

# How Would Minimum Experience Standards Affect the Distribution of Out-of-Hospital Endotracheal Intubations?

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**Study objective:** Out-of-hospital endotracheal intubation is a complex intervention. One strategy for improving the quality of a complex intervention is to limit the procedure to practitioners or agencies that meet minimum procedure experience standards. The system-level influence of such limits is unknown. We seek to determine how minimum endotracheal intubation experience standards influence the number and distribution of out-of-hospital endotracheal intubations.

**Methods:** We used 2003 Pennsylvania statewide emergency medical services (EMS) data. We included endotracheal intubations that could be attributed to a valid rescuer, EMS agency, and minor civil division. We calculated the total number of endotracheal intubations performed across the state. We calculated the absolute and relative changes in total, cardiac arrest, nonarrest, pediatric, and trauma endotracheal intubation when the procedure was limited to on-scene rescuers meeting minimum endotracheal intubation experience standards, ranging from zero to 20 annual endotracheal intubations. We evaluated the same relationships when the procedure was limited to EMS agencies meeting minimum endotracheal intubation experience standards, ranging from zero to 200 annual endotracheal intubations. We evaluated these relationships with line plots and geographic information system maps.

**Results:** During the study period there were 11,771 endotracheal intubations (7,854 cardiac arrest, 3,917 non-arrest, 1,325 trauma and 561 pediatric endotracheal intubations). Limiting endotracheal intubations to rescuers with at least 3, 5, 10, and 15 endotracheal intubations per year would result in relative endotracheal intubation reductions of 12%, 32%, 79%, and 93%, respectively. Limiting endotracheal intubations to EMS agencies with at least 20, 30, 50, 100, and 150 endotracheal intubations per year would result in relative endotracheal intubation reductions of 15%, 27%, 41%, 65%, and 73%, respectively. Cardiac arrest endotracheal intubations would exhibit the largest absolute reduction.

**Conclusion:** Minimum endotracheal intubation experience standards would result in absolute and relative reductions in total and subgroup endotracheal intubations. These findings provide vital perspectives about the system-wide organization of out-of-hospital airway management. [Ann Emerg Med. 2007;50:246-252.]

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## INTRODUCTION

### Background

Out-of-hospital rescuers have performed endotracheal intubation on critically ill patients for more than 25 years.<sup>1-4</sup> Recent studies highlight significant out-of-hospital endotracheal intubation shortcomings, including adverse events, poor outcomes, and limited rescuer training and experience.<sup>5-20</sup>

A logical strategy for improving the quality of a medical intervention is to limit the procedure to providers with adequate clinical experience.<sup>21</sup> Examples of this strategy include the establishment of trauma, myocardial infarction, and stroke care centers.<sup>22-25</sup> Under this approach, out-of-hospital endotracheal intubation would be limited to practitioners or agencies meeting defined minimum endotracheal intubation experience standards.

### Editor's Capsule Summary

#### *What is already known on this topic*

Quality improvement strategies for medical interventions include limitation of the procedure to practitioners with adequate clinical experience. The impact of this approach as applied to out-of-hospital endotracheal intubation is unknown.

#### *What question this study addressed*

How minimum experience standards would affect the number and distribution of out-of-hospital intubations.

#### *What this study adds to our knowledge*

Using 2003 Pennsylvania statewide EMS data, the authors determined that restricting intubation to providers who had performed a minimum number that year would decrease the number of procedures by 12% (3-intubation minimum) to 93% (15-intubation minimum). Restricting intubation to EMS agencies that met minimum agency-wide annual numbers would have a similar effect.

#### *How this might change clinical practice*

Experience-based quality improvement strategies may affect the availability and approach to airway management in EMS.

private and municipal agencies operating at local and regional levels provide EMS. Pennsylvania EMS personnel are diverse, encompassing first responders, emergency medical technicians, paramedics, out-of-hospital registered nurses, and EMS physicians practicing in career and volunteer capacities. Advanced life support vehicles may have 1 or 2 advanced life support rescuers. EMS practice settings encompass dense urban population centers (for example, Philadelphia and Pittsburgh), as well as extensive suburban and remote rural areas. Eleven independent agencies provide air medical services across the state. Although all air medical rescuers may use neuromuscular-blockade-assisted (rapid sequence) endotracheal intubation, only select ground EMS units use sedation-facilitated endotracheal intubation.

### Data Collection and Processing

We used data from the Pennsylvania Emergency Medical Services Patient Care Report Dataset, an administrative database of all EMS patient care incidents in Pennsylvania. All EMS services in Pennsylvania are required to use computer charting systems that transmit patient care data to the statewide database in a standardized format. Services without access to computer charting software must submit patient care reports on standard computer scan forms. Data are collected regionally and then pooled and audited before being merged into a central data set.

Following National Highway Traffic Safety Administration standards for EMS data collection and reporting, Pennsylvania Emergency Medical Services Patient Care Report Dataset contains data about patient characteristics, nature and severity of illness, injury patterns, administered drugs, procedures and interventions, and information about the EMS service and out-of-hospital rescuers delivering care.<sup>26</sup> We used data for the study period January 1 to December 31, 2003.

### Selection of Participants

We excluded all incidents without a patient contact; for example, "standby" duty or cancelled calls.

We included data on patients receiving successful endotracheal intubation, as reported by out-of-hospital rescuers. Endotracheal intubation success was based on rescuer self-reports; there are no statewide protocols for independent confirmation by a second rescuer or physician. The Pennsylvania Emergency Medical Services Patient Care Report Dataset does not include information on unsuccessful endotracheal intubations or postendotracheal tube placement events.

For each incident, the Pennsylvania Emergency Medical Services Patient Care Report Dataset indicates the identification codes of the responding EMS agency, as well the individual rescuer performing the endotracheal intubation. We excluded procedures without a valid EMS agency or rescuer identification code.

The Pennsylvania Emergency Medical Services Patient Care Report Dataset also indicates the geographic location of the incident, using minor civil division codes. A minor civil division

### Importance

Although no studies have evaluated the efficacy of minimum endotracheal intubation experience standards, this hypothetical approach has many important system-level implications. Because organizational or implementation barriers may affect the effectiveness or design of an intervention, a clear understanding of the effect of minimum experience standards on the number and distribution of endotracheal intubations is essential.

### Goals of This Investigation

We sought to evaluate the potential effects of minimum endotracheal intubation experience standards on the number and distribution of endotracheal intubations across the Commonwealth of Pennsylvania.

## MATERIALS AND METHODS

### Study Design and Setting

This study was approved by the University of Pittsburgh institutional review board. In this effort, we used Pennsylvania statewide administrative data to model the hypothetical effects of minimum procedure experience standards on the number and distribution of out-of-hospital endotracheal intubations.

The structure of emergency medical services (EMS) in Pennsylvania is diverse, encompassing a range of care configurations and practice settings. In general, independent

is defined as “a type of governmental unit that is the primary governmental or administrative division of a county or statistically equivalent entity in many states and statistically equivalent entities.”<sup>27</sup> Other terms denoting minor civil division include “township,” “town,” and “district,” among others. Because part of the analysis encompassed geographic mapping, we excluded cases that did not contain a valid Pennsylvania minor civil division code.

We calculated the total number of endotracheal intubations performed by each rescuer. If the patient record indicated more than 1 rescuer performing an endotracheal intubation, we allocated endotracheal intubation experience to both rescuers. We similarly calculated the number of endotracheal intubations performed by each EMS agency.

We also calculated the number of endotracheal intubations performed by each rescuer and agency in the following patient subgroups: cardiac arrest, nonarrest, pediatric, and trauma. We defined cardiac arrest endotracheal intubations as intubated patients who received cardiopulmonary resuscitation chest compressions or automated external defibrillator use or those with an ECG rhythm of ventricular fibrillation, ventricular tachycardia, pulseless electrical activity, or asystole. We classified all other endotracheal intubation patients as nonarrests. We defined pediatric endotracheal intubation as intubated patients younger than 18 years.

Although the Pennsylvania Emergency Medical Services Patient Care Report Dataset does not contain conventional descriptors of injury severity such as the Abbreviated Injury Scale, the Injury Severity Scale, or Trauma-Injury Severity Scale, the data do indicate the presence of injuries and their corresponding body regions.<sup>28-30</sup> In addition, rescuers subjectively rate overall severity of illness according to the ordinal scale minor/moderate/life-threatening. We therefore defined trauma endotracheal intubations as intubated patients with at least 1 injury and a severity of illness rated moderate or life-threatening.

### Primary Data Analysis

The primary objective of this analysis was to determine how a range of minimum endotracheal intubation procedure experience standards would influence the total number of statewide endotracheal intubations. We reasoned that in clinical practice the most logical approaches would be to define minimum endotracheal intubation experience by individual rescuer or individual EMS agency.

We first considered minimum endotracheal intubation experience standards defined by individual rescuer. We defined rescuer endotracheal intubation experience as the number of endotracheal intubations performed by each rescuer during the study period. According to the range of rescuer endotracheal intubation experience observed in the data set, we varied minimum experience standards from zero to 20 endotracheal intubations per year per rescuer. We estimated total statewide endotracheal intubations for each minimum experience standard, including only procedures in which at least 1 rescuer

possessed annual endotracheal intubation experience meeting or exceeding this figure. For example, at a minimum experience standard of 1 endotracheal intubation per year, we included endotracheal intubations performed by all rescuers. At a minimum experience standard of 5 endotracheal intubations per year, we included only endotracheal intubations in which at least 1 rescuer with 5 or more endotracheal intubations during the study period was present. Our approach presumed that the rescuer with the most endotracheal intubation experience would be available to perform the procedure. We depicted this relationship by using line plots, graphing anticipated total endotracheal intubations versus rescuer-based minimum endotracheal intubation experience standards. We repeated this process for each endotracheal intubation patient subgroup (cardiac arrest, nonarrest, trauma, pediatric). We also examined the relative changes in total and subgroup endotracheal intubations.

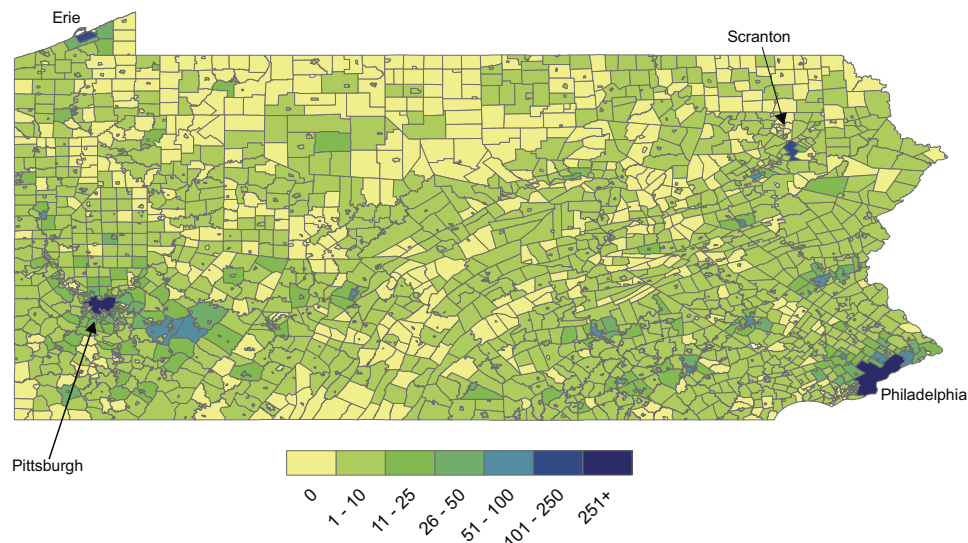
We repeated the process with minimum endotracheal intubation experience standards defined by individual EMS agency. We defined EMS agency endotracheal intubation experience as the number of endotracheal intubations performed by each agency during the study period. According to the range of EMS agency endotracheal intubation experience observed in the data set, we varied minimum experience standards from zero to 200 endotracheal intubations per year per EMS agency. We similarly estimated and depicted absolute and relative changes in total and subgroup endotracheal intubations with these standards.

To evaluate the geographic distribution of endotracheal intubations, we plotted the number of endotracheal intubations in each minor civil division on a geographic information system map. To maintain consistency with other regions, we combined the minor civil divisions of Pittsburgh (codes 02001 to 02062) into a single region. We conducted all analyses with Stata 9.0 (StataCorp, College Station, TX) and ArcGIS 9 (ESRI, Redlands, CA).

### RESULTS

During the study period, there were 11,998 endotracheal intubations, of which 11,771 were attributable to an individual rescuer, EMS agency, and a geographic location (minor civil division) in Pennsylvania. The 11,771 endotracheal intubations included 7,854 cardiac arrest, 3,917 nonarrest, 1,325 trauma, and 561 pediatric endotracheal intubations. Air medical units performed 849 endotracheal intubations. Endotracheal intubations occurred mainly in dense urban centers; for example, Pittsburgh, Philadelphia, Erie, and Scranton (Figure 1). Of 2,572 minor civil divisions, 814 (31.6%) had no endotracheal intubations.

Endotracheal intubations were performed by 3,442 rescuers (range 1 to 23 endotracheal intubation per rescuer; median 3; interquartile range [IQR] 1 to 5). Assuming that the procedures were not reallocated, rescuer-based minimum endotracheal intubation experience standards would have various anticipated effects on the total number of endotracheal intubations (Figures



**Figure 1.** Geographic distribution of endotracheal intubation in Pennsylvania (number of endotracheal intubations per minor civil division). Reflects procedures performed during study period January to December 2003.

2A, B). For example, a minimum experience standard of 3 endotracheal intubations per year per rescuer would reduce total endotracheal intubations by less than 12%. In contrast, higher minimum experience standards of 5, 10, and 15 endotracheal intubations per year would result in disproportionately larger relative endotracheal intubation reductions of 32%, 79%, and 93%, respectively. Although rescuer-based minimum endotracheal intubation experience standards would reduce the relative numbers of subgroup endotracheal intubations (cardiac arrest, nonarrest, trauma, and pediatric endotracheal intubation) proportionately, the largest absolute endotracheal intubation reduction would occur in the cardiac arrest subgroup.

Approximately 370 EMS agencies performed endotracheal intubations (range 1 to 1,407 endotracheal intubation per agency; median 17; IQR 7 to 33). An EMS agency-based minimum endotracheal intubation experience standard of 20 endotracheal intubations per year would reduce total endotracheal intubation by less than 15% (Figures 3A, B). Higher minimum experience standards of 30, 50, 100, and 150 endotracheal intubations per year would result in larger relative endotracheal intubation reductions of 27%, 41%, 65%, and 73%, respectively. Although agency-based minimum experience standards would reduce all subgroup endotracheal intubations, the largest relative and absolute endotracheal intubation reductions would occur in the cardiac arrest subgroup.

## LIMITATIONS

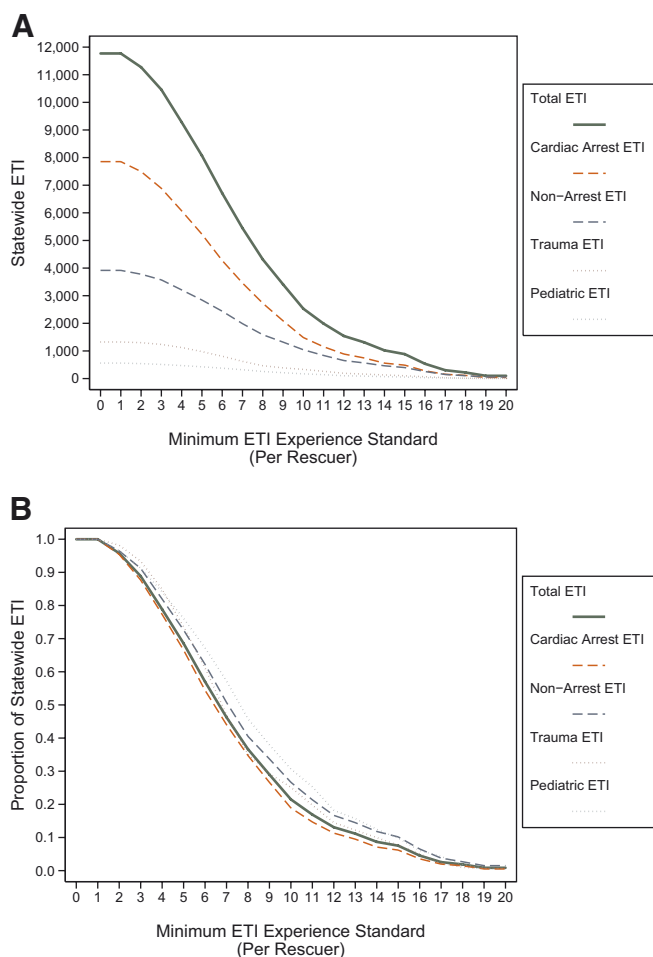
We used the same data set to identify experience levels and predict the effects of minimum endotracheal intubation experience standards. In practice, one would identify experience from a historic period and evaluate the resultant standards on a subsequent period. It is not clear whether the primary inferences

would have changed with the use of data from separate periods. It is also not clear how data from a different or longer study period would alter the primary inferences. Our analysis infers experience based on a single calendar year and does not account for cumulative or lifetime endotracheal intubation experience. Our observations also do not account for additional nonclinical endotracheal intubation training opportunities such as operating room or human simulation sessions.

Our analysis describes Pennsylvania only. A similar effort with data from other regions of the United States may result in different findings. Pennsylvania is demographically diverse and is likely representative of many EMS systems nationally.

Because only basic life support units may have covered the 814 minor civil divisions with no endotracheal intubations, we may have underestimated the number of potential endotracheal intubations in these regions. However, there were only 478 cases of bag-valve-mask ventilation in these areas; these observations would not have affected the primary inferences. Air medical agencies may treat larger numbers of critically ill cases, potentially skewing the endotracheal intubation experience figures observed in this analysis. However, exclusion of the 849 air medical endotracheal intubations from this series likely would not affect the primary inferences.

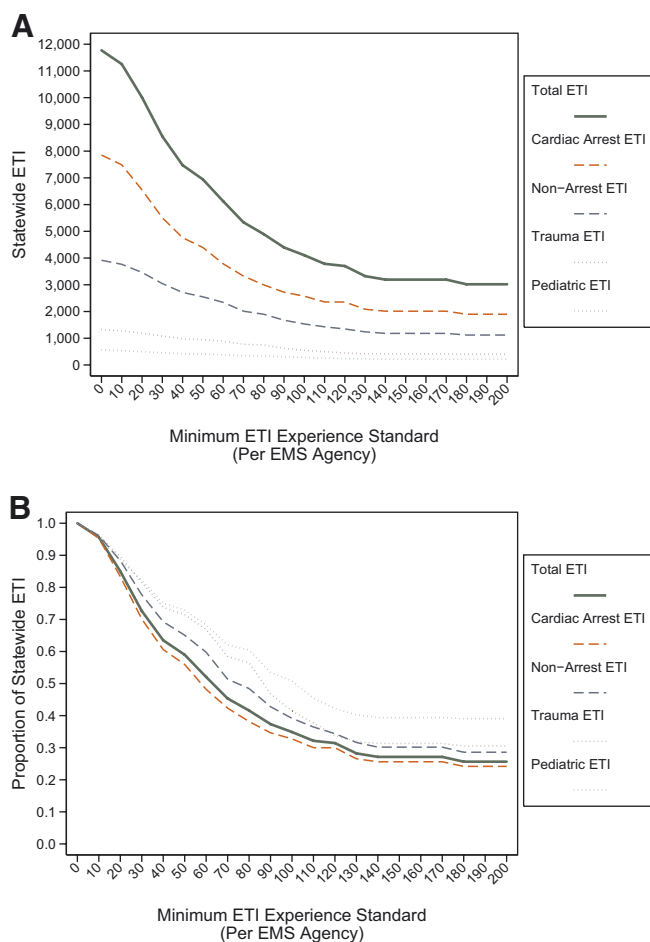
Because of the design of the Pennsylvania Emergency Medical Services Patient Care Report data set, we were able to evaluate successful endotracheal intubation only. Unsuccessful endotracheal intubations may comprise up to 15% of total out-of-hospital airway management encounters.<sup>7</sup> We could not identify instances with endotracheal intubation complications or deferred endotracheal intubation. However, it is not clear how these data would have altered the primary findings.



**Figure 2.** A, Anticipated effects of rescuer-based minimum endotracheal intubation experience standards on absolute number of statewide endotracheal intubations. Reflects procedures performed during the study period January to December 2003. B, Anticipated effects of rescuer-based minimum endotracheal intubation experience standards on relative number of statewide endotracheal intubations. Reflects procedures performed during the study period January to December 2003. ETI, Endotracheal intubation.

## DISCUSSION

A system-wide approach to improving outcomes and the quality of care may include limiting specialty services to centers and practitioners with adequate training and experience.<sup>21</sup> This strategy ensures that the most qualified personnel or teams carry out complex medical interventions. Acute care in-hospital examples of this strategy include the establishment of trauma, myocardial infarction, and stroke care centers.<sup>22-25</sup> Although clinicians view paramedic out-of-hospital endotracheal intubation as an essential acute care skill, few studies indicate improved outcomes from the intervention.<sup>14-16</sup> Several efforts underscore the adverse events associated with out-of-hospital endotracheal intubation, as well as the limited experience in training and clinical experience received by out-of-hospital



**Figure 3.** A, Anticipated effects of EMS agency-based minimum endotracheal intubation experience standards on absolute number of statewide endotracheal intubations. Reflects procedures performed during the study period January to December 2003. B, Anticipated effects of EMS agency-based minimum endotracheal intubation experience standards on relative number of statewide endotracheal intubations. Reflects procedures performed during the study period January to December 2003.

rescuers.<sup>5,6,8,9,11,12,17-20</sup> Given these observations, one might consider a similar model of care for out-of-hospital endotracheal intubation, limiting the intervention to rescuers or agencies meeting defined minimum levels of clinical experience.

This analysis does not indicate the actual or potential effectiveness of minimum endotracheal intubation experience standards. Rather, our effort offers essential perspectives of this hypothetical approach, predicting how minimum endotracheal intubation experience standards might influence the total number and distribution of procedures across a statewide EMS system. The clinical effectiveness of an intervention may depend on the close interplay between its efficacy and manner of system-wide implementation.<sup>31,32</sup> The identification of system implementation challenges is essential because these factors can affect the effectiveness or influence the design of an

intervention. In extreme situations, the identification of significant system-level barriers may nullify the question of efficacy. Given the diversity of EMS structure, staffing, and training in the United States, even without supporting efficacy data, our examination of the effects of minimum endotracheal intubation experience standards on the system-wide distribution of endotracheal intubations is appropriate and essential.

Our observations allude to vital questions related to minimum endotracheal intubation experience standards. For example, what are the quantities and types of patients most affected by experience standards? How many rescuers and which regions would be most affected? A reduction in the number of endotracheal intubations would require the introduction of alternate airway management methods; what types of alternate strategies would we need, and where would we deploy them? If EMS providers or patients resist non-endotracheal intubation alternatives, where might this phenomenon be most evident?

Our analysis offers several preliminary answers. For example, endotracheal intubation experience standards would have the greatest impact on cardiac arrest endotracheal intubations. Current advanced cardiac life support guidelines deemphasize endotracheal intubation for cardiac arrests, and selected EMS agencies have reacted by substituting Combitube (esophageal-tracheal twin-lumen airway device) and King-LT insertion for endotracheal intubation in these patients<sup>33,34</sup> (W. D. Fales, personal communication, January 2007; A. Yee, personal communication, January 2007). Therefore, the notion of limiting endotracheal intubations on these patients is plausible and may not require major shifts in clinical practice or workplace culture. Another perspective involves outliers with the lowest endotracheal intubation experience. The adoption of low minimum experience standards ( $\leq 3$  endotracheal intubations per rescuer or  $\leq 20$  endotracheal intubations per agency) would limit endotracheal intubations by the least experienced providers without affecting major reductions in the overall number of procedures.

Some agencies might respond to the concept of minimum endotracheal intubation experience standards by providing multiple advanced-level rescuers at critical calls, ensuring the availability of a practitioner with sufficient endotracheal intubation experience. However, our analysis presumed that the on-scene rescuer with the most endotracheal intubation experience was available to perform endotracheal intubation. Therefore, it is not clear whether alternate dispatch strategies would significantly change the predicted procedural totals.

The geographic distribution of endotracheal intubations offers other key perspectives of minimum experience standards. In this analysis, we used rescuer- and agency-based minimum experience standards because they are easier to conceptualize than geographically defined standards. However, in practice it might be difficult to operationalize rescuer- or agency-based standards. For example, individual rescuers or EMS agencies with the least experience would lag behind their more experienced peers, never having the opportunity to gain

endotracheal intubation experience. It may also be difficult to frame or justify minimum experience policies to individual rescuers and EMS agencies, who may view inequities in these policies. In this study, we observed natural geographic divisions between the number of endotracheal intubations in dense urban areas and sparse rural areas. Thus, one might define airway management strategies regionally, classifying endotracheal intubation versus no endotracheal intubation by geographic regions rather than by individual experience. We emphasize that this is only 1 potential approach to the regional organization of out-of-hospital airway management; other strategies are possible.

In conclusion, minimum endotracheal intubation experience standards would result in absolute and relative reductions in total and subgroup endotracheal intubations. These findings provide vital perspectives about the system-wide organization of out-of-hospital airway management.

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