Procedural Experience With Intubation: Results From a National Emergency Medicine Group

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Study objective: Although intubation is a commonly discussed procedure in emergency medicine, the number of opportunities for emergency physicians to perform it is unknown. We determine the frequency of intubation performed by emergency physicians in a national emergency medicine group.

Methods: Using data from a national emergency medicine group (135 emergency departments [EDs] in 19 states, 2010 to 2016), we determined intubation incidence per physician, including intubations per year, intubations per 100 clinical hours, and intubations per 1,000 ED patient visits. We report medians and interquartile ranges (IQRs) for estimated intubation rates among emergency physicians working in general EDs (those treating mixed adult and pediatric populations).

Results: We analyzed 53,904 intubations performed by 2,108 emergency physicians in general EDs (53,265 intubations) and pediatric EDs (639 intubations). Intubation incidence varied among general ED emergency physicians (median 10 intubations per year; IQR 5 to 17; minimum 0, maximum 109). Approximately 5% of emergency physicians did not perform any intubations in a given year. During the study, 24.1% of general ED emergency physicians performed fewer than 5 intubations per year (range 21.2% in 2010 to 25.7% in 2016). Emergency physicians working in general EDs performed a median of 0.7 intubations per 100 clinical hours (IQR 0.3 to 1.1) and 2.7 intubations per 1,000 ED patient visits (IQR 1.2 to 4.6).

Conclusion: These findings provide insights into the frequency with which emergency physicians perform intubations. [Ann Emerg Med. 2019;■:1-9.]

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INTRODUCTION

Background

Intubation is a critical procedure in acutely ill and injured patients and a central skill in emergency medicine training. Improper performance of intubation can result in complications.[1-3] Furthermore, emergency airway cases are often complex and involve critically ill patients. Intubation skill acquisition and maintenance requires mentored teaching and continuing practice.[4] In controlled settings, 20 to 50 intubation attempts are suggested as sufficient to develop competence.[5-7] However, other work suggests that up to 250 intubations are required for emergency physicians to become proficient with this procedure in cardiac arrest patients.[8] Although previous multicenter studies have examined emergency department (ED) intubation processes, these were predominantly performed at academic centers, and the frequency of these procedures, especially in community EDs, is unknown.[9]

Importance

Studies of complex medical procedures suggest that procedural frequency influences patient outcomes. It is generally assumed that clinical practice is sufficient to maintain proficiency with critical procedures such as intubation. However, existing data on the incidence of ED intubations, especially in the community setting, are limited. Understanding the frequency of intubations is potentially important in efforts to optimize quality and competence in clinical emergency airway management.

Goals of This Investigation

We sought to evaluate the incidence of intubation by emergency physicians in a national emergency medicine group.

Editor's Capsule Summary

What is already known on this topic

Intubation is a core procedure in the emergency department.

What question this study addressed

How often do emergency physicians perform intubation?

What this study adds to our knowledge

In this series of 53,904 intubations performed by 2,108 emergency physicians in a national practice group, practitioners performed a median of 10 intubations per year (interquartile range 5 to 17). One fourth of emergency physicians performed 4 or fewer intubations per year.

How this is relevant to clinical practice

These results shed light on the intubation procedural frequency in contemporary emergency medicine practice. Additional methods are needed for ascertaining intubation proficiency and defining minimum experience thresholds.

MATERIALS AND METHODS

Study Design and Setting

We performed a retrospective longitudinal study using data from a national emergency medicine group (US Acute Care Solutions). This study was approved by the Allegheny Health Network institutional review board.

During the study period, US Acute Care Solutions provided physician services at 135 EDs in 19 states. The group maintains a data set of all clinical ED encounters handled by group physicians. The curation of the study data set has been previously described.[10] In summary, the group maintains its own billing and coding specialists who are required to have or acquire relevant certification(s) and have ongoing training, auditing, and external evaluation in billing and coding. These specialists code for the performance of intubation (Current Procedural Terminology code 31500) according to direct chart abstraction and also according to only chart documentation of confirmed complete performance of the procedure. The data set includes completed airway procedures, not merely the attempt. This group also maintains an electronic demographic and credentialing database of all practitioners and tracks providers' clinical hours electronically (Tangier, Sparks, MD; Shift Admin, Columbia, SC).

Selection of Participants

We included all ED visits and in-house resuscitation events ("codes") with attending emergency physician response and a reported Current Procedural Terminology code for intubation (31500). All emergency physicians involved in at least 25 visits at a facility per month were included. We categorized intubations by location as general EDs, pediatric EDs, and freestanding EDs or urgent care sites. General EDs were those in which the mean patient age was older than 18 years. Pediatric EDs were those in which the mean patient age was younger than 18 years. Freestanding EDs and urgent care sites were EDs not attached to a hospital and without on-site admission of patients beyond an observation unit. We conducted physician analysis at the level of the physician-facility-month (ie, general emergency physicians were those working in that month in a general ED, pediatric emergency physicians were those working in that month in a pediatric ED, etc). If physicians worked at 2 different facilities in a given month, they were analyzed separately by facility that month.

We excluded other service lines (eg, hospitalists) and other facilities (eg, observation units, nursing homes) staffed by this physician group. ED characteristics, including trauma center designation (Level I or II), teaching facility (ie, presence of residency programs, including in emergency medicine), annual ED volume, and type of ED (general, pediatric, or freestanding/urgent care), were identified. We included data for clinical encounters between January 1, 2010, and December 31, 2016.

Methods of Measurement

We identified all visits with a coded procedure for intubation (Current Procedural Terminology code 31500). We manually reviewed a random sample of 100 intubation and 100 nonintubation patient records to assess the accuracy of billing reports for the performance of intubation in the ED and did not find any cases of misclassification. We similarly examined 100 intubations during in-house codes, finding no cases of misclassification.

We then evaluated all 1,495 charts coded with intubation in which the visit disposition was discharge or discharge against medical advice, given the expected infrequency of this disposition for intubated patients.[11] We did find miscoding of these dispositions, but not performance of intubation, in 80.9% (1,209) of these charts (should have had a coded disposition of admitted, died, transferred, or in-house code, whereas the remaining 19.1% [286] were true discharges [including discharges against medical advice after extubation in the ED]). We corrected the disposition of these visits in

our analysis. We also performed a direct chart audit of 828 charts in which the listed patient age was younger than 1 year or older than 100 years. In 141 charts (17%) with listed patient age older than 100 years, we found a discrepancy. We therefore adjusted the analysis to reflect the corrected age in these rare circumstances. Finally, we performed an audit of 100 charts with a coded intubation and visit disposition of died in the ED, admission, or transfer to evaluate the accuracy of their disposition and procedural coding and found no inaccuracies. All audits were performed by one author (K.M.).

From the visit- and procedure-level data, we constructed 2 data sets, one with data aggregated at the physician-month level (Figure E1, available online at http://www.annemergmed.com) and another with data aggregated at the facility-month level (Figure E2, available online at http://www.annemergmed.com). ED volume is recorded annually by the group and classified by volume bands annually according to the number of ED visits: less than 20,000; 20,000 to 39,999; 40,000 to 59,999; 60,000 to 79,999; and greater than 80,000. The group also maintains documentation on other facility characteristics, including teaching center status (ie, facility with residency programs, including in emergency medicine) and trauma-level designation. We combined Level I and II trauma centers into a single category. We geocoded facilities to their census region (Northeast, South, Midwest, and West). Payer mix was calculated as the percentage of visits with a primary payer of commercial, Medicare, Medicaid, self-pay, or other. Case mix was measured with the Agency for Healthcare Research and Quality Clinical Classification Software. Using the primary *International Classification of Diseases, Ninth Revision* and *10th Revision* diagnosis, we calculated the percentage of visits classified into each Clinical Classification Software category (n=18) at the facility and physician level.

Intubations were assigned to a facility and an attending physician of record when abstracted and billed by this group. We did not include cases in which intubations could not be matched to an attending physician. Provider-months with fewer than 25 visits assigned to them were also excluded from the analysis, along with any intubations assigned to them.

Outcome Measures

The primary outcome was the incidence of emergency physician intubation performance by emergency physicians per year. Secondary outcomes included intubations per 100 clinical hours (including both ED and in-house codes) and intubations per 1,000 ED patient visits. Because we measured our primary outcome as an annual incidence rate, for this analysis we excluded any physicians who appeared in the data set for less than 12 months in a given calendar year. This removed approximately 25% of the physician-months from the data set for any given year. For intubations per 100 hours, we excluded any physician-months with missing hours (1.6% of the total physician-months).

Primary Data Analysis

We used descriptive statistics to characterize the facilities, physicians, and intubations included in the study, reporting means with SDs and medians with interquartile ranges (IQRs). We then calculated the incidence rate of intubations per 100 clinical hours and intubations per 1,000 ED patient visits by type of site and physician (general, pediatric, and freestanding/urgent care) and examined unadjusted trends over time.

We sought to examine the incidence of intubations as performed by emergency physicians, and although this primarily represents intubations performed in the ED, there may be instances in which providers perform intubation outside the ED. Because emergency physicians have the responsibility to respond to in-house codes in some facilities, we included these intubations in our analysis of physician performance of this procedure. We included these in-house procedures in the analysis of intubations per year and intubations per 100 clinical hours and excluded them in our analysis of intubations per 1,000 ED patient visits. To account for variations in clinical responsibilities, we also calculated the outcome measures including only emergency physicians working on average greater than 100 clinical hours per month in a calendar year.

Multiple facility factors potentially affect intubation rates, and individual providers and facilities did not remain constant throughout the entire period. For intubations performed in general EDs, we used fixed-effects linear regression to determine adjusted intubations per year, intubations per 100 clinical hours, and intubations per 1,000 ED patient visits, adjusted for ED volume, patient age, case mix (Clinical Classification Software codes >5% of intubations), payer mix, geographic region, ED admission rate, year, and facility or physician effects (Figures E3 to E6, available online at http://www.annemergmed.com). Finally, we provide descriptive data on case mix, including ED facility geography and characteristics; in-house code characteristics; and rates of intubation adjusted for geographic region, physician practice type (nocturnist or not), and physician age (Tables E1 to E4, available online at http://www.annemergmed.com) characteristics. All calculations were completed with Stata (version 15.1; StataCorp, College Station, TX).

Table. Facility, physician, and intubation characteristics.

	Facilities, N=135	Emergency Physicians, N=2,108	General ED Intubations, N=53,265	Pediatric ED Intubations, N=639
Facility type*				
General EDs	124 (91.9)	2,022 (95.9)	53,265 (100.0)	
Pediatric EDs	6 (4.4)	121 (5.7)	–†	639 (100.0)
Urgent care/freestanding EDs	5 (3.7)	91 (4.3)	–	–
Trauma centers	15 (11.1)	377 (17.9)	16,353 (30.7)	118 (18.5)
Teaching hospitals	15 (11.1)	387 (18.4)	17,231 (32.3)	472 (73.9)
Census region				
Northeast	29 (21.5)	477 (22.6)	9,656 (18.1)	0
Midwest	31 (23.0)	511 (24.2)	13,895 (26.1)	0
South	41 (30.4)	613 (29.1)	14,561 (27.3)	119 (18.6)
West	34 (25.2)	507 (24.1)	15,153 (28.4)	520 (81.4)
Size of facility (average annual visit volume)				
<20,000	35 (25.9)	149 (7.1)	1,355 (2.5)	49 (7.7)
20,000–39,999	52 (38.5)	719 (34.1)	12,077 (22.7)	393 (61.5)
40,000–59,999	28 (20.7)	702 (33.3)	16,657 (31.3)	0
60,000–79,000	14 (10.4)	369 (17.5)	14,033 (26.3)	0
≥80,000	6 (4.4)	169 (8.0)	9,143 (17.2)	197 (30.8)
Mean patient age	39.8 (8.4)	41.4 (10.6)	58.5 (20.2)	4.4 (6.7)
Patient payer mix, %	**Mean (SD)**		**No. (%)**	
Commercial	27.0 (9.5)	26.2 (7.8)	8,770 (16.5)	126 (19.7)
Medicaid	21.6 (8.7)	24.5 (10.1)	7,967 (15.0)	389 (60.9)
Medicare	31.2 (11.6)	29.8 (12.8)	25,963 (48.7)	0
Self	17.0 (8.1)	16.5 (8.9)	9,617 (18.1)	122 (19.1)
Other	0.0 (0.0)	0.0 (0.0)	948 (1.8)	2 (0.3)
Physician age, y				
<40	–	1,088 (51.7)	–	–
40–49	–	544 (25.9)	–	–
50–59	–	335 (15.9)	–	–
≥60	–	136 (6.5)	–	–
Physician sex	–		–	–
Men	–	1,420 (67.4)	–	–
Women	–	688 (32.6)	–	–
Nocturnists	–	139 (6.6)	–	–
General EDs/emergency physicians	**N=124**	**N=2,022**		
ED volume/y, median (IQR)	37,546 (20,572–50,204)	2,536 (1,152–3,679)	–	–
ED admissions/y, median (IQR)	6,072 (3,178–10,289)	500 (236–791)	–	–
ED intubations/y, median (IQR)‡	75 (38–151)	9.0 (4.0–15.0)	–	–
ED admissions per 100 ED patient visits, mean (SD)	18.2 (7.1)	22.7 (10.2)	–	–
ED intubations per 1,000 ED patient visits, median (IQR)	2.3 (1.5–3.3)	3 (1–5)	–	–
In-house intubations/y, median (IQR)‡		0.0 (0.0–0.0)	–	–
Clinical h/y, mean (SD)		1,037.9 (585.5)	–	–
Intubations per 100 clinical hours, median (IQR)		0.7 (0.3–1.1)	–	–

Table. Continued.

	Facilities, N=135	Emergency Physicians, N=2,108	General ED Intubations, N=53,265	Pediatric ED Intubations, N=639
Pediatric EDs/emergency physicians	**N=6**	**N=121**		
ED volume/y, median (IQR)	30,254 (12,777–70,549)	2,707 (612–3,751)	–	–
ED admissions/y, median (IQR)	2,525 (1,285–7,817)	261 (50–428)	–	–
ED intubations/y, median (IQR)‡	28 (14–38)	1.0 (0.0–4.0)	–	–
ED admissions per 100 ED patient visits, mean (SD)	9.2 (3.9)	11.0 (6.6)	–	–
ED intubations per 1,000 ED patient visits, median (IQR)	0.8 (0.3–1.3)	0 (0–1)	–	–
In-house intubations/y, median (IQR)‡		0.0 (0.0–0.0)	–	–
Clinical h/y, mean (SD)		999.8 (725.3)	–	–
Intubations per 100 clinical hours, median (IQR)		0.1 (0.0–0.2)	–	–
Intubation dispositions				
Admitted	–	–	34,943 (65.6)	527 (82.5)
Transfer	–	–	6,828 (12.8)	15 (2.3)
Died in ED	–	–	6,692 (12.6)	88 (13.8)
In-house code	–	–	4,365 (8.2)	1 (0.2)
Discharged	–	–	266 (0.5)	1 (0.2)
Left against medical advice	–	–	19 (<1)	0
Other	–	–	151 (0.3)	7 (1.1)
Unknown	–	–	1 (<1)	0

Data are presented as No. (%) unless otherwise indicated.
*Facility types at the physician level are not mutually exclusive (ie, physicians can work at multiple facility types).
†Dashes indicate that there is no value for this cell in that column.
‡Includes only physicians with 12 months worked in a given calendar year.

RESULTS

Characteristics of Study Subjects

A total of 53,904 intubations performed by 2,108 emergency physicians at 135 facilities were included. These included 53,265 intubations performed by 2,022 emergency physicians working in 124 general EDs, 639 intubations performed by 121 emergency physicians working in 6 pediatric EDs, and 0 intubations performed by 91 emergency physicians in 5 freestanding EDs or urgent care centers during the study period. Of the 135 facilities, 11% (n=15) were trauma centers and 11% (n=15) were teaching facilities, and the mean monthly ED volume was 3,191 (SD 1,784) (Table).

Main Results

Median intubation incidence varied across providers (median 10 intubations/year; IQR 5 to 17; minimum 0, maximum 109) (Figure 1*A*). During the study period, 24.1% of general ED emergency physicians performed fewer than 5 intubations per year, ranging from 21.2% in 2010 to 25.7% in 2016 (Figure 2*A*). Even after excluding physicians who worked less than 100 clinical hours per month on average, approximately 17% of emergency physicians performed fewer than 5 intubations in any given year (Figure 2*D*).

Emergency physicians working at general EDs performed a median of 0.7 intubations per 100 clinical hours (IQR 0.3 to 1.1) (Figure 1*B*). When only emergency physicians working on average greater than 100 clinical hours per month were included, results were similar (median 0.7; IQR 0.4 to 1.2) (Figure 1*E*). Pediatric emergency physicians performed fewer intubations (median 0.1 intubations/100 clinical hours; IQR 0.0 to 0.2) (Table).

Emergency physicians at general EDs performed a median of 2.7 intubations per 1,000 ED patient visits (IQR 1.2 to 4.6) (Figure 1*C*). Results were similar when only emergency physicians working on average greater than 100 clinical hours per month were included (median 2.9/1,000 ED patient visits; IQR 1.6 to 4.7) (Figure 1*F*).

LIMITATIONS

Our study has several limitations. This is an administrative data set and thus dependent on coder accuracy for documenting procedure performance. However, as noted above, this coding on direct chart review appears accurate. We manually reviewed multiple charts for

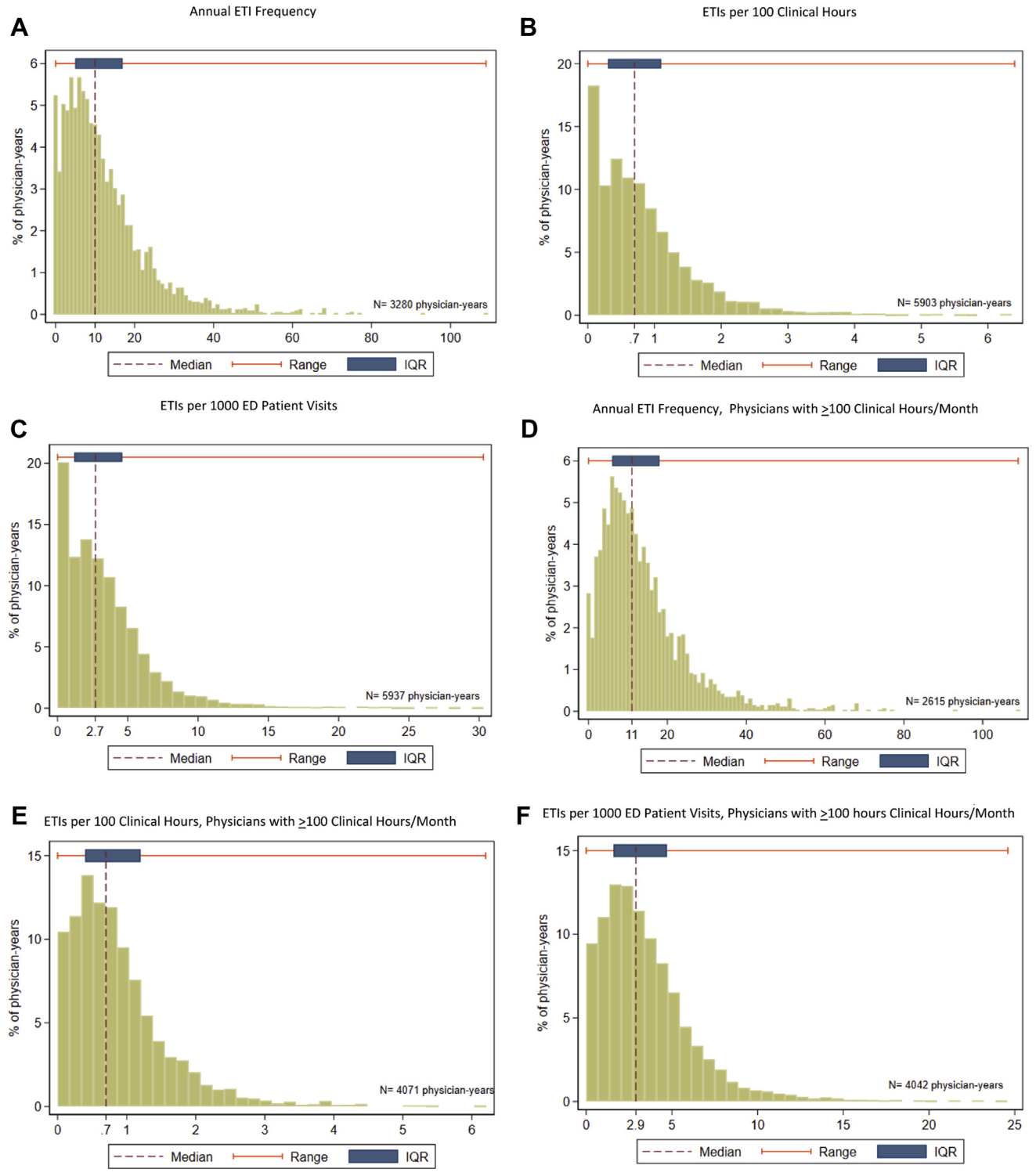

Figure 1. Histograms of intubations performed per year and intubation rates as measured by the number of intubations (ETIs) performed per 100 clinical hours and 1,000 ED patient visits. Histograms include all general ED emergency physicians (*A* to *C*) and general ED emergency physicians with at least an average of 100 clinical hours per month in the year (*D* to *F*). Annual ETI frequency includes only physicians who were in the data set for all 12 months in a given calendar year. Annual ETI frequency and ETIs per 100 clinical hours include intubations performed during in-house codes. ETIs per 1,000 ED patient visits include only intubations performed in the ED.

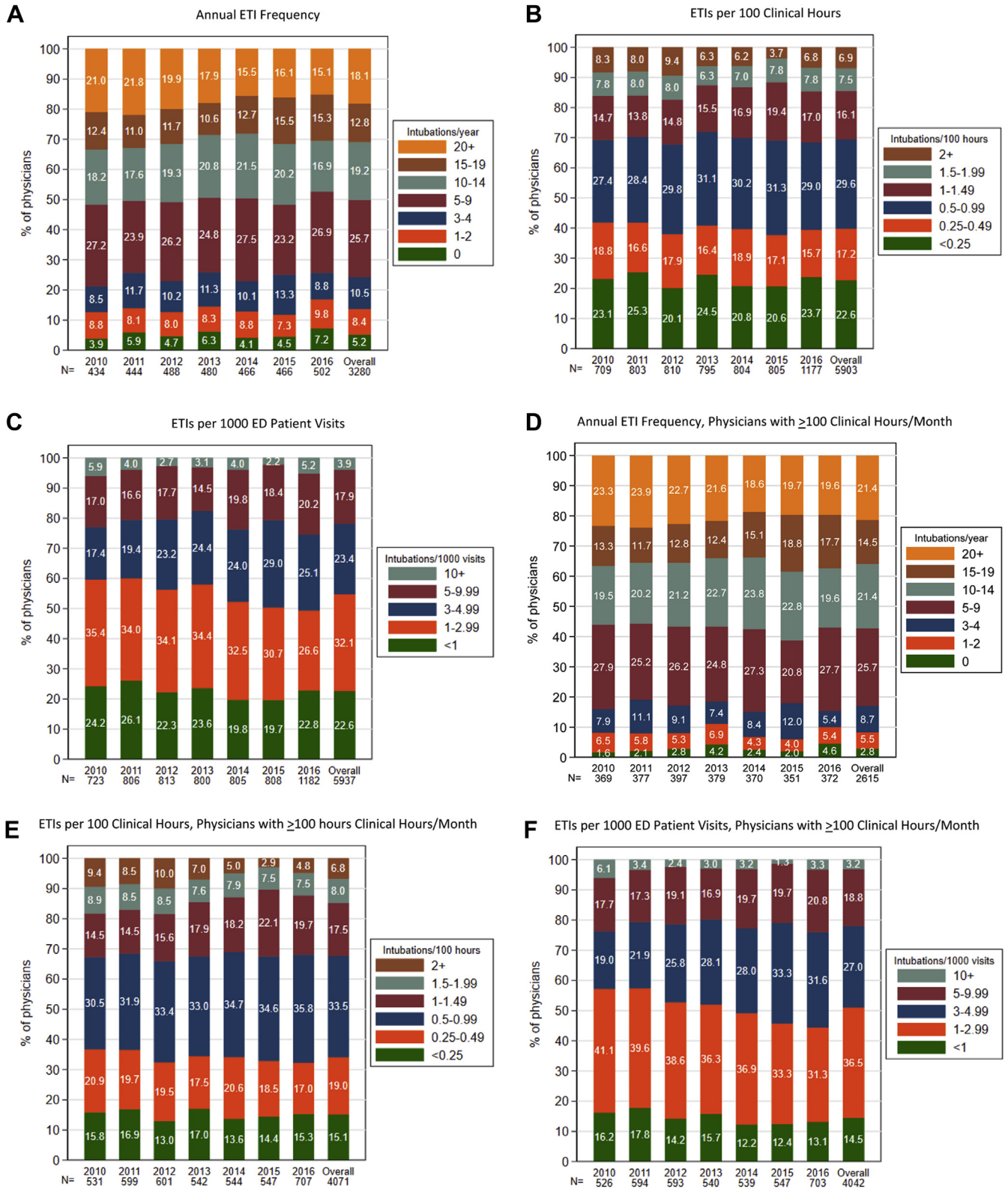

Figure 2. Total intubations performed per year and intubations performed per 100 clinical hours and 1,000 ED patient visits by frequency categories for all general emergency physicians (*A* to *C*) and general emergency physicians with at least 100 hours worked per month (*D* to *F*). Annual ETI frequency includes only physicians who were in the data set for all 12 months in a given calendar year. Annual ETI frequency and ETIs per 100 clinical hours include intubations performed during in-house codes. ETI per 1,000 ED patient visits include only intubations performed in the ED.

accuracy, including disposition, in-house codes, and extremes of ages, to ensure the validity of the data. We were unable to determine performance details of the intubations (eg, number of attempts required to perform the intubation, complications associated with the procedure). The data set reports only intubations performed by or under the supervision of an attending emergency physician. Although this should be an accurate representation of intubations performed at nonteaching facilities and excludes intubations by other subspecialties in the ED (eg, anesthesiology), the exact rate of intubation performed directly by the attending physicians at teaching facilities is likely lower because it is often performed by trainees (eg, residents) with attending physician supervision. This may have led to an overestimation of the frequency of intubations performed by emergency physicians at academic centers in this study. We may have missed periodic absences of providers if they dropped in and out of the dataset within a calendar year. Our population represents data from one national emergency medicine group. Although our data represent a strong estimate of intubation rates across EDs in a large geographic distribution across the United States, how these data generalize to all settings or practice locations will require additional study.

DISCUSSION

In this study, annual intubation incidence varied among emergency physicians, with a median of 10 per year, and approximately one quarter of emergency physicians performed fewer than 5 annual intubations. Intubation is a prominent procedure in emergency medicine practice. Our study provides new national insights of intubation performance in general EDs.

Our results do not indicate the minimum number of intubations necessary for emergency physicians to acquire or maintain proficiency. Proficiency is a function of both skill acquisition and maintenance. Although the minimum experience thresholds for emergency physician acquisition of intubation skill are unknown, previous work has suggested that 20 intubations may be needed to develop intubation skill[5]; up to 250 intubations may be needed to acquire proficiency in specific patient populations (ie, cardiac arrest).[8] Most emergency physicians likely attain these experience thresholds during residency training. However, the minimum experience for maintaining intubation skill is unknown. Although the median intubation experience of 10 intubations per year might be viewed as adequate, it is less clear whether lower thresholds (<5/year) are sufficient. Additional factors potentially affecting minimum intubation procedural skill proficiency and maintenance thresholds include patient and provider factors, such as patient acuity mix and difficult airway anatomy, the skill level of the provider, length of time since the last intubation, and outcome of the last intubation.[12-15] Future work is necessary to better delineate the procedural experience needed for baseline and continuing intubation proficiency.

If clinical exposure proves insufficient for maintaining proficiency with intubation, other avenues for skill maintenance may be needed. Previous work has suggested that deliberate practice, whereby individuals dedicate time to mentally rehearse a procedure or technique, can help maintain skills.[16,17] Simulation offers another avenue for individuals to practice the mechanics of intubation and other critical procedures in a safe environment. Advanced simulation models involving motion analysis and haptic feedback may help to develop and maintain skills by providing feedback to individuals on their technique.[18] Finally, mentored procedures, in which another provider supervises and provides feedback on the procedures, can help to guide providers through infrequently performed skills while sharing knowledge between providers. What methods best help emergency physicians maintain proficiency with intubation and how often to perform them will require additional research, especially in the community ED setting, in which there are few data on whether the above reinforcement techniques are practiced. However, our work suggests that there is a need for the entire emergency medicine community to examine how continuing procedural proficiency with intubation should be maintained and evaluated, rather than rely solely on infrequent performance in clinical practice.

In conclusion, these findings provide insights in regard to the frequency of emergency physician performed intubation. Future work will need to examine how these intubation rates affect skill performance.

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Author contributions: JNC, JMP, AC, and AV conceived the study. KM oversaw the detailed chart quality control and data extraction described. MZ performed the statistical analysis of the study. JNC, MZ, AC, and AV drafted the article. All authors conducted a critical review and revision of the article. AV takes responsibility for the paper as a whole.

All authors attest to meeting the four ICMJE.org authorship criteria: (1) Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; AND (2) Drafting the work or revising it critically for important intellectual content; AND (3) Final approval of the version to be published; AND (4) Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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