Attachment A

One vs. two paramedics: Does ambulance crew configuration affect scene time or performance of certain clinical skills?

By

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Abstract

Background: Emergency Medical Services (EMS) organizations have a wide range of options in the design and composition of their individual systems. Many have opted to provide a paramedic on every emergency call in a single-tiered response plan, but little evidence exists to demonstrate that ambulances staffed with two paramedics provide a different level of care than those with a single paramedic and another prehospital provider. The Wake County EMS System is unique in that one half of all ambulances have dual paramedic crews while the other half has single paramedic crews, all under the same organization and training.

Objective: The purpose of this study is to compare scene times and performance of specific clinical skills for two-paramedic and one paramedic crews for a variety of high acuity emergency response scenarios. Methods: We conducted a retrospective cohort study by examining electronic medical records from the Wake County EMS system from 6/1/2003 to 6/1/2006. We selected patients treated for traumatic injuries, cardiac arrest, cardiac emergencies, and respiratory distress that required emergent transport using lights and sirens. For these clinical scenarios, we defined our cohort as patients that received response from ambulances with a Two Paramedic Crew (TPC) versus those with a Single Paramedic Crew (SPC). For each group, we abstracted information on patient demographics, scene times, placement of IVs, and performance of endotracheal intubation. For analysis, we compared continuous variables
with T-Tests for all means and categorical data using Chi Square of Fisher’s Exact test. **Results:** A total of 5,770 patients met inclusion criteria for all clinical scenarios. For scene time for all patients, no significant difference between TPC vs. SPC groups was noted (17.8 vs. 17.6 minutes, \( p = 0.35 \)). When stratified by clinical scenario, TPC groups had a non-significant shorter scene time for trauma and cardiac arrest patients and SPC groups had a shorter scene time for respiratory distress. No difference was seen between groups for cardiac emergencies. For all intubations, TPC groups had a slightly higher rate of success for both eventual success (0.89 vs. 0.86, \( p=0.23 \)) and first attempt success (0.63 vs. 0.59, \( p=0.12 \)) when compared to SPC groups. For IV placement, TPC groups had a small but significant higher rate of eventual success (0.89 vs. 0.87, \( p=0.04 \)), but not for success on IV placement on the first attempt (0.71 vs. 0.69, \( p = 0.24 \)). When stratified by clinical scenario, TPC and SPC groups did not differ significantly on performance of either intubation of IV placement for any group. **Conclusions:** We noted that TPC ambulances had similar scene times and slightly improved rates of intubation and IV placement success when compared to SPC staffed ambulances. These differences were small and should be placed in context with the clinical scenario. For our four groups of high-acuity patients there was little difference noted if care was provided by either a TPC or SPC ambulance.
Introduction

Emergency medical services (EMS) systems across the United States have a wide variety of organizational designs and strategies to provide prehospital care. In broad terms, systems may choose to deploy ambulances with all basic life support (BLS) personnel, all advanced life support (ALS) personnel, or a hybrid system of units staffed with providers with various levels of training. Most EMS organizations evolved without the benefit of evidence-based guidelines or research on optimal ambulance crew configurations and many current system designs reflect early political or economic decisions instead of evidence on optimal patient care or efficiency of deployed resources.

While there has been much investigation and debate on providing BLS vs. ALS staffed ambulances, little work has been published comparing these options to ambulances staffed with configurations of personnel with different training. A prospective cohort study of “Advanced Paramedic Skilled Units” in Melbourne, Australia found that ambulances with two paramedics had longer scene times, attempted more ALS procedures on-scene, and had a non-statistically significant higher rate of failures for these procedures when compared with teams with one paramedic and a BLS provider. However, the specific types of procedures were not defined and no information on the medical indications for each procedure or the eventual outcome for any patients was reported. In their discussion the authors presumed that the slightly
higher failure rates by two paramedic teams were due to the higher
number of attempted procedures, but did not address the issue further.

Recently, the New York City Fire Department has considered
changing their policies to move from a system of two paramedic-staffed
ambulances to one with hybrid units of a paramedic and an emergency
medical technician (EMT). They report this new policy is necessary
because a current nationwide paramedic shortage has prevented hiring
sufficient numbers of ALS-trained paramedics and that such a system
could improve their disaster response capability and average emergency
response time for the system. In considering this change in policy, they
note that "There is no published data that shows improved clinical
effectiveness by ALS ambulances that are staffed with two paramedics." It
is also noteworthy that there are no published data that show the clinical
effectiveness of ALS ambulances staffed with one paramedic and one
BLS provider.

To further investigate the issue of optimal ambulance crew staffing
configuration, we conducted a retrospective cohort analysis of specific
emergency response calls from the Wake County EMS System. This
system is unique for the present study because half of all ambulances are
staffed with two paramedics and half with a paramedic and a BLS
provider. Our purpose was to compare specific clinical parameters of
EMS crew performance, scene times, and survival for cardiac arrest
between ambulances with two ALS trained paramedics versus those with a single paramedic and a BLS provider.

**Methods**

**Study Design.** We conducted a retrospective cohort analysis using three years of archived prehospital patient care reports from the Wake County EMS quality improvement database. Because this study examined a database of existing electronic medical records collected for quality assurance purposes, the University North Carolina School of Medicine Institutional Review Board approved all study components and waived requirements for informed consent.

**Study Setting and Population.** The Wake County EMS System is the sole provider of emergency prehospital services in Wake County, North Carolina, serving an estimated population of 719,520 and covering a geographic area of 832 square miles. Annually, the system responds to an average of 65,000 emergency calls and transports an average of 45,000 patients to local hospitals.

The system operates a multi-component, single-tiered ambulance response system to provide patient care for all emergency response calls, with a total of 250 ALS providers operating from 33 ambulances. Fire-department based first-responders (FR) provide BLS care for all emergency calls and generally reach the scene before the ambulance
because of their wide geographic disbursement throughout the county. Ambulance crews respond with either two ALS-trained paramedics or a paramedic and a BLS provider. This second provider may include an EMT-Intermediate or an EMT-Basic. Thus, all calls are evaluated by an ALS capable ambulance and crews do not differ in their equipment or ability to perform any advanced ALS procedure or treatment protocol if deemed necessary. There is no protocol or procedure to send a specific type of ambulance crew to any type of call based on patient criteria or acuity from the EMS dispatch center and the choice of the responding unit is based on ambulance availability and geographic proximity to the location of the emergency call. Within the system, individual paramedics may predominantly work in a two paramedic crew, a single paramedic crew, or both but tend to work in either one configuration or another the majority of the time.

**Study Protocol.** All data for the study originated from the Wake County EMS Quality Assurance Database, which contains over 300,000 archived records of patient care encounters for emergency response calls. These medical records are completed by paramedics after each call and are recorded concurrently in the database. For patients with cardiac arrest, these records are linked to hospital reports, with admission, treatment, and discharge information automatically included as part of the final EMS
electronic records. System administrators review this database for a wide variety of quality assurance indicators on a regular basis.

From the database, we studied 4 specific populations based on patient clinical condition from April 2003 to April 2006. These included patients with traumatic injury, cardiac arrest, other cardiac emergencies, and respiratory distress based on information provided paramedics from the emergency call. To select higher acuity patients who might require more ALS procedures, we only included those transports that were considered emergent and used lights/sirens for transport to the hospital based on the clinical judgment of the ambulance crew.

For each clinical scenario, we identified the configuration of the responding ALS ambulance crew and created two groups for analysis. We identify these “Two Paramedic Crew” (TPC) or “Single Paramedic Crew” (SPC) cohorts based on the documentation in each patient record. From there, we extracted information on patient demographics, scene times for each call, and performance of the clinical procedures of placement of intravenous (IV) lines and endotracheal intubation for each category of call. Wake EMS does not use rapid sequence intubation and has no protocols for sedation-facilitated intubation. For each clinical procedure, we recorded the number of attempts per patient and the outcome of each attempt. For cardiac arrests we also recorded hospital admission and discharge rates of all patients. We excluded those patient encounters that did not provide documentation of the crew configuration,
patients under the age of 15, and any crew configuration that did not include a paramedic.

**Measurement.** For each of the four categories of emergency calls, we focused on the elements of scene time and the completion of specific procedures. We defined “scene time” as the interval between the arrival of the ambulance unit and the departure of that unit from the scene. All times rely on the record of emergency dispatch system and their official central clock and computerized time-keeping software.

For performance of clinical procedures, we define each as follows. For IV line placement, we defined an “attempt” as any self-reported and documented effort to place an IV line placement and “success” as self-reported completion of the procedure. For endotracheal intubation (ETI), we similarly defined an “attempt” as any self-reported attempt to intubate the patient and “success” as documented completion of placement of the endotracheal tube. From these definitions, we define an “eventual success rate” as dichotomous eventual success divided by the total number of attempts required. For a “first attempt success rate,” we defined a dichotomous success for procedural completion on the first attempt divided by the number of total first attempts for both procedures. We also calculated a “mean attempt per patient” to measure how many trials were required per patient if a procedure was performed, regardless of the eventual outcome. Inclusion in each procedure category was not
mutually exclusive and it is possible that a patient could receive an ETI attempt, an IV attempt, or both.

**Data Analysis.** We abstracted all information into Microsoft Access 2003 (Microsoft Corp., Redmond, WA) and analyzed all data using SPSS version 14.0 (SPSS Inc., Chicago, ILL). For all data, we calculated means for continuous variables and calculated percent frequencies for categorical variables of procedural success rates. To compare groups of continuous variables, we performed independent t-tests on all means. For comparisons of categorical data, we used Chi-Square testing and Fisher’s exact test when appropriate. Because we have little background information on our research question and because this retrospective design was intended to generate hypotheses and information for future study, we had no initial power calculations for our analysis and analyzed all data that met our inclusion criteria.

**Results:**

During the 3 year study period we identified 6611 patients who met criteria for our 4 clinical scenarios. Of these, 841 patients did not meet inclusion criteria and were thus removed from all data analysis because they were under the age of 15 or had no record of the ambulance crew configuration, resulting in a final study population of 5770. Table 1 summarizes the number of patients in each clinical scenario stratified by
our two paramedic crew (TPC) and single paramedic crew (SPC) and
provides basic demographic information on each group.

For the entire study population, were found no significant
differences in scene time when we compare calls from TPC versus SPC
groups (17.8 vs. 17.6 minutes, p = 0.35). When we stratified our study by
clinical scenario, the TPC groups had slightly shorter scene times when
compared to SPC groups for trauma and cardiac arrest patients, but these
differences were not statistically significant. For the SPC group, only the
respiratory distress group had a lower scene time (Mean difference = 1.6
minutes, 95% CI 0.9 to 2.3 minutes, p<0.001). Results for scene times
are summarized in Table 2.

For our trauma group, 2,583 patients met inclusion criteria and all
were included for analysis. Two paramedic crews attempted 56
intubations versus 33 attempted in the single paramedic crew group, but
there was no statistically significant difference in number of procedures
performed per patient (Mean 1.4 vs. 1.5, p = 0.48). Overall, the TPC
group had a greater eventual success rate for completion of the intubation
procedure (79% vs. 70 %), but this difference was not statistically
significant (p = 0.32). Similarly, the TPC group had a higher rate of
success on their first attempt at intubation when compared to the SPC
group (61% vs. 55%), but this difference failed to reach statistical
significance (p=0.66). For IV placement, the TPC teams attempted more
procedures (1567 vs. 1012), but did not attempt more per-patient when
compared to SPC teams (mean 1.5 vs. 1.6, p=0.17). Rates of IV placement were similar for both eventual success (93% vs. 92%, p = 0.11) and for success on the first attempt (77% vs. 77%, p = 0.93) in both groups.

For cardiac arrest, 894 patients met inclusion criteria. Comparing TPC and SPC teams, each attempted 582 and 312 intubations respectively and the groups did not differ in their number of attempts per patient (1.6 vs. 1.6, p = 0.98). Two paramedic crews also had a higher non-significant rate of eventual intubation success (0.92 vs. 0.89, p = 0.11) and on first-attempt success (0.65 vs. 0.59, p = 0.11). For placement of IVs, two paramedic teams attempted 531 procedures and one paramedic teams attempted 295, with no significant difference in the number of attempts per patient (1.8 vs. 1.7, p = 0.46). For IV placement, the two types of crews had similar rates of eventual procedural success (0.89 vs. 0.88, p = 0.87) as well as success on the first attempt (0.64 vs. 0.61, p = 0.45).

For cardiac emergencies, 1030 patients met criteria for inclusion for analysis. TPC teams attempted more intubations than SPC Teams (9 vs. 2), but attempted less intubations per patient (1.8 vs. 3, p = 0.60). For intubations, TPC Teams also had a higher success rate (0.78 vs. 0.50, p = 1.0) and had a higher rate of success on their first attempt when compared to SPC teams(0.44 vs. 0.00, p = 1.0), but neither of these differences were statistically significant. For IV placement, the TPC group
attempted 552 procedures compared to 475 attempts in SPC group, but the average number of attempts per patient was identical. TPC teams did show a statistically significant higher rate of eventual IV placement (0.91 vs. 0.87, p = 0.03) and a higher rate of success on their first attempt (0.74 vs. 0.68, p = 0.03).

For respiratory distress, 1263 patients met inclusion criteria. For intubations, TPC teams attempted more procedures than SPC teams (74 vs. 30), but no difference in attempts per patient was seen (1.3 vs. 1.4, p = 0.52). SPC teams had more success in eventual intubation (0.83 vs. 0.74, p = 0.32) and in successful completion of intubation on the first attempt (0.67 vs. 0.64, p = 0.76), but neither of these differences in success rates reached statistical significance. For IV Placements, the TPC group attempted more procedures than SPC group (749 vs. 507), but the mean number of attempts (1.5 vs. 1.5, p = 0.52), eventual success rate (0.79 vs. 0.79, p = 0.88), and success rate on the first IV attempt (0.59 vs. 0.58, p = 0.99) was virtually identical for each type of team.

For all patient groups, we pooled all procedural data for similar analysis and results are summarized in Table 3. For intubation, we noted no differences in the number of attempts between groups but did see a non-significant higher rate of success in the TPC group for both eventual success (0.89 vs. 0.86, p = 0.23) and first-attempt success (0.63 vs. 0.59, p = 0.12) in the procedure. For IV placement, both groups attempted the same number of procedures per patient and the TPC crew had a small but
statistically significant higher rate of success when compared to the SPC group (0.89 vs. 0.87, p = 0.04). The rate of first attempt IV success was slightly higher in TPC groups (0.71 vs. 0.69, p = 0.24), but this result was not statistically significant.

Discussion

Our data demonstrate that ambulances staffed with two paramedics do not have considerably different scene times but may have slightly higher rates of success on performance of intubation and IV placement when compared to single paramedic crews.

Our findings are in contrast to work by Kelly and Currell, who reported that “All-APS Crews” had statistically significant longer scene times of 1.38 minutes when compared to “Mixed Crews” for all types of critical patients\(^5\). We saw no such difference in our study population when all patient records were combined and found that our similar group of two paramedic crews had virtually identical scene times when compared to single paramedic crews. However, we did note that two paramedic crews had slightly lower scene times for trauma and cardiac arrest patients when compared to single paramedic crews (0.6 and 0.4 minutes respectively), but that these differences were not statistically significant. We also noted an increase in scene times for two paramedic crews for respiratory distress patients, but it is unclear why these results differ from our other subgroups. Also in contrast to Kelly and Currell, we saw no significant
decrease in success for any advanced procedure in the two paramedic crew group and noted a general trend of greater procedural success for the TPC group across all subgroups except for respiratory distress.

In examination of our data of differences in scene times between our ambulance crew configurations, it is important to note that interpretation of our results should take the clinical situation of each scenario into consideration. For example, our 0.6 minute difference in scene time in our trauma groups may or may not be clinically significant for this population given the importance time to hospital treatment in critically injured patients. In contrast, our findings for cardiac arrest are unlikely to be clinically important given that differences in scene time in cardiac arrest patients has not been established as an independent risk factor for survival or adverse outcomes. For any EMS system, the clinical significance of scene time should be evaluated on an individual basis and application of our results should be considered in context of local situations and system goals. However, our results do show that the magnitude of scene time differences between our different paramedic crew configurations are relatively small and do not support concerns that two paramedic crews might have prolonged scene times by attempting more procedures on scene.

Our data documenting success rates of intubation are consistent with previously published reports of paramedic performance of this procedure. Similarly, our differences in intubation success by clinical
scenario are consistent with other studies showing that intubation is easier in cardiac arrest patients than in non-arrest or trauma patients who not receive rapid sequence intubation (RSI) or paralytic agents to facilitate the procedure\textsuperscript{11, 13, 14}.

When comparing two paramedic crews to single paramedic crews, it is unclear why the two groups differ in their success rates for performance of ETI and it is debatable if these relatively small differences are clinically significant. Previous work has shown that procedural competence in performance of ETI is higher in paramedics who perform the procedure more often\textsuperscript{15} and it could be argued that the higher number of cases requiring ETI in all TPC clinical scenarios could increase success through a practice effect for this group of paramedics. However, the actual number of procedures performed per-paramedic in the TPC group is impossible to determine from our database and it is likely that certain providers perform the procedure more often relative to others in this group. This is reasonable given that previous studies have demonstrated that the numbers of ETI attempts are not uniform in a given paramedic population and that many paramedics may go years without attempting intubation at all\textsuperscript{16, 17}. Our findings also show that TPC and SPC groups do not differ in their number of intubation attempts per patient and this is consistent with published reports documenting that as many as 30% of all prehospital intubations require multiple attempts per patient before successful completion\textsuperscript{13}. Our results also do not seem to support the view
that one paramedic crews could improve procedural competence by focusing the procedure the hands of fewer providers, thus creating a potential practice effect that could increase success rates through greater attempts per provider. However, this is a difficult conclusion given the relatively small differences seen between the TPC and SPC groups and the lack of patient information that would allow our analysis to control our procedural outcomes for patients with greater illness or injury severity.

Our results for completion of IV placement are also consistent with previous studies documenting prehospital provider success for this procedure\textsuperscript{18-20}. Despite a statistically significant difference in the overall success rate of the procedure between our TPC and OPC groups (0.89 vs. 0.87, \( p = 0.04 \)), it is unlikely that this difference is clinically significant. This result is expected given that the numbers of IV procedures performed is far in excess to ETI attempts, which would erode any difference in procedural competence from a practice effect between the TPC and OPC groups.

**Limitations:**

Several limitations of our study deserve mention and consideration. First, we obtained all data retrospectively from a quality assurance database that is not designed as a primary research collection instrument. Our data contains no information on illness or injury severity of specific
patients and it was thus impossible to control for these differences. In selection of our four clinical groups, we chose patients who were transported via ambulance using lights and sirens. For each call, the decision on the type of transport was determined by each paramedic team individually in all cases. It is possible that teams with two paramedics could differ in their level of comfort of treating critical patients when compared with one paramedic teams and that this difference could affect the decision to use lights and sirens in transport. Therefore, it is possible that our cohorts contain records of patients that differ in unmeasured ways that affect our outcomes. In interpretation of this study and limitations in our design, it is also important to note that this effort is primarily designed to generate hypotheses about ambulance crew configuration and the potential effect of paramedic staffing on patient care.

Similarly, our database contains no information on individual paramedic or BLS providers. In our analysis, we have no way to compare groups based on years of experience, number of procedures performed, or any other measure on the provider level that could establish or predict their clinical ability. In addition, all information recorded on patient care procedures represents paramedic self-report data that may be incomplete or subject to certain biases that under-report failure of clinical procedures. In our formation of groups, we also treated all BLS providers equally when compared to paramedics and given the differences in skills of EMT-B, EMT-D, and EMT-I certifications it is possible that our single paramedic
crews differ in unmeasured ways. Furthermore, it is possible that the study of ambulance crews could be confounded by unequal distribution of skills and responsibilities within the TPC group, especially if one partner performs many more procedures or if there is unequal sharing of patient care responsibilities. This type of situation could bias our results or confound any comparison with the SPC groups in which the paramedic must perform all advanced skills.

When applying these results to other EMS systems, it should be noted that this study originated from a single prehospital system in a single county and that our results may represent a cohort of paramedics that are unique in their overall level of training, procedural competence, and experience. Our organization is also a mixed urban/suburban system and results here may not apply to more rural or urban locations. Similar prospective studies should be performed in other EMS systems in other types of geographic settings or on a national level to provide further investigation of the complex issue of paramedic staffing on patient care.

Conclusions:

In our study, we found that ambulance teams with two paramedics had similar scene times and slightly improved rates of endotracheal intubation and placement of IV catheters when compared with single paramedic teams. When stratified by four clinical scenarios, two paramedic crews had lower scene times for trauma and cardiac arrest patients but a higher scene times for respiratory distress. We noted no
difference in scene times between cardiac emergency patients in either
group. We also found rates of eventual success and first-attempt success
of performance of endotracheal intubation and placement of IV catheters
had a higher trend in two paramedic crews, but that these results varied in
magnitude and statistical significance.

References:

30, 2005.


<table>
<thead>
<tr>
<th></th>
<th>Two Paramedic Crews</th>
<th>Single Paramedic Crews</th>
<th>Mean Difference (Minutes)</th>
<th>P-value</th>
<th>95% Confidence Interval of Difference</th>
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<tr>
<td>Trauma Average Age (years)</td>
<td>1569 36.1</td>
<td>1014 37.4</td>
<td>0.6</td>
<td>0.06</td>
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<td>Cardiac Arrest Average Age (years)</td>
<td>582 63.5</td>
<td>312 63.9</td>
<td>0.4</td>
<td>0.53</td>
<td>-0.9 to 1.7</td>
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<td>Cardiac Emergency Average Age (Years)</td>
<td>554 63.3</td>
<td>476 63.8</td>
<td>0.0</td>
<td>0.99</td>
<td>-0.8 to 0.8</td>
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<td>Respiratory Distress Average Age (Years)</td>
<td>756 68.5</td>
<td>507 68.1</td>
<td>1.5</td>
<td>&lt;0.001</td>
<td>0.8 to 2.2</td>
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</table>

**NOTE:** This only provides information on calls in which a clinical procedure was performed (i.e. intubation, IV, or both).
Table 3: Comparison of intubation and IV placement in all patients who received a procedure by ambulance crew configuration. (* Note: These groups are not mutually exclusive, i.e. a patient could have received an IV, an intubation, or both).

<table>
<thead>
<tr>
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<th>Two Paramedic Crews</th>
<th>Single Paramedic Crews</th>
<th>P Value</th>
</tr>
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<tr>
<td><strong>Number of Patients</strong></td>
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<tr>
<td>Total Attempts</td>
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<td>348</td>
<td></td>
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<tr>
<td>Mean Attempts (Per Patient)</td>
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<td>1.5</td>
<td>0.90</td>
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<tr>
<td>Range</td>
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<tr>
<td></td>
<td>6</td>
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<tr>
<td>Eventual Success Rate</td>
<td>0.89</td>
<td>0.86</td>
<td>0.23</td>
</tr>
<tr>
<td>First Attempt Success Rate</td>
<td>0.63</td>
<td>0.59</td>
<td>0.12</td>
</tr>
<tr>
<td><strong>IV Placement</strong></td>
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<tr>
<td>Total Attempts</td>
<td>3399</td>
<td>2289</td>
<td>0.65</td>
</tr>
<tr>
<td>Mean Attempts (Per Patient)</td>
<td>1.5</td>
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<td>Range</td>
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<td>15</td>
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<tr>
<td>Eventual Success Rate</td>
<td>0.89</td>
<td>0.87</td>
<td>0.04</td>
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<tr>
<td>First Attempt Success Rate</td>
<td>0.71</td>
<td>0.69</td>
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INTRODUCTION

Modern EMS developed during the late 1960 from efforts designed to respond to cardiac arrest and trauma patients in the field\textsuperscript{1-3} and generally developed without the benefit of research or evidence to provide guidance for optimal system design\textsuperscript{3,4}. Instead, local political or economic concerns drove most early system design decisions and rarely included references to specific patient care outcomes\textsuperscript{2}. Given the importance of EMS to the overall healthcare system, more information is needed on patient treatment protocols, system design, and other key issues that affect the ability of prehospital providers to provide optimal care to their patients.

Definition of Terms

In the United States today, there is considerable diversity of reported EMS system design\textsuperscript{1,2} and most studies provide few standardized definitions to describe the composition of emergency response units in individual organizations\textsuperscript{5}. This creates difficulties in assessment of the published scientific literature on the topic and requires an initial visitation of general terms necessary for a meaningful discussion.

In the past, prehospital care has been divided along two broad categories. The first division is known as Basic Life Support (BLS) and generally includes provision of patient care activities like initial assessment or basic patient care. Within BLS, skills like first aid and cardiopulmonary resuscitation (CPR) are available to both pre-hospital medical care
providers and the lay public\textsuperscript{5}. Further skills like oxygen administration and the use of electronic defibrillators for cardiac arrest are also included under BLS care. The second division, Advanced Life Support (ALS), generally includes more advanced procedures beyond the BLS level\textsuperscript{6}, but use of this term has been criticized as vague and less useful in modern systems that often blur the lines between provider level and responsibility\textsuperscript{7}. In general, the term ALS includes higher-level paramedic skills and abilities like endotracheal intubation and administration of intravenous medications, while the term BLS includes skills below the paramedic level.

Within EMS systems, varying levels of specific providers are recognized and defined by their scope of practice. The United States National Highway Traffic Safety Administration (NHTSA) officially recognizes four levels of prehospital providers and defines the criteria for their practice and training requirements\textsuperscript{1}. These include medical first responder (FP), emergency medical technician-basic (EMT-B), emergency medical technician-intermediate (EMT-I) or advanced EMT, and emergency medical technician-paramedic (EMT-P). An additional provider is often also recognized called an emergency medical technician-defibrillator (EMT-D), which denotes additional training of the EMT-B to use automatic external defibrillators (AEDs). In addition to these national standards, individual states generally have requirements for practice and certification beyond those required by the NHTSA\textsuperscript{6}. 
For additional clarity, we define the following terms to further describe EMS system design. A "one-tier system" is a system that employs paramedic-staffed ALS units to respond to all prehospital calls. In this design, a paramedic is paired with another prehospital provider, ranging from an EMT-B to another paramedic. In contrast, a "tiered system" uses multiple types of response teams with various levels of certification to provide more specialized care. For example, many organizations use a first tier staffed with EMT-B providers from local fire departments to provide the initial evaluation and care of all patients and then provide a second tier team composed of paramedics for further evaluation, treatment, and transport only if needed. Some have used sophisticated triage mechanisms to send first-tier teams of BLS providers to evaluate low acuity calls in an effort to spare ALS crews from responding, which in theory allows higher level crews to focus on more critical incidents.

Finally, the actual compositions of individual crews may differ within a system. For our discussion, a "Two Paramedic Crew" (TPC) is defined as a two person ambulance staffed by two certified paramedics with higher level training and access to ALS treatments and procedures. The exact level of care and individual protocols for these paramedic providers will vary by local system policy. In contrast, a "Single Paramedic Crew" (SPC) combines a single paramedic with another prehospital provider of a
lower certification and training. This second provider could include an EMT-B, EMT-D, or an EMT-I.

**EMS System Design**

In the prehospital care literature, very little evidence-based guidelines have been published on optimal EMS system design and composition. The majority of the available literature deals with the specific issue of using all-ALS capable providers versus a system that uses a tiered response that mixes types of emergency response teams based on specific criteria for each type of call.

Stout, Pepe, and Mosesso provide an excellent background and discussion of the merits of different system designs. Specifically, they compare all-ALS trained paramedic ambulance systems with systems that use specific ambulances staffed by paramedics and others staffed by EMT-Basics focusing on BLS care. In all-ALS systems, they argue that offering a paramedic with advanced training on every call may provide better patient care by providing more experience and more ability to perform advanced procedures if needed. They also cite that efficiency in these systems could be higher because they typically employ specialized dispatch programs that link scheduling and deployment with specific acuity and temporal demand for services from the community. On the other hand, they contend that a tiered response system could be more efficient because the majority of 911 calls do not require ALS-level care or skills,
citing that less than 15 percent of all prehospital responses require any ALS intervention\textsuperscript{10}. They further hypothesize that a tiered system could provide faster response times for critical patient by sending crews with lower certification to lower acuity calls, thus sparing crews with higher training for calls likely to need more advanced ALS treatment and procedures. This focus of ALS-trained crews on higher level acuity calls could also create increased opportunities for individual paramedics to utilize ALS procedures like endotracheal intubation or administration of medications, skills which may improve when practiced on a more frequent basis. Finally, they argue that fewer paramedics in a system could lead to greater efficiency through lower costs of employment and continuing medical education because ALS skills require more intensive and more expensive training programs.

Among systems that provide ALS-trained paramedics on each response, very little evidence exits on the question of whether to use two paramedics or a single paramedic and another BLS provider for emergent calls. The only published examination of this issue is a cohort study of "Advanced Paramedic Skilled Units" (APS) in Melbourne Australia that compared scene times and success rates of certain procedures between crews with two advanced paramedic providers (defined as All-APS crews) versus those with a single advanced provider and a lower level provider (defined as "Mixed Crews"). In a prospective, non-randomized study of over 1700 critical calls, they reported that mean scene time for mixed
crews was 15.54 minutes compared with 16.92 minutes for all-APS units\textsuperscript{11}. They also reported that the All-APS crews performed more patient procedures on-scene, but found that these crews had a non-statistically significant lower success rates for these procedures when compared to Mixed Crews. The study is limited by the failure to define the specific types of procedures performed, the lack of information on the clinical scenario for each patient, and the lack of documentation of any patient outcomes or rates of hospital admission or discharge. It is also unclear if the differences in scene times represent any meaningful clinical differences between groups. Despite these limitations, these results provide a point at which to begin further examination of the issue.

Another early examination EMS crew configuration and the performance of prehospital interventions sought to examine the differences in teams of three ALS-trained paramedics versus those with two identical providers in Greenville, North Carolina\textsuperscript{12}. This observational, before-and-after investigation found that the two-person EMS crews had statistically significant longer scene times when compared with three-person crews, but that the overall number of procedures performed on-scene did not differ between the two groups\textsuperscript{12}. While this represents an important early study in the relationship between EMS system design and patient care, it is limited by the fact that no actual patient outcomes are reported and by the lack of correlation with differences in scene times with any meaningful clinical outcomes. The
external validity of the results are also limited because very few modern EMS agencies across the country use ambulance teams with three paramedics and because most systems use First Responders that provide adequate BLS assistance and manpower for most calls.

The New York City Fire Department has recently considered changing their policies to move from a system of two paramedic-staffed ambulances to one with hybrid units of a paramedic and an EMT\textsuperscript{13}. They report this new policy is necessary because a current nationwide paramedic shortage has prevented hiring sufficient numbers of ALS-trained paramedics and that such a system could improve their disaster response capability and average emergency response time for the system. However, in considering this change in policy, they note that “There is no published data that shows improved clinical effectiveness by ALS ambulances that are staffed with two paramedics.”\textsuperscript{13}

Many of the same issues in the debate between an all-ALS TPC versus a tiered BLS/ALS system are applicable to a system that employs SPC crews to provide prehospital care. Like all-ALS systems, hybrid crews have the advantage of providing an ALS provider to each call. However, having only one ALS provider could also provide the advantage of greater efficiencies in employment and training because the numbers of required ALS skilled providers would be lower, which could potentially lower the costs to the system overall. Similarly, having a mixed crew could also potentially allow improvements in patient care by exposing
paramedics to more critical situations and procedures per year, which could improve their proficiency through greater practice and exposure. On the other hand, all-ALS crews could be more beneficial in that all providers would have the same level of access to all system protocols and could thus function interchangeably in any patient care situation. A system with all-ALS crews may also be more efficient from a scheduling and training point of view because all paramedics in the system could be considered interchangeable, allowing all policies and training procedures to be standardized for all providers.

Controversies in Prehospital and EMS research

Research in EMS has been widely criticized and debated. Prehospital investigations are notoriously difficult to conduct and many commonly performed prehospital treatments and procedures lack rigorous study and evaluation for effectiveness. Others have cited a lack of appropriate research models to translate existing treatments to the prehospital environment, the inability to randomize and withhold treatments that could be considered the current standard of care, and the lack of sufficient numbers of EMS systems that collect high-quality data and generate subsequent research as further weakness in the prehospital and EMS literature. Standardized measures, validated data collection instruments, and well-defined outcomes are also found less frequently in prehospital research and this shortage of investigational tools severely
limits the ability of researchers to study many new or existing treatments\textsuperscript{14}. Even when these methods are implemented, most prehospital studies are unable to have sufficient blinding and often lack rigorous design to minimize bias and increase confidence in the stated results\textsuperscript{14}. These concerns and criticisms make interpretation of the prehospital literature difficult and further complicate the assessment of EMS system designs.

**Effectiveness of Advanced Life Support in the Prehospital Setting**

Within the published literature, controversy exists over the actual effectiveness of Advanced Life Support (ALS) over Basic Life Support (BLS) care in the prehospital care setting. Currently, the only intervention with the most proven benefit to mortality is early access to electrical defibrillation for cardiac arrest from ventricular fibrillation (VF)\textsuperscript{15-19}.

In the largest prehospital study ever conducted, researchers from the Canadian province of Ontario sought to examine the question of the marginal benefit of adding the ALS skills and treatment protocols to a system with defibrillation-only capacity for prehospital cardiac arrest patients. Called the Ontario Prehospital Advanced Life Support Study (OPALS), this well-conducted before-after design trial added the skills of endotracheal intubation and administration of standard intravenous advanced cardiac life support medications through standardized education and training of paramedics in over 17 cities in the Canadian province of Ontario\textsuperscript{20}. The study enrolled 1391 patients in the defibrillation-only phase
and 4247 patients in the ALS phase then compared their rates of hospital admission and survival to discharge after treatment for cardiac arrest. The ALS treatment group found slight improvement to survival to hospital admission, but surprisingly the investigators noted no increase in the primary outcome of survival to hospital discharge. By contrast, witnessed arrest, bystander CPR, or access to rapid defibrillation improved survival to hospital admission and hospital discharge for all patients. This large, well-designed study raises concerns about the efficacy of advanced life support for cardiac arrest, especially in comparison with basic life support interventions that require less time or resources. However these results only examine ALS care for cardiac arrest patients, which represent an important but small fraction of all patients seen by paramedics on a daily basis. Further research on ALS care from paramedics is currently under study for trauma and respiratory distress patients, but this work is ongoing and results have yet to be published as of the current date21.

With regard to response and treatment of conditions other than cardiac arrest in the prehospital setting, considerable further controversy exists and less clear evidence has been published for evaluation. For example, the issue of ALS in trauma patients is an enormous source of disagreement that has resulted in a large body of literature both for and against. In short, the debate centers on the appropriate role of advanced procedures like IV line placement or endotracheal intubation performed by paramedics on the scene in patients suffering from severe traumatic
injuries versus more expedient transport to the hospital for more definitive treatment.

The first view in the debate, generally called the "scoop and run" approach, advocates minimal performance of any interventions on-scene and instead emphasizes the rapid transportation of trauma patients to a hospital for more comprehensive evaluation and treatment. Advocates here argue that patients with severe injuries need surgical interventions and treatment beyond the scope of any prehospital provider and that any small gain from on-scene treatment will be outweighed by time lost to these critical interventions.

On the other side of the issue, proponents argue that trauma patients can receive potentially life-saving interventions for many life-threatening conditions on scene and that these treatments should not be delayed. This view does not advocate spending long amounts of time on the scene with these patients, but does advocate for the performance of specific key skills like endotracheal intubation (ETI) and placement of intravenous (IV) lines either on-scene or en route to the hospital if deemed necessary.

Summary of ALS vs. BLS Issues

The study of ALS and BLS care in the prehospital setting is difficult and continuing controversies exist on optimal treatment protocols and levels of care. Many common standard-of-care practices in EMS have
established benefits, while others have shown insignificant improvements or may actually prove harmful. It may be argued that many marginal ALS skills and protocols are excessively expensive to implement and keep up-to-date, especially when compared to more proven BLS interventions. Whenever possible, EMS systems should seriously re-examine current protocols and procedures to ensure that their level of care coincides with published literature and local medical opinion. Similarly, an all-ALS system using TPC ambulances may examine this evidence and determine if having less ALS providers in SPC ambulance configurations is more efficient.

**Prehospital Scope of Practice: Discussion of Specific ALS Paramedic Skills and Procedures**

**Endotracheal Intubation**

Endotracheal intubation (ETI) is a cornerstone of most modern EMS treatment protocols and has provided the gold-standard for management of the prehospital airway in a wide variety of life-threatening clinical scenarios for over 20 years\(^23,24\). This invasive procedure allows prehospital providers to ensure a patent airway and enables provision of artificial respirations and oxygenation to a patient who is unable to adequately breathe without assistance, which may prove to be life-saving in a critical illness or injury\(^24,25\). The basic goal is to provide adequate ventilation and optimal inspiratory and expiratory intervals to ensure
proper oxygenation to a critically ill or injured patient. ETI also provides a route for administration of certain medications, allows opportunities for tracheal suction and removal of foreign body obstructions, and may allow greater protection of the airway from gastric aspiration and subsequent pulmonary infections.

Previous research has shown mixed results for performance of ETI in the field by paramedics. For the past three decades, studies have reported a wide range of success rates for procedural completion of ETI by paramedics ranging from 50% to 98%. These success rates are difficult to interpret because most of the published literature is based on retrospective studies of a wide range of patients, with substantial potential for reporting bias or selective outcome evaluation based on attempting ETI in easier cases. In general, studies show higher rates of successful intubation for cardiac arrest patients, but lower rates in traumatically injured populations because awake or un-relaxed patients are generally harder to intubate when compared to the un-responsive state of cardiac arrest. Similarly, studies reporting techniques of medication-facilitated intubation or rapid sequence intubation (RSI) using sedative and paralytic medications generally report similar success rates to cardiac arrest patients because patients are unresponsive and paralyzed after treatment. Most of the published literature on prehospital ETI also reports results from smaller samples from individual EMS systems, which
vary dramatically in level of medical oversight, training, and capability to perform advanced procedures in general.

Even if eventually completed, ETI may require multiple attempts before successful outcome. In an examination of data collected from a large prospective, observational study of prehospital endotracheal intubations, Wang and Yealy demonstrated that multiple attempts to successfully complete the procedure are required in 30 percent of all patients and that some required as many as six attempts to achieve eventual success\(^\text{39}\). Within the study, participating prehospital providers included paramedics, out-of-hospital nurses, and physicians, with 94 percent of all ETI attempts from paramedics. The authors reported no differences in success rates by type of provider, but noted higher cumulative rates among patients with cardiac arrest and in those patients in which rapid sequence intubation was used to facilitate the procedure. For all subgroups, the number of cumulative success rates for ETI seemed to plateau after 3 attempts, leading to the suggestion by the authors that EMS systems should consider protocols to limit providers to no more than three intubation attempts per patient. Within their results, the investigators provided no links between successful ETI placement and scene times or patient outcomes and identified this as an important limitation to the interpretation of their results.

While the evidence that paramedics can consistently perform ETI in the field is mixed, it is important to note that this procedure has not been
shown to improve patient outcomes in rigorously designed trials when compared to other methods of airway management. To date only one such randomized control trial exists, which compared endotracheal intubation to bag-valve mask (BVM) for pediatric trauma patients under the age of 12.\textsuperscript{40} Investigators assigned pediatric patients to treatment group based on the day of the week, with odd days receiving BVM (n = 410) and even days receiving ETI (n = 420). When compared, the authors reported no differences in survival or improvements in neurological outcome for either ETI or BVM, suggesting that less-invasive airway management techniques are as effective as ETI for pediatric patients. No such study has been conducted in adults to date and the issue is not likely to be investigated given the widespread acceptance of ETI as the gold-standard for definitive airway management in severely ill or injured adults in the prehospital setting.

For adults, no similar prospective clinical trial comparing ETI versus another method of ventilation in the prehospital setting has been conducted to date. The best current evidence comes from a retrospective examination of trauma patients from New Orleans reported that patients receiving ETI without RSI protocols had a higher mortality rate when compared to patients receiving only BVM (88.9\% vs. 30.9\%, p<0.001\textsuperscript{41}). However, patients who received ETI had higher injury severity scores (ISS) and a more severe mechanism of injury when compared to patients in the BVM group. Once investigators controlled for these factors, there
was no survival advantage noted between groups. Between groups, patients receiving ETI had a slightly longer scene time when compared to BVM patients (22.0 vs. 20.1 min), but this did not affect controlled mortality differences between groups and appears to be clinically irrelevant. At best, these results show that ETI is as effective as BVM in adults and at worst shows that we should reconsider ETI as the standard of care for airway management in trauma patients.

Other work has shown that ETI may be harmful under certain circumstances. In the San Diego Rapid Sequence Intubation Trial, researchers sought to determine if ETI using a system-wide RSI protocol improved outcomes in patients with severe traumatic head injuries. They compared the experimental group to matched historical controls who received no intubation and found a dramatically higher mortality in those receiving RSI-facilitated ETI for all groups (33% vs. 24.2% mortality, p<0.05). When stratifying for injury severity, this relationship persisted and the treatment groups demonstrated even higher rates of mortality for more severely injured patients. In their discussion, the authors debate the cause of their results and speculate that the increase in mortality from the treatment group could have occurred from intrathoracic hyperinflation from excessive ventilation, transient hypoxemia, bradycardia, or increased scene times for patients receiving RSI-facilitated ETI.
ETI Complications

Potential complications of ETI have also been well documented. These include aspiration and subsequent pulmonary infection, misplaced endotracheal tubes, intubation of the right main stem bronchus, broken teeth, and cardiac arrhythmias\textsuperscript{27, 29, 40, 43, 44}. Multiple attempts are often necessary for eventual procedure completion\textsuperscript{27, 39} and repeated attempts have been linked to periods of oxygen deprivation or physical injury of the airway\textsuperscript{45}. Others have cited further potential problems with prehospital ETI, noting that success rates for completing the procedure are inconsistent or low\textsuperscript{46} and that performance of the procedure on the scene may prolong the time to eventual evaluation and more definitive treatment at a hospital setting\textsuperscript{47, 48}.

Of the potential adverse specific events associated with ETI, misplaced tubes represent the most serious and potentially catastrophic result. A non-tracheal ETI can result in ineffectual respiration or inadvertent gastric distension with air that should instead be directed to the lungs\textsuperscript{49}. In a critically ill or injured patient who truly needs placement of an endotracheal tube for ventilation and oxygenation, failure to complete this procedure virtually ensures a fatal outcome and may render all other treatments and efforts useless.

More recently a prospective examination of 108 consecutive prehospital intubations in Orlando, Katz and Falk reported an alarmingly high 25 percent rate of misplaced ET tubes\textsuperscript{49}. These results are important
because identify a higher rate of this complication in a prospective format, suggesting that this error may be more prevalent than originally thought. The authors also noted that misplaced ET tubes are suspect to under-reporting from potential detection biases in current surveillance methods and that this should be addressed when considering ETI in the field. However, the design of the study failed to provide a method to survey paramedics and determine their frequency of use of confirmation techniques or circumstances surrounding the misplaced tubes, so it is difficult to determine how these results occurred. In their discussion, the authors report many potential reasons for these results and speculate that the problem was not with the actual procedure, but with the local system and the inconsistencies in training and medical oversight. For example, they note that the prehospital system under study was not organized in a uniform system under the supervision of an emergency medicine-trained medical director and that this led to a lack of uniformity in standards and training contributed to the results. They also note that out-of-hospital end-tidal carbon dioxide (ETCO₂) detectors were inconsistently used by all paramedic providers and advised use of such devices by other EMS systems as a potential method to provide a more reliable verification of tube placement.

The conclusion that ETCO₂ detection devices are necessary and may decrease misplaced ET tubes is supported by other work published literature. In a study of an EMS system in Maine with no protocol for use
of ETCO₂ detection methods, researchers reported a similar rate of ET tube misplacement of 12\%⁵⁰. A subsequent follow-up study in the same system studied by Katz and Faulk noted that the rate of misplaced endotracheal tubes fell from 25 percent to 9 percent after the implementation of a new protocol using (ETCO₂) detection devices⁵¹. More recent work has reported similar rates of misplaced tubes using more rigorous protocols to verify ETI placement, noting a total rate of 5.8 percent non-tracheal prehospital intubations⁵². Of those non-tracheal tubes, none occurred in patients treated by paramedics using these new devices⁵¹. Of those complications, no verification device was used in 75 percent of cases, providing more evidence for the importance of these methods to detect proper ET tube placement. While it is clear that these devices can lower the rate of non-tracheal endotracheal tube location, it is probable that these devices can never be 100\% effective and there is no consensus that any acceptable rate of this complication can or should be considered reasonable⁵³.

A Potential Unintended ETI Side Effect: Thoracic Hyperinflation

Recent research has demonstrated that ETI may have an unintended serious effect on hemodynamic status of certain patients and may cause adverse outcomes through a mechanism of thoracic hyperinflation. Once an ET tube is successfully placed, providers generally ventilate the patient using a bag-valve mask (BVM) device with
manual rates of inflation. For patients with low blood pressure or low cardiac output (hemorrhagic shock, cardiac arrest, etc), excessive rates of BVM ventilation could increase intra-thoracic pressure by providing inadequate expiratory intervals and trapping air in the lungs. Here increased pressure can decrease blood return to the heart, leading to low blood pressure and low cardiac output. In a critically ill or injured patient, this can lead to poor outcomes and potential death.

Originally, several investigators described this phenomenon in a variety of settings. Aufderheide and Lurie first noted that prehospital providers often provided excessive rates of ventilation after intubation of cardiac arrest patients, despite adequate training on proper ALS protocols and procedures. In the same study, they applied these findings to porcine models of cardiac arrest and demonstrated that excessive ventilation after ETI decreased survival and coronary perfusion pressure dramatically. In similar porcine models of moderate hemorrhage, Pepe showed that survival decreases with escalating artificial respiratory rates after intubation and that lower ventilatory rates provided sufficient oxygenation and greater hemodynamic stability.

Based on these results, changes have been made in current CPR and resuscitation recommendations. The new American Heart Association (AHA) Guidelines, released in November of 2005, have called for decreased ventilatory rates in all cardiac arrest patients to 8 to 10 breaths per minute. If ETI is performed, the AHA also recommends the
usage of impedance threshold devices (ITD) to increase venous return to
the heart and to decrease excessive intrathoracic pressure associated
with the procedure. One such device, called the ResQPOD®, has been
shown to increase survival to hospital admission by 50 percent when
compared to historical controls receiving standard ETI alone. While
these devices have yet to show improvements in long-term survival when
used in the prehospital setting, they have the potential to improve
outcomes given their theoretical and experimentally demonstrated results
on hemodynamic performance and may provide a method to address
potential confounders that reduce survival in patients who receive ETI.

Challenges of ETI in the Field

Performance of ETI is a complex procedure requiring cognitive and
motor skills that must quickly and effective adjust to the individual patient
characteristics and requirements for successful implementation. It must
be performed rapidly, often under intense pressure from a critical patient.
The actual procedure may also be hindered by many patient factors,
including variable levels of consciousness, protective airway reflexes,
anatomical variations, and the presence of secretions, vomit, blood, or
other substances that can block visualization of the airway. Current
standards emphasize that once ETI is performed, steps must be taken to
ensure proper tube placement, including physical examination to assess
bilateral air entry into the lungs, use of end-tidal CO2 detectors, or placement of esophageal detector devices to avoid the complication of non-tracheal placement. After confirmation of placement, providers must secure the tube and perform continual assessment to verify proper tube position, especially after any movement of the patient.

In addition to the difficulties in performing ETI, the accuracy of completing and replicating the procedure is further complicated by additional factors that may reduce procedural competence. The pre-hospital setting, which by its very nature is often unstable and potentially dangerous, may make ETI difficult and even impossible in certain situations. Paramedics also generally lack access to more advanced equipment or procedures like RSI, which makes the procedure more difficult when compared with intubations performed in the hospital setting. Other factors like paramedic experience and frequency of intubation attempts may also influence ETI proficiency and performance, with evidence that the skill can become extinguishable over time without sufficient practice.

**Paramedic Training and Skill Maintenance of ETI Skills**

Once the decision to include ETI within the scope of practice for paramedic providers is made for an EMS system, the key issue becomes the assurance that the procedure is effectively taught to paramedics. Once initially trained, it is important that adequate opportunities to
maintain these skills through adequate practice and continuing medical education are available as well. Without measures to ensure proper skill training and competence, ETI will never be an effective treatment for the prehospital setting.

The National Highway Traffic Safety Administration (NHTSA) establishes all criteria for initial education of prehospital providers and these standards have been organized into a national curriculum outlining minimal requirements for each levels of training. With regard to ETI, NHTSA requires that all paramedic curriculums ensure at least five successful intubations on live patients as a requirement for graduation. This represents a minimum level of training and individual paramedic educational programs or local systems may require more initial training as a condition of certification and practice. For perspective, anesthesiologists and emergency medicine physicians must perform a minimum of 35 successful ETI's to fulfill respective requirements for certification in their residency training.

Traditionally, multiple educational and training approaches have been implemented to teach ETI. Most learn through a combination of lectures, procedural practice on mannequins, and actual intubation of live patients in controlled settings of an operating room (OR) environment. Stewart studied the issue of intubation education techniques and reported that paramedics could be trained with a variety of combinations of methods including animal labs, mannequin, and operating room methods,
with no differences in success rates for intubation for any one method\textsuperscript{30}. However, the external validity of these results should be viewed with some skepticism because all outcome measures recorded field intubation of cardiac arrest patients, a group that has been proven to be easier to intubate than groups like trauma patients or children. It is also important to note that investigators saw no difference in success rates only after adjusting for operator experience, with unadjusted procedural success rates of 76 percent in manikin-only trained groups and 92 percent in OR-trained groups. Given that paramedic students generally have minimal operator experience, it may be more appropriate to apply these unadjusted rates to these groups and recommend OR training given the superior results from this method.

In a more recent effort randomized trial, Hall et. al compared paramedic ETI training with traditional OR methods on live patients to a manikin-based human simulator method\textsuperscript{66}. They reported no statistically different rates of successful intubation ability between these groups when compared on their primary outcome of successful intubation of live OR patients (87.8% vs. 84.8%, p=0.42). However, it is important to note that no blinding of group evaluation could be conducted and that their primary outcome is only a surrogate marker paramedic ability to perform ETI in the uncontrolled prehospital environment\textsuperscript{67}.

At present, there are no clear scientific answers on the adequate number of endotracheal intubations needed to ensure procedural
competence for paramedic students. In a longitudinal examination of data from 60 different paramedic training programs across the US, they reported a median number of 7 successful ETI procedures per student before graduation\textsuperscript{68}. Based on a target rate of 90% successful procedure completion, they used a multivariable logistic regression model to estimate that these students needed 15 to 25 intubations on average to produce the desired level of competence. This conclusion is worrisome given national guideline recommendations\textsuperscript{64} and the investigators express concerns that paramedic programs will never be able to provide sufficient similar training to their students\textsuperscript{68}.

Once the formal education process is complete, there may be even fewer opportunities for practicing paramedics to perform ETI because it is an infrequent procedure in most prehospital settings. An examination of a large statewide database of prehospital intubations from Pennsylvania found that ALS providers performed a median of 1 intubation per year, with 67% of all providers performing less than 2 prehospital ETI procedures per year. Similar results have been reported in other states, with less than 40% of rural paramedics performing ETI annually and less than 2% performing 5 or more procedures each year\textsuperscript{69}. These reports are worrisome given that research has shown significant correlations between intubation success rates in cardiac arrest patients and the number of ETI procedures attempted per year by paramedics\textsuperscript{52} and that many EMS
systems do not require any specific number of live intubations per year in their CME requirements.

**Intravenous (IV) Line Placements and IV Fluids**

Placement of intravenous (IV) catheters for vascular access by prehospital providers is a widely accepted practice and virtually all EMS protocols allow this procedure for the administration of fluids and certain medications when appropriate. For many patients, this is a critical intervention and represents the only method to deliver many treatments necessary on-scene. In addition their utility for immediate use, many EMS systems allow providers to place IVs without specific treatment goals as part of routine standing-order protocols for care for certain types of patients. These prophylactic IVs are either used later in the field, accessed in the hospital, or never used at all. As with prehospital ETI, the debate revolves around the determination of which procedures are appropriately performed in the field and which should be delayed until the hospital setting.

**IV Placement and Vascular Access**

Paramedics have demonstrated that they can be trained to consistently and accurately place peripheral IV catheters in the prehospital setting. Early work by Slovis reported a 92% and 82% success rate in trauma and medical patients respectively, with no differences in
procedural competence when performed on the scene or en-route to the hospital\textsuperscript{71}. Others have described similar results, with general success rates in excess of 90\%\textsuperscript{72-75} for the procedure.

Complications of prehospital IV access have also been reported. In an retrospective review of two months of data comparing prehospital and emergency department-initiated IV lines, Lawrence and Lauro noted an alarmingly high 34\% infection rate of the prehospital group\textsuperscript{76}. The most common infections included phlebitis and nondescript febrile illness. In a larger and more rigorously designed study, Levine noted a much lower 0.12\% rate of infection of prehospital-initiated IV lines and reported no significant different infection rate between prehospital and in-hospital performed procedures\textsuperscript{77}. Given these results, most EMS systems regard this as a relatively safe procedure and this has lead to more wide-spread acceptance of prophylactic IV placement at the discretion of the ambulance crew.

While prehospital providers have proven that they can accurately and consistently place IV lines, the time needed to perform this intervention is much more controversial. Spaite noted mean intervals of time for IV placement of 1.3 to 2.0 minutes, with at least 94\% of all procedures performed within 4 minutes of initial attempt\textsuperscript{72}. These results are somewhat misleading however because they neglected the time required for procedural set-up and time required to administer the medication, both of which may contribute to the real outcome of concern.
of total time on scene by the treatment team. Others have noted minimal to no delay in transport from the procedure when performed on-scene\textsuperscript{73, 78, 79}.

In contrast, others have reported significant delays in scene time associated with placement of IV lines. In a study of paramedic care for cardiac arrest patients, McSwain estimated that attaining IV access added 12 minutes to scene times in cardiac arrest patients and noted a general association of prolonged scene times and poor prognosis\textsuperscript{80}. Another study by Donovan noted that IV access added 13 minutes to scene time for patients with respiratory arrest, seizures, and cardiac arrest, but did not increase the chances of those patients to receive IV medication in the ED within 10 minutes\textsuperscript{81}. Similar concerns over prolonged scene times have been demonstrated in other systems\textsuperscript{22, 48} and many have suggested that the small volumes of fluid administered may not be beneficial when compared with more rapid transport, especially when transport times are short\textsuperscript{47, 48}.

After procedural completion, IV access allows prehospital providers to administer treatment with fluids or specific medications depending on local system policies and protocols. The discussion of all potential IV treatments available to paramedics is beyond the scope of this discussion. However, it is worth noting that the OPALS study noted no improvement in cardiac arrest survival after implementation of ALS protocols including multiple commonly used ACLS IV medications\textsuperscript{20}. 

\textsuperscript{28}
METHODS

Study Design

We conducted a retrospective cohort analysis to determine the relationship between EMS crew configuration on prehospital scene times, on paramedic performance of specific clinical skills, and on certain outcomes in cardiac arrest patients. Because this study examined a database of existing electronic medical records collected for quality assurance purposes, the University North Carolina School of Medicine Institutional Review Board approved all study components and waived requirements for informed consent.

We chose a retrospective cohort analysis to examine our research question for several reasons. First, very little is known on the effect of EMS crew configuration on paramedic performance or on patient care and there are very few studies on which to base our initial investigational design. We hope to utilize this study to generate hypotheses and to establish the initial background data for the Wake County EMS system and then employ this information to study the issue in more depth in a prospective design. Next, a cohort study design is well-suited to our research question because the realities of research in the prehospital environment often prevent randomization or higher-level experimental designs. Finally, the Wake County EMS quality assurance database is a
high-quality source of patient care information that provides a large amount of data and easily defined cohorts for a prospective review.

**Study Setting and Population**

All data for this study originated from prehospital patient care encounters in Wake County, North Carolina, which includes an estimated population of 719,520 and a geographic area of 832 square miles. Within this area Wake County EMS is the sole provider of prehospital emergency medical care and transport, responding to an average of 65,000 calls and 45,000 hospital transports per year. The system employs over 250 full and part-time prehospital medical providers operating from 33 ambulances, as well as over a dozen administrative positions responsible for system oversight and day-to-day operations. For 2005, the system had an annual budget of over 10 million dollars.

Wake EMS operates a multi-component, single-tiered paramedic response system to provide patient care for all emergency response calls. Within the first component of the system, fire fighters trained as First Responders provide basic life support (BLS) and generally reach the scene before any other emergency responders due to their wide geographic dispersal throughout the county. These providers perform tasks such as initial patient assessment, recording of vital signs, and can perform BLS skills of CPR and electric defibrillation if needed. In the second component, the individual ambulance response unit consists of an
advanced life support (ALS) equipped ambulance staffed by either a dual paramedic team or a team composed of a single paramedic and an additional prehospital provider. This second crew member may include a range of providers with varying levels of training, including an EMT-I, an EMT-Basic, or a First Responder. Thus, all emergency calls are evaluated by ALS crews, but the compositions of these teams differ by their number of paramedic providers. Once on scene, these ALS units are responsible for all decisions regarding patient care and have equal ability to perform all ALS protocols and procedures.

There is no protocol or procedure to send a specific type of ambulance crew to any type of call based on patient criteria or acuity from the EMS dispatch center and the choice of the responding unit is based on ambulance availability and geographic proximity to the location of the emergency call. Within the system, individual paramedics may predominantly work in a two paramedic crew, a single paramedic crew, or both but tend to work in either one configuration or another the majority of the time.

For the purposes of this study, we defined all providers by their certification and rank within the system, which determines their ability to perform certain duties and tasks in the prehospital setting. Categories here include Paramedic, EMT-Intermediate, EMT-Basic, and First Responder. For further clarification, we define “Two Paramedic Crews” (TPC) as ambulance units with two ALS-certified Paramedic providers and
"Single Paramedic Crews" (SPC) as an ambulance unit with a single paramedic paired with any other type of prehospital provider.

The Wake County EMS system operates on a foundation of indirect and direct medical oversight to provide direction and guidance to all prehospital providers in their patient care duties. Indirect medical oversight includes standing-order protocols and patient care policies which provide a "pre-authorized course of care" that may be implemented by providers in the field without direct contact with a physician (Cite book page 306). Direct medical oversight is provided by concurrent communication with a physician, which includes either the Medical Director of Wake EMS or another emergency department-based physician.

In order to ensure that prehospital providers are competent and up-to-date on all protocols and policies, Wake EMS implements a rigorous screening application process upon initial hiring and requires extensive monthly continuing education from all levels of providers. All initial applicants must have national or state licensure for their individual level of certification and must interview with the medical director and administrative staff to ensure competence. After the screening and hiring process has been completed, each provider must complete a period of supervised employment in which they work with a Field Training Officer (FTO) as part of an ambulance crew. During this time, they must become familiar with all patient care protocols, perform a certain number of patient
evaluations and treatments, and may be required complete certain procedures like field or operating-room endotracheal intubation. If the new employee meets all of these requirements, they interview with the medical director in an oral-exam format to ensure protocol mastery. Once this interview is successfully completed, they are deemed fit to practice in the system without direct supervision. This process requires varying amounts of time and is typically completed in 3 to 9 months, but must be completed within one year of initial hire.

All prehospital medical providers employed by Wake County EMS are also required to undergo annual continuing medical education (CME). All ALS providers must attend 18 hours of continuing education under the supervision of the medical director and must go through a yearly scope of practice exam on system policies and protocols. To meet these educational requirements, lectures and online distance education methods are used to cover core topics in prehospital medical care.

**Study Protocol and Data Collection**

Within the Wake County EMS System, all prehospital patient care encounters are documented and recorded in an electronic database for evaluation and quality assurance purposes. Paramedics are responsible for all initial documentation and complete a computerized patient care record on portable computers after each patient encounter. This record is completed regardless if the patient is transported to the hospital or if they
remain on the scene and must be completed before the end of each working shift. For patients evaluated for cardiac arrest, these records are linked to hospital reports, with admission and discharge information automatically included as part of the EMS database. No further hospital admission or discharge information on any other chief complaint is formally included or evaluated by Wake County EMS as part of their quality assurance process. This database contains over 4 years of information and over 300,000 patient care records.

To compare the performance dual paramedic and split paramedic crews, we examined patient care records for four specific types of emergency response calls. These included patients with the primary complaint of respiratory distress, traumatic injury, chest pain, and cardiac arrest, as defined by the emergency response transport codes based on information provided by paramedics about the emergency call. To select higher acuity patients who might require more ALS procedures, we only included those transports that were considered emergent and used lights/sirens for transport to the hospital. Because of the wide-variability of prehospital medical care, we chose these groups to provide a more homogeneous comparison of TPC and SPC groups. Others have noted that interpretation of success rates for certain ALS procedures in the field may be confounded by this patient variability and that certain populations like trauma or pediatric patients may provide inherently more difficult when compared with other groups\textsuperscript{82}. These presentations are also very
common in the prehospital setting and represent situations in which both
ALS and BLS skills have been studied in the past.

We queried the Wake County EMS database for our four chief
complaints from April 1st 2003 to April 1st 2006. For each chief complaint,
we identified the configuration of the responding ALS crew and divided
each into a “dual paramedic crew” (TPC) or a “single paramedic crew”
(SPC) cohort based on the documentation in each patient record. From
there, we extracted information on patient demographics, scene time,
patient contact time, and performance of clinical skills like IV cannulation
and endotracheal intubation for each group. We excluded those patient
encounters that did not provide documentation of the crew configuration,
patients under the age of 18, and any crew configuration that did not
include a paramedic.

**Measurement and Outcomes**

Measurement of each variable and outcome within the study relied
on pre-determined definitions and calculations as follows. We focused on
the elements of on-scene time intervals and completion of specific
procedures for all four clinical scenarios.

We provide the following definitions of times recorded for each of
the following variables. We defined “scene time” as the interval between
the arrival of the ambulance unit and the departure of that unit from the
scene. All recorded times rely on the record of emergency dispatch
system and their official central clock and computerized recording software.

For performance of clinical procedures, we define each as follows. For IV line placement, we defined an "attempt" as any self-reported and documented effort to place an IV line placement and "success" as self-reported completion of the procedure. For endotracheal intubation (ETI), we similarly defined an "attempt" as any self-reported attempt to intubate the patient and "success" as documented completion of placement of the endotracheal tube. From these definitions, we define an "eventual success rate" as dichotomous eventual success divided by the total number of attempts required. For a “first attempt success rate,” we defined a dichotomous success for procedural completion on the first attempt divided by the number of total first attempts for both procedures. We also calculated a “mean attempt per patient” to measure how many trials were required per patient if a procedure was performed, regardless of the eventual outcome. Inclusion in each procedure category was not mutually exclusive and it is possible that a patient could receive an ETI attempt, an IV attempt, or both.

Data Analysis

We abstracted all data into Microsoft Access 2003 (Microsoft Corp., Redmond, WA) and performed all analyses with SPSS version 14.0 (SPSS Inc., Chicago, ILL). For basic demographics, we calculated means for
continuous variables and calculated percent frequencies for categorical variables. To compare groups of continuous variables, we performed unpaired t-tests on all means. For comparisons of categorical data, we used Chi Square testing and Fisher’s exact test when appropriate. Because we have little background information on our research question and because this retrospective design was intended to generate hypotheses and information for future study, we had no initial power calculations for our analysis and analyzed all data that met our inclusion criteria.

Results:

During the 3 year study period we identified 6611 patients who met criteria for our 4 clinical scenarios. Of these, 841 patients did not meet inclusion criteria and were thus removed from all data analysis because they were under the age of 15 or had no record of the ambulance crew configuration, resulting in a final study population of 5770 (Summarized in Figure 1). Table 1 summarizes the number of patients in each clinical scenario stratified by our two paramedic crew (TPC) and single paramedic crew (SPC) and provides basic demographic information on each group.

For the entire study population, were found no significant differences in scene time when we compare calls from TPC versus SPC groups (17.8 vs. 17.6 minutes, p = 0.35). When we stratified our study by clinical scenario, the TPC groups had slightly shorter scene times when compared to SPC groups for trauma and cardiac arrest patients, but these
differences were not statistically significant. For the SPC group, only the respiratory distress group had a lower scene time (Mean difference = 1.6 minutes, 95% CI 0.9 to 2.3 minutes, p<0.001). Results for scene times are summarized in Table 2.

For our trauma group, 2,583 patients met inclusion criteria and all results for intubation and IV placement are summarized in Table 3. Two paramedic crews attempted 56 intubations versus 33 attempted in the single paramedic crew group, but there was no statistically significant difference in number of procedures performed per patient (Mean 1.4 vs. 1.5, p = 0.48). Overall, the TPC group had a greater eventual success rate for completion of the intubation procedure (79% vs. 70 %), but this difference was not statistically significant (p = 0.32). Similarly, the TPC group had a higher rate of success on their first attempt at intubation when compared to the SPC group (61% vs. 55%), but this difference failed to reach statistical significance (p=0.66). For IV placement, the TPC teams attempted more procedures (1567 vs. 1012), but did not attempt more per-patient when compared to SPC teams (mean 1.5 vs. 1.6, p=0.17). Rates of IV placement were similar for both eventual success (93% vs. 92%, p = 0.11) and for success on the first attempt (77% vs. 77%, p = 0.93) in both groups.

For cardiac arrest, 894 patients met inclusion criteria and all results for procedures measured are summarized in Table 4. Comparing TPC and SPC teams, each attempted 582 and 312 intubations respectively and
the groups did not differ in their number of attempts per patient (1.6 vs.
1.6, p = 0.98). Two paramedic crews also had a higher non-significant
rate of eventual intubation success (0.92 vs. 0.89, p = 0.11) and on first-
attempt success (0.65 vs. 0.59, p = 0.11). For placement of IVs, two
paramedic teams attempted 531 procedures and one paramedic teams
attempted 295, with no significant difference in the number of attempts per
patient (1.8 vs. 1.7, p = 0.46). For IV placement, the two types of crews
had similar rates of eventual procedural success (0.89 vs. 0.88, p = 0.87)
as well as success on the first attempt (0.64 vs. 0.61, p = 0.45).

For cardiac emergencies, 1030 patients met inclusion criteria and
all results of procedures performed in these patients are summarized in
Table 5. TPC teams attempted more intubations than SPC Teams (9 vs.
2), but attempted less intubations per patient (1.8 vs. 3, p = 0.60). For
intubations, TPC Teams also had a higher success rate (0.78 vs. 0.50, p =
1.0) and had a higher rate of success on their first attempt when
compared to SPC teams (0.44 vs. 0.00, p = 1.0), but neither of these
differences were statistically significant. For IV placement, the TPC group
attempted 552 procedures compared to 475 attempts in SPC group, but
the average number of attempts per patient was identical. TPC teams did
show a statistically significant higher rate of eventual IV placement (0.91
vs. 0.87, p = 0.03) and a higher rate of success on their first attempt (0.74
vs. 0.68, p = 0.03).
For respiratory distress, 1263 patients met inclusion criteria and Table 6 summarizes all results for this group. For intubations, TPC teams attempted more procedures than SPC teams (74 vs. 30), but no difference in attempts per patient was seen (1.3 vs. 1.4, p = 0.52). SPC teams had more success in eventual intubation (0.83 vs. 0.74, p = 0.32) and in successful completion of intubation on the first attempt (0.67 vs. 0.64, p = 0.76), but neither of these differences in success rates reached statistical significance. For IV Placements, the TPC group attempted more procedures than SPC group (749 vs. 507), but the mean number of attempts (1.5 vs. 1.5, p = 0.52), eventual success rate (0.79 vs. 0.79, p = 0.88), and success rate on the first IV attempt (0.59 vs. 0.58, p = 0.99) was virtually identical for each type of team.

For all patient groups, we pooled all procedural data for similar analysis and results are summarized in Table 7. For intubation, we noted no differences in the number of attempts between groups but did see a non-significant higher rate of success in the TPC group for both eventual success (0.89 vs. 0.86, p = 0.23) and first-attempt success (0.63 vs. 0.59, p = 0.12) in the procedure. For IV placement, both groups attempted the same number of procedures per patient and the TPC crew had a small but statistically significant higher rate of success when compared to the SPC group (0.89 vs. 0.87, p = 0.04). The rate of first attempt IV success was slightly higher in TPC groups (0.71 vs. 0.69, p = 0.24), but this result was not statistically significant.
Discussion

Our data demonstrate that ambulances staffed with two paramedics do not have considerably different scene times but may have slightly higher rates of success on performance of intubation and IV placement when compared to single paramedic crews.

Our findings are in contrast to work by Kelly and Currell, who reported that “All-APS Crews” had statistically significant longer scene times of 1.38 minutes when compared to “Mixed Crews” for all types of critical patients. We saw no such difference in our study population when all patient records were combined and found that our similar group of two paramedic crews had virtually identical scene times when compared to single paramedic crews. However, we did note that two paramedic crews had slightly lower scene times for trauma and cardiac arrest patients when compared to single paramedic crews (0.6 and 0.4 minutes respectively), but that these differences were not statistically significant. We also noted an increase in scene times for two paramedic crews for respiratory distress patients, but it is unclear why these results differ from our other subgroups. Also in contrast to Kelly and Currell, we saw no significant decrease in success for any advanced procedure in the two paramedic crew group and noted a general trend of greater procedural success for the TPC group across all subgroups except for respiratory distress.
In examination of our data of differences in scene times between our ambulance crew configurations, it is important to note that interpretation of our results should take the clinical situation of each scenario into consideration. For example, our 0.6 minute difference in scene time in our trauma groups may or may not be clinically significant for this population given the importance time in critically injured patients. In contrast, our findings for cardiac arrest are unlikely to be clinically important given that differences in scene time in cardiac arrest patients has not been established as an independent risk factor for survival or adverse outcomes. For any EMS system, the clinical significance of scene time should be evaluated on an individual basis and application of our results should be considered in context of local situations and system goals. However, our results do show that the magnitude of scene time differences between our different paramedic crew configurations are relatively small and do not support concerns that two paramedic crews might have prolonged scene times by attempting more procedures on scene.

Our data documenting success rates of intubation are consistent with previously published reports of paramedic performance of this procedure. Similarly, our differences in intubation success by clinical scenario are consistent with other studies showing that intubation is easier in cardiac arrest patients than in non-arrest or trauma
patients who not receive rapid sequence intubation (RSI) or paralytic agents to facilitate the procedure\textsuperscript{36, 39, 82}.

When comparing two paramedic crews to single paramedic crews, it is unclear why the two groups differ in their success rates for performance of ETI and it is debatable if these relatively small differences are clinically significant. Previous work has shown that procedural competence in performance of ETI is higher in paramedics who perform the procedure more often\textsuperscript{82} and it could be argued that the higher number of cases requiring ETI in all TPC clinical scenarios could increase success through a practice effect for this group of paramedics. However, the actual number of procedures performed per-paramedic in the TPC group is impossible to determine from our database and it is likely that certain providers perform the procedure more often relative to others in this group. This is reasonable given that previous studies have demonstrated that the numbers of ETI attempts are not uniform in a given paramedic population and that many paramedics may go years without attempting intubation at all\textsuperscript{69, 85}. Our findings also show that TPC and SPC groups do not differ in their number of intubation attempts per patient and this is consistent with published reports documenting that as many as 30\% of all prehospital intubations require multiple attempts per patient before successful completion\textsuperscript{39}. Our results also do not seem to support the view that one paramedic crews could improve procedural competence by focusing the procedure the hands of fewer providers, thus creating a
potential practice effect that could increase success rates through greater attempts per provider. However, this is a difficult conclusion given the relatively small differences seen between the TPC and SPC groups and the lack of patient information that would allow our analysis to control our procedural outcomes for patients with greater illness or injury severity.

Our results for completion of IV placement are also consistent with previous studies documenting prehospital provider success for this procedure\textsuperscript{71-73}. Despite a statistically significant difference in the overall success rate of the procedure between our TPC and OPC groups (0.89 vs. 0.87, \( p = 0.04 \)), it is unlikely that this difference is clinically significant. This result is expected given that the numbers of IV procedures performed is far in excess to ETI attempts, which would erode any difference in procedural competence from a practice effect between the TPC and OPC groups.

\textbf{Limitations:}

Several limitations of our study deserve mention and consideration. First, we obtained all data retrospectively from a quality assurance database that is not designed as a primary research collection instrument. Our data contains no information on illness or injury severity of specific patients and it was thus impossible to control for these differences. In
selection of our four clinical groups, we chose patients who were transported via ambulance using lights and sirens. For each call, the decision on the type of transport was determined by each paramedic team individually in all cases. It is possible that teams with two paramedics could differ in their level of comfort of treating critical patients when compared with one paramedic teams and that this difference could affect the decision to use lights and sirens in transport. Therefore, it is possible that our cohorts contain records of patients that differ in unmeasured ways that affect our outcomes. In interpretation of this study and limitations in our design, it is also important to note that this effort is primarily designed to generate hypotheses about ambulance crew configuration and the potential effect of paramedic staffing on patient care.

Similarly, our database contains no information on individual paramedic or BLS providers. In our analysis, we have no way to compare groups based on years of experience, number of procedures performed, or any other measure on the provider level that could establish or predict their clinical ability. In addition, all information recorded on patient care procedures represents paramedic self-report data that may be incomplete or subject to certain biases that under-report failure of clinical procedures. In our formation of groups, we also treated all BLS providers equally when compared to paramedics and given the differences in skills of EMT-B, EMT-D, and EMT-I certifications it is possible that our single paramedic crews differ in unmeasured ways. Furthermore, it is possible that the
study of ambulance crews could be confounded by unequal distribution of skills and responsibilities within the TPC group, especially if one partner performs many more procedures or if there is unequal sharing of patient care responsibilities. This type of situation could bias our results or confound any comparison with the SPC groups in which the paramedic must perform all advanced skills.

When applying these results to other EMS systems, it should be noted that this study originated from a single prehospital system in a single county and that our results may represent a cohort of paramedics that are unique in their overall level of training, procedural competence, and experience. Our organization is also a mixed urban/suburban system and results here may not apply to more rural or urban locations. Similar prospective studies should be performed in other EMS systems in other types of geographic settings or on a national level to provide further investigation of the complex issue of paramedic staffing on patient care.

**Conclusions:**

In our study, we found that ambulance teams with two paramedics had similar scene times and slightly improved rates of endotracheal intubation and placement of IV catheters when compared with single paramedic teams. When stratified by four clinical scenarios, two paramedic crews had lower scene times for trauma and cardiac arrest patients but a higher scene times for respiratory distress. We noted no difference in scene times between cardiac emergency patients in either
group. We also found rates of eventual success and first-attempt success of performance of endotracheal intubation and placement of IV catheters had a higher trend in two paramedic crews, but that these results varied in magnitude and statistical significance.

References

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81. Donovan PJ, Cline DM, Whitley TW, Foster C, Outlaw M. Prehospital care by EMTs and EMT-Is in a rural setting:


Figure 1: Patient Selection Flow Diagram. Exclusions (*) include patients below the age of 15, cases with no recorded scene time, and cases with no recorded crew configuration.
<table>
<thead>
<tr>
<th>Clinical Scenario</th>
<th>Two Paramedic Crews</th>
<th>Single Paramedic Crews</th>
<th>Mean Difference (Minutes)</th>
<th>P-value</th>
<th>95% Confidence Interval of Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trauma</td>
<td>1569 36.1</td>
<td>1014 37.4</td>
<td>0.6</td>
<td>0.06</td>
<td>-0.01 to 1.1</td>
</tr>
<tr>
<td>Cardiac Arrest</td>
<td>582 63.5</td>
<td>312 63.9</td>
<td>0.9</td>
<td>0.36</td>
<td>-0.1 to 1.9</td>
</tr>
<tr>
<td>Cardiac Emergency</td>
<td>554 63.3</td>
<td>476 63.8</td>
<td>0.0</td>
<td>0.99</td>
<td>-0.8 to 0.8</td>
</tr>
<tr>
<td>Respiratory Distress</td>
<td>756 68.5</td>
<td>507 68.1</td>
<td>1.5</td>
<td>&lt;0.001</td>
<td>0.8 to 2.2</td>
</tr>
</tbody>
</table>

**NOTE:** This only provides information on calls in which a clinical procedure was performed (i.e. intubation, IV, or both).
Table 3: Comparison of intubation or IV placement in trauma patients who received a procedure by ambulance crew configuration. (* Note: These groups are not mutually exclusive, i.e. a patient could have received an intubation, an IV, or both).

<table>
<thead>
<tr>
<th></th>
<th>Two Paramedic Crews</th>
<th>Single Paramedic Crews</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of Patients</strong></td>
<td>1569</td>
<td>1014</td>
<td></td>
</tr>
<tr>
<td><strong>Intubations</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Attempts</td>
<td>56</td>
<td>33</td>
<td></td>
</tr>
<tr>
<td>Mean Attempts (Per Patient Attempt)</td>
<td>1.4</td>
<td>1.5</td>
<td>0.48</td>
</tr>
<tr>
<td>Range Minimum Maximum</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Eventual Success Rate</td>
<td>0.79</td>
<td>0.70</td>
<td>0.32</td>
</tr>
<tr>
<td>First Attempt Success Rate</td>
<td>0.61</td>
<td>0.55</td>
<td>0.66</td>
</tr>
<tr>
<td><strong>IV Placement</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Attempts</td>
<td>1567</td>
<td>1012</td>
<td></td>
</tr>
<tr>
<td>Mean Attempts (Per Patient)</td>
<td>1.5</td>
<td>1.6</td>
<td>0.17</td>
</tr>
<tr>
<td>Range Minimum Maximum</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Eventual Success Rate</td>
<td>0.93</td>
<td>0.92</td>
<td>0.11</td>
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<tr>
<td>First Attempt Success Rate</td>
<td>0.77</td>
<td>0.77</td>
<td>0.93</td>
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</table>
Table 4: Comparison of intubation and IV placement in cardiac arrest patients who received a procedure by ambulance crew configuration. (* Note: These groups are not mutually exclusive, i.e. a patient could have received an IV, an intubation, or both).

<table>
<thead>
<tr>
<th></th>
<th>Two Paramedic Crews</th>
<th>Single Paramedic Crews</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of Patients</strong></td>
<td>582</td>
<td>312</td>
<td></td>
</tr>
<tr>
<td><strong>Intubations</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Attempts</td>
<td>540</td>
<td>283</td>
<td></td>
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<tr>
<td>Mean Attempts (Per Patient Attempt)</td>
<td>1.6</td>
<td>1.6</td>
<td>0.98</td>
</tr>
<tr>
<td>Range Minimum Maxmum</td>
<td>1</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Eventual Success Rate</td>
<td>0.92</td>
<td>0.89</td>
<td>0.11</td>
</tr>
<tr>
<td>First Attempt Success Rate</td>
<td>0.65</td>
<td>0.59</td>
<td>0.11</td>
</tr>
<tr>
<td><strong>IV Placement</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Total Attempts</td>
<td>531</td>
<td>295</td>
<td></td>
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<tr>
<td>Mean Attempts (Per Patient)</td>
<td>1.8</td>
<td>1.7</td>
<td>0.46</td>
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<tr>
<td>Range Minimum Maxmum</td>
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<td>1</td>
<td>15</td>
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<tr>
<td>Eventual Success Rate</td>
<td>0.89</td>
<td>0.88</td>
<td>0.87</td>
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<tr>
<td>First Attempt Success Rate</td>
<td>0.64</td>
<td>0.61</td>
<td>0.45</td>
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Table 5: Comparison of intubation or IV placement in cardiac emergency patients who received a procedure by ambulance crew configuration. (* Note: These groups are not mutually exclusive, i.e. a patient could have received an IV, an intubation, or both).

<table>
<thead>
<tr>
<th></th>
<th>Two Paramedic Crews</th>
<th>Single Paramedic Crews</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of Patients</strong></td>
<td>554</td>
<td>476</td>
<td></td>
</tr>
<tr>
<td><strong>Intubations</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Attempts</td>
<td>9</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Mean Attempts (Per Patient Attempt)</td>
<td>1.8</td>
<td>3</td>
<td>0.60</td>
</tr>
<tr>
<td>Range Minimum Maximum</td>
<td>1, 3</td>
<td>2, 4</td>
<td></td>
</tr>
<tr>
<td>Eventual Success Rate</td>
<td>0.78</td>
<td>0.50</td>
<td>1.0</td>
</tr>
<tr>
<td>First Attempt Success Rate</td>
<td>0.44</td>
<td>0.00</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>IV Placement</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Attempts</td>
<td>552</td>
<td>475</td>
<td></td>
</tr>
<tr>
<td>Mean Attempts (Per Patient Attempt)</td>
<td>1.5</td>
<td>1.5</td>
<td>0.08</td>
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<tr>
<td>Median Attempts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range Minimum Maximum</td>
<td>1, 6</td>
<td>1, 7</td>
<td></td>
</tr>
<tr>
<td>Eventual Success Rate</td>
<td>0.91</td>
<td>0.87</td>
<td>0.03</td>
</tr>
<tr>
<td>First Attempt Success Rate</td>
<td>0.74</td>
<td>0.68</td>
<td>0.03</td>
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Table 6: Comparison of intubation and IV placement in respiratory distress patients who received a procedure by ambulance crew configuration. (* Note: These groups are not mutually exclusive, i.e. a patient could have received an IV, an intubation, or both).

<table>
<thead>
<tr>
<th></th>
<th>Two Paramedic Crews</th>
<th>Single Paramedic Crews</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of Patients</strong></td>
<td>756</td>
<td>507</td>
<td></td>
</tr>
<tr>
<td><strong>Intubations</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Total Attempts</td>
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<td>30</td>
<td></td>
</tr>
<tr>
<td>Mean Attempts (Per Patient)</td>
<td>1.3</td>
<td>1.4</td>
<td>0.52</td>
</tr>
<tr>
<td>Range</td>
<td>1</td>
<td>1</td>
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</tr>
<tr>
<td>Minimum</td>
<td>4</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Maximum</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eventual Success Rate</td>
<td>0.74</td>
<td>0.83</td>
<td>0.32</td>
</tr>
<tr>
<td>First Attempt Success Rate</td>
<td>0.64</td>
<td>0.67</td>
<td>0.76</td>
</tr>
<tr>
<td><strong>IV Placement</strong></td>
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</tr>
<tr>
<td>Total Attempts</td>
<td>749</td>
<td>507</td>
<td></td>
</tr>
<tr>
<td>Mean Attempts (Per Patient)</td>
<td>1.5</td>
<td>1.5</td>
<td>0.52</td>
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<tr>
<td>Range</td>
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</tr>
<tr>
<td>Minimum</td>
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<td>5</td>
<td></td>
</tr>
<tr>
<td>Maximum</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eventual Success Rate</td>
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<td>0.79</td>
<td>0.88</td>
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<tr>
<td>First Attempt Success Rate</td>
<td>0.59</td>
<td>0.58</td>
<td>0.99</td>
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</tbody>
</table>
Table 7: Comparison of intubation and IV placement in all patients who received a procedure by ambulance crew configuration. (* Note: These groups are not mutually exclusive, i.e. a patient could have received an IV, an intubation, or both).

<table>
<thead>
<tr>
<th></th>
<th>Two Paramedic Crews</th>
<th>Single Paramedic Crews</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of Patients</strong></td>
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<td>2309</td>
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<tr>
<td><strong>Intubations</strong></td>
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<tr>
<td>Total Attempts</td>
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<td>348</td>
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<tr>
<td>Mean Attempts (Per Patient)</td>
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<td>0.90</td>
</tr>
<tr>
<td>Range</td>
<td>Minimum</td>
<td>Maximum</td>
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</tr>
<tr>
<td></td>
<td>1</td>
<td>9</td>
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<tr>
<td>Eventual Success Rate</td>
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<td>0.86</td>
<td>0.23</td>
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<tr>
<td>First Attempt Success Rate</td>
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<td>0.59</td>
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<tr>
<td><strong>IV Placement</strong></td>
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<tr>
<td>Total Attempts</td>
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<td>2289</td>
<td>0.65</td>
</tr>
<tr>
<td>Mean Attempts (Per Patient)</td>
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<td>1.5</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>Minimum</td>
<td>Maximum</td>
<td></td>
</tr>
<tr>
<td></td>
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<td>10</td>
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</tr>
<tr>
<td>Eventual Success Rate</td>
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<td>0.87</td>
<td>0.04</td>
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<tr>
<td>First Attempt Success Rate</td>
<td>0.71</td>
<td>0.69</td>
<td>0.24</td>
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</tbody>
</table>