and December 2020 due to the COVID pandemic, and a separate analysis was carried out excluding academic year 2020 to determine if this had a significant effect on the chosen outcomes. We calculated several measures of per-shift clinical efficiency: PPH, number of RVUs generated per hour, average time from resident assignment to disposition (RATD), and average time from disposition to resident note final signature for each shift PGY-2 residents worked. A single measure of the quality of care provided was further assessed by measuring the number of patients with return visits requiring admission to the hospital within 5 days (bouncebacks). RATD provides insight into the amount of time between a resident is assigned to a patient case on the EHR to when the order has been placed for their disposition (admitted, transferred, or discharged). This metric was chosen to address the potential confounding effects of hospital boarding and ED crowding, as these are hospital factors outside the control of the individual ED residents. Though the attending physician technically generates the RVUs, these data can be tracked at the patient level as a proxy measurement for patient complexity and amount of work required of the treating provider. Measuring bouncebacks as a surrogate marker of quality of care provided has been commonly used in the ED literature and is collected by our department's quality team.[11–14] Additionally, it was felt that bouncebacks could potentially be affected by medical students as they could potentially catch historical details that may have otherwise been missed. These outcomes were compared across shifts when PGY-2 residents were or were not paired with medical students completing a required 2-week EM rotation. The 2-week EM rotation is situated within one of the four 3-month blocks of core rotations that could be completed at some point during Months 19–30 of the medical school curriculum. At our institution, the preclinical curriculum ends after the first 18 months of the curriculum. This EM experience is offered earlier than is typical for EM rotations, which typically occur in the latter portions of the curriculum.[15] Each student was scheduled for six 9-h shifts in the ED and were paired with a single PGY-2 resident each shift. When possible, these shifts were scheduled with the same one or two PGY-2 residents during the rotation to allow a limited longitudinal partnership to develop which may itself have a positive impact on the metrics utilized. All PGY-2 residents were eligible for pairing with medical students as well as all rotating medical students completing Months 19–30 of medical school. During the rotation, students were encouraged to help with patient history taking, updating patients/families to new findings, call medical power of attorneys/care facilities, prepare discharge instructions, call consults, and prepare the documentation for the ED encounter.

All nonovernight and nonpediatric shifts worked by EM residents in the second year of residency during the study period were eligible for inclusion. Pediatric and overnight shifts were excluded due to differences in patient demographics, volumes, acuity, and clinical structure. Shifts where the student on shift was more advanced and completing an elective EM rotation during Months 31–48 of medical school were also excluded as these students are paired with attendings instead of residents.

This study was preliminarily reviewed by our institutional review board and determined to be exempt from formal review. Consent was not obtained by residents or medical students as this was retrospective analysis involving an existing educational intervention using standard educational techniques.

Data extraction and preparation

To ensure the fidelity of student–resident pairing data, several sources of information were considered: scheduling data (ShiftAdmin), archived medical student schedules, and EHR data on when students completed a note on a patient. We found that the scheduling data was incomplete for the beginning of our study period and focused our investigation on EHR data and archived schedules. Initially, there were some discrepancies; for example, residents were said to have been paired with a medical student when they were not and vice versa. Upon review of archived emails from the clerkship team and the students, we concluded that physical copies of the schedule did not reflect frequent shift changes by medical students and residents such as shift swaps or last-minute substitutions due to illness. Ultimately, the EHR data best reflected true resident–student pairings, and analyses were performed based on these data.

After defining resident shifts eligible for inclusion and extracting resident–student pairings from EHR data, distributional characteristics of the raw outcomes were examined. A visual inspection of influence plots suggested the presence of a small number of extreme outliers for PPH. Analysis of PPH with and without the top and bottom percentile outliers from PPH suggested that while model parameter estimates were moderately impacted by exclusion of outliers there was no change in the overall conclusions about the relationship between PPH, teaching shift status, and model covariates; the results of the PPH analysis are presented with outliers trimmed. Significant right tail skewness was present in the RVU, RATD, and time to note completion outcomes, as is typical for these measurements, so natural log transforms of RVU, RATD, and time to note completion were used to correct for skewness, and further analysis of these outcomes was based on the transformed data. Finally, the total bouncebacks were dichotomized such that a shift where any bouncebacks occurred was coded "1" and a shift where zero bouncebacks occurred was coded "0." This was necessary to account for the extremely scant data on shifts where more than one bounceback occurred.

Along with resident–student pairings and efficiency outcomes, features of resident shifts were also extracted from the EHR. The number of ED patients currently in the department at the start of shift was used as a measurement of crowding in the hospital during the shift (including those in the waiting room who had checked in with the registration desk), consistent with prior literature.[16,17] The proportion of patients with an ED management plan represented patients who visited the ED frequently, who may have had complex care needs that could reduce resident throughput/PPH metrics. Acuity at triage captured the patient's perceived complexity when picked up by a resident (as measured by the Emergency Severity Index [ESI]) and final billing level (e.g., 99281–99285) as a proxy for the complexity of care for patients which residents (and paired medical students) saw on shift. For the analysis, acuity was dichotomized into "low acuity" (ESI 3–5) and "high acuity" (ESI 1–2). Complexity was also dichotomized into "low complexity" (99281–3) and "high complexity" (99284–99285).

Statistical analysis

Least-squares regression was used to model the association of teaching shift status with each of the continuous outcomes (PPH, log-transformed RVU, log-transformed RATD, and log-transformed time to note completion) while controlling for features of the hospital status and patient population seen on shift; logistic regression was used to model the relationship between teaching shift status and then dichotomous bounceback occurrence variable. For each regression, the outcome was predicted by teaching shift status and a vector of covariates: model covariates included ED census at start of shift, shift start time, percentage of shift patients with ED management plans, percentage of shift patients identified as high acuity, and percentage of shift patients identified as high complexity. An interaction term was also included to investigate the relationship between medical student shift status and complexity, reasoning that the complexity (measured by final billing level) most closely represented the patient burden that the resident had to manage on shift.

RESULTS

While 1844 records met the inclusion criteria (214 shifts with a paired medical student and 1630 without), the number of records used in the analyses varied by outcome. This represented data collected involving shifts from 46 residents and 330 students. For log-transformed RVU, log-transformed RATD, and dichotomized bouncebacks, all 1844 resident shifts were analyzed. For log-transformed time to note completion, 22 cases were excluded due to negative values, leaving 1822 cases for analysis. For PPH, a total of 1807 resident shifts were included after trimming the top and bottom 1% of outliers. Omnibus tests for all regression models were statistically significant, indicating that the inclusion of model covariates explained significant variability in each of the outcomes (PPH—$F(10, 1796) = 152.01$, $p < 0.0001$, $R^2 = 0.4584$; log-transformed RVU—$F(10, 1833) = 72.75$, $p < 0.0001$, $R^2 = 0.2841$; log-transformed time to note completion—$F(10, 1811) = 12.76$, $p < 0.0001$, $R^2 = 0.066$; log-transformed RATD—$F(10, 1833) = 79.91$, $p < 0.0001$, $R^2 = 0.3036$; dichotomized bouncebacks—$\chi^2(10) = 32.7627$, $p = 0.0003$, AIC = 1643.126). The analysis of each outcome excluding the data from academic year 2020 can be found in Data S1–S5. Excluding the academic year 2020 data did not result in meaningful differences change the results for the studied outcomes.

After covariates were adjusted for, medical student shift status was a statistically significant predictor of increases in PPH ($p < 0.0001$) and log-transformed RVU ($p = 0.0161$) but was not significantly associated with log-transformed RATD ($p = 0.6941$), log-transformed time to note completion ($p = 0.1604$), or bounceback status ($p = 0.9840$). Shifts where residents were paired with medical students were predicted to see an additional 1.131 ([95% CI 0.660–1.602]) PPH and produce an additional 1.923 RVUs (95% CI 1.130–3.273) per shift relative to shifts without medical students, holding other covariates constant. Regression weights for all predictors are presented by outcome in Table 1. The interaction between medical student shift status and complexity was also significant for PPH ($p < 0.0001$) and log-transformed RVU ($p = 0.0449$) such that the relative increase in each outcome associated with a medical student on shift was eliminated in the presence of a higher proportion of complex patients. The data for PPH and RVU can be seen in Figures 1 and 2, respectively.

DISCUSSION

We found resident efficiency was higher when paired with a medical student as measured by the number of patients seen per shift and RVUs. While earlier studies showed decreased productivity (as measured by RVU and PPH) between residents working with senior medical students and residents working alone, our focus was specifically on examining the effects of second-year residents working with junior medical students during their initial clinical rotations.

Previous studies have been mixed when evaluating the effects of learners in the clinical environment. One study showed some decrease in certain measures of departmental efficiency, such as

TABLE 1 Linear/logistic regression weights for teaching shift status and covariates on PPH, log-transformed RVU, log-transformed time to note completion, log-transformed LOS, and likelihood of bouncebacks.

	Linear regression weights				Logistic regression weights
	PPH	Log-RVU	Log-note time	Log-LOS	Bouncebacks
Intercept	1.587***	3.343***	5.851***	4.859***	−0.985[a]
Department census	0.118***	0.101***	0.543***	0.188***	0.129[a]
ED management plan status	0.982***	0.782***	0.497[a]	0.038[a]	−0.551[a]
% High acuity at triage	−0.049[a]	0.195***	0.401[a]	0.124***	0.035[a]
% High acuity at final billing	−0.191*	0.375***	−0.572[a]	0.585***	−0.346[a]
Teaching shift status	1.131***	0.654*	−2.025[a]	−0.078[a]	0.045[a]
Interaction: teaching shift × % high acuity at final billing	−1.088***	−0.585*	1.711[a]	0.070[a]	−0.115[a]
7 a.m. shift status	−0.388***	−0.291***	0.438*	0.222***	−1.301**
8 a.m. shift status	−0.064*	−0.030*	0.333[a]	0.123***	0.131[a]
9 a.m. shift status	−0.193***	−0.068*	0.888***	0.224***	−0.244[a]
3 p.m. shift status	−0.475***	−0.350***	0.050[a]	−0.042***	−0.617***

Note: Analysis sample includes AY2020 shifts for all outcomes: also excludes top and bottom percentile outliers for PPH. Log-transformed RVU is calculated as the natural logarithm of the raw RVU value on each shift. Log-transformed time to note completion is calculated as the natural logarithm of the average time from patient disposition to note completion on each shift. Log-transformed time to note completion is calculated as the natural logarithm of the average time from patient disposition to note completion on each shift. Department census is mean centered and standardized; shift status is dummy coded with 5 p.m. shift as referent.

Abbreviations: LOS, length of stay; PPH, patients seen per hour; RVU, relative value unit.

[a]Not significant.

*$p < 0.05$. **$p < 0.01$. ***$p < 0.001$.

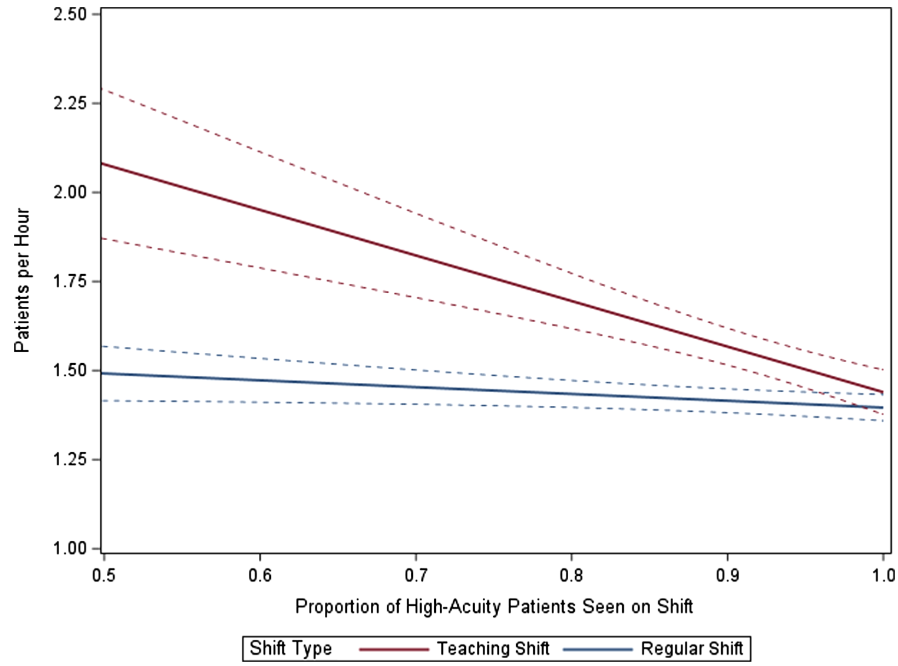

FIGURE 1 PPH by PGY-2 residents over proportion of high-acuity patients when a student is paired (teaching shift) versus when a student is not paired (regular shift). PPH, patients seen per hour.

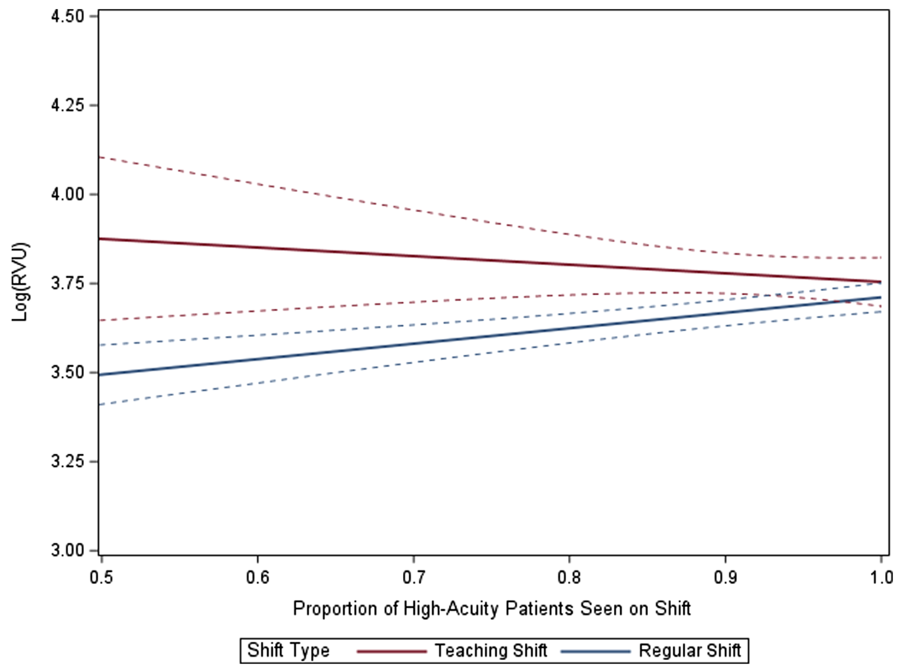

FIGURE 2 RVUs generated over proportion of high-acuity patients seen by PGY-2 residents when a student is paired (teaching shift) versus when a student is not paired (regular shift). RVUs, relative value units.

increased patient LOS and time to disposition decision; however, this was a senior resident-level trainee, who may not be analogous to a medical student learner.[18] One study found essentially no difference in RVUs or PPH in the ED when PGY-2 residents were precepting.[8] In other studies of medical students in the clinical environment, one showed an 11%–30% increase in RVUs when medical students were present but this study occurred in an OB-GYN outpatient clinic and looked at the pairing between an attending physician and a medical student.[9] It was speculated that the presence of a medical student enabled OB-GYN faculty to generate higher RVUs by providing more comprehensive patient history information, facilitating accurate coding of clinic visits, and increasing billable counseling services. It is possible that having a medical student allows for similar benefits in an ED environment by decreasing the amount of time a resident spends in individual patient rooms thereby increasing overall team efficiency. This would allow them to see more patients and potentially perform more time-consuming patient care tasks, such as procedures, and thus generate more RVUs.

For the two main efficiency outcomes (PPH and RVU), teaching shifts are a significant predictor and, in both cases, relate positively to efficiency. Holding everything else constant, residents with medical students tend to see more PPH and generate more

RVUs. However, there is a statistically significant interaction between patient acuity and teaching shift status, indicating that as patient acuity increases, the positive association between teaching shift status and the efficiency outcomes decreases. The interaction is only significant in the PPH and RVU outcomes, and neither teaching shift status nor the interaction between teaching shifts and acuity are significant for the bouncebacks or time to note completion.

The finding that a paired medical student on shift did not result in a statistically significant increase in the number of bouncebacks implies that not only is efficiency improved but also provides preliminary evidence that the quality of care provided may not negatively affected either. However, it is important to note that there are other quality measures that could be affected by the pairing of a medical student (e.g., time to antibiotics/pain medication, CT utilization)[19] and this represents an area of potential future research. This study also found that the relationship between the pairing of a student and the efficiency metrics decreases as patient acuity increases. This may be because there are fewer opportunities for the students to assist with patient care tasks within their abilities, as the complex tasks required for the care of critical patients have been hypothesized to interfere with, rather than contribute to, learning.[20]

According to CLT, individuals have limitations on the amount of information they can process in their working memory simultaneously. While this holds true, our study challenges the assumption that having a medical student would be an additional source of extraneous cognitive load. Despite the additional responsibility including teaching and managing the experience of an additional learner, the presence of a medical student may help offset extraneous cognitive load, as they can assist with other more patient care responsibilities that the resident would otherwise have to perform, especially when shifts feature relatively less complex patients. Since learning occurs best under scenarios without excessive cognitive load,[16] it is possible that students may even contribute to resident education by freeing up resident cognitive resources for internalizing knowledge; this represents an avenue for future research. However, it is also possible that residents working with students found other ways to decrease both extraneous and intrinsic cognitive load. This could include picking up patients perceived to be lower acuity based on their chief complaint and ESI. Such "cherry picking" of patients has been demonstrated previously by residents in other scenarios.[21] This may be suggested in our own data given the interaction between the efficiency outcomes and patient acuity level. On a more positive note, it could be that residents are instead selecting patients that they perceive to provide greater learning experiences for the students they are working with. Collecting information on whether residents are deliberately altering their patient selection when students are paired represents a potential avenue for future study.

The findings from this study could be attributable to factors unique to our learning environment. Medical students are actively integrated into the medical team as much as possible, learning through observation and hands-on experience. For example, Phase 2 medical students all receive a detailed orientation to ED-specific documentation that has been previously published,[22] which may explain why documentation times were lower with a student. There is also a focused attempt to match student schedules with the same one or two residents to develop a more longitudinal experience, which has been described elsewhere but is not standard for academic EM clerkships.[23] Additional research is necessary to interrogate the potential importance of these factors for creating the additional efficiency found in this study.

The results of this study may offer valuable insights to residency program leadership and clerkship directors seeking to promote student involvement, even early in their medical school experience. Pairing residents and medical students may allow residents to fulfill a teaching role without negatively impacting efficiency, which is in line with the ACGME core competency of practice-based learning and improvement for residency education.[24] Looking forward, it will be important to explore the medical students' perspective on the structure of the rotation to ensure that their educational goals are being met as well as explore what teaching strategies are most effective on shift. Additionally, it will be important to see if other measures of the quality of patient care (e.g., adequate analgesia) are positively affected in a similar fashion.

LIMITATIONS

One potential limitation of this study is that it was only conducted at a single institution and therefore may not be representative of the impact of medical student pairings with residents at other institutions due to unique aspects of the healthcare environment at the study site. Therefore, it will be important to replicate these results in both other EDs and medical schools.

It is also possible that some of the shifts in which a medical student was paired with the resident were not captured by the data extraction; similar concerns have been noted in other studies.[25] However, multiple iterations of the data extraction were performed prior to the final analysis to minimize any uncaptured shifts.

We did not collect any data on changes in patient satisfaction that could potentially occur given the resident–student pairing model. It is possible that students could affect satisfaction positively or negatively, although a previous study in the ED environment found no effect.[26]

Another limitation of this study was its observational nature. Residents were not instructed to provide any specific learning experiences while being paired with the medical students. Data on which teaching strategies were utilized by residents on shift was also not obtained. Therefore, it is unclear whether teaching quality is associated with any of the efficiency measures studied here or which teaching strategies may be most effective for students in this environment is still unknown and provides an important avenue of further research.

CONCLUSIONS

Second-year emergency medicine residents who are paired with junior medical students see more patients per shift, generate more relative value units, and sign their note faster than when they are not paired with a student. This study provides evidence that the students' ability to perform patient care tasks may offset the additional cognitive burden required for residents to teach and supervise them.

AUTHOR CONTRIBUTIONS

Nicole Liang—study concept/design, acquisition of data, drafting of manuscript. Corlin M. Jewell—study concept/design, acquisition of data, analysis and interpretation of data drafting of manuscript, critical revision of the manuscript for important intellectual content. Dann J. Hekman—study concept/design, acquisition of data, analysis and interpretation of data drafting of manuscript, critical revision of the manuscript for important intellectual content. Christopher Shank—analysis and interpretation of data drafting of manuscript, critical revision of the manuscript for important intellectual content, statistical expertise. Benjamin H. Schnapp—study concept/design, acquisition of data, analysis and interpretation of data drafting of manuscript, critical revision of the manuscript for important intellectual content.

FUNDING INFORMATION

Nicole Liang received a $3200 stipend from the Shapiro Summer Research Program provided by the University of Wisconsin School of Medicine and Public Health and the BerbeeWalsh Department of Emergency Medicine.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

ORCID

Corlin M. Jewell https://orcid.org/0000-0002-3551-6918
Benjamin H. Schnapp https://orcid.org/0000-0001-5031-8269

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Liang N, Jewell CM, Hekman DJ, Shank C, Schnapp BH. PGY-2 emergency medicine residents are more efficient when paired with an early clinical medical student. *AEM Educ Train*. 2024;8:e11028. doi:10.1002/aet2.11028