Time Saved with the Use of Emergency Warning Lights and Siren While Responding to Requests for Emergency Medical Aid in a Rural Environment

Jeffrey Ho, MD, Mark Lindquist, MD

ABSTRACT

Objective. To determine whether the use of warning lights and siren saves a significant amount of time for ambulances responding to requests for emergency medical aid in a rural emergency medical services (EMS) setting. **Methods.** A prospective design was used to determine run times for ambulances responding to calls with lights and siren (code 3) and for a similarly equipped "chase" ambulance traveling to the same destination via the same route without lights and siren, while obeying all traffic laws (code 2) within a rural setting. Data were collected for run time intervals, distance traveled, visibility, road surface conditions, time of day, and day of the week. Descriptive statistics, a paired Student's t-test, and analysis of variance were used to test for significant differences between code 2 and code 3 operations, as well as the other variables listed above. **Results.** Sixty-seven runs were timed during a 21-month period. The average code 3 response interval was 8.51 minutes. The average code 2 response interval was 12.14 minutes. The 3.63 minutes saved on average represents significant time savings of 30.9% ($p < 0.01$). Shorter runs had higher time savings per mile than the longer runs. Run distance was the only variable that was statistically significant in affecting time saved during a code 3 response. **Conclusion.** Code 3 operation by EMS personnel in a rural EMS setting saved significant time over code 2 operation when traveling to a call. **Key words:** lights and siren; ambulances; rural; emergency medical services; time savings.

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The use of warning lights, siren, and emergency driving techniques for emergency medical services (EMS) vehicles has become a controversial topic. Traditionally, it has been assumed that time is saved by responding to requests for medical aid with warning lights, siren, and emergency driving techniques (code 3).

However, because many EMS responses are for nonemergencies, some have argued in favor of responding to requests for medical aid without warning lights, siren, and emergency driving techniques (code 2). This argument is supported by literature suggesting that code 3 operation is ineffective and dangerous while offering minimal time savings.[1–6]

Current literature shows that code 3 operation of emergency vehicles increases the risk of injury to EMS personnel and the general public.[1,3,7–9] One prospective study comparing code 2 and code 3 responses in an urban environment (city population of 378,000) showed a mean time savings of 3.02 minutes.[10] Another study by Brown et al. in a less-densely-populated city environment (city population of about 170,000) showed an average time savings of 1 minute, 46 seconds.[11] However, after conducting a MEDLINE literature search, we failed to identify a prospective study comparing code 2 and code 3 response times in a rural environment. In this study, we evaluated the time saved by code 3 response when compared with code 2 response in a rural setting.

Materials and Methods

We prospectively evaluated a convenience sample of Code 3 ambulance runs dispatched by a county 911 public service agency center within a predominantly rural county (Becker County, Minnesota). The advanced life support ambulance service responded to 1,657 requests for medical aid from one station located in the city of Detroit Lakes, Minnesota, in 1997. The station is in the south central part of a primary service area covering 1,197 square miles, and some responses require a 40-mile one-way drive. The city of Detroit Lakes has an estimated population of 7,295. The total county population is 28,830, with 29% of people less than 18 years of age, 45% 18–54 years of age, and 26% more than 55 years of age.[12,13] Sixty-four percent (1,060) of the calls in 1997 were in the Detroit Lakes city limits, and 36% (597) were outside the city. Data were collected from a privately managed, hospital-owned advanced life support ambulance service during a prescribed 21-month period (January 1997 to September 1998). The first author's institutional review board and the ambulance service ownership approved this project prior to its initiation.

A standard type III ambulance with state-approved code 3 lights and siren responded to emergency calls utilizing the equipment and emergency driving techniques. The "chase" vehicle was a standard type II

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Address correspondence and reprint requests to: Jeffrey Ho, MD, Department of Emergency Medicine, Hennepin County Medical Center, 701 Park Avenue South, Minneapolis, MN 55415. e-mail: <ho911doc@qwest.net>.

ambulance with identical equipment and markings, driven in accordance with all traffic laws and signs. The ambulance was staffed with one paramedic and one emergency medical technician (EMT), and the chase vehicle was staffed by one of the investigators, along with a paramedic or EMT. The ambulance crew and the investigator were all equipped with identical digital stopwatches and two-way radio transceivers for communication. The investigator carried a data collection sheet with predetermined data points to be collected during the run.

Calls were selected for chase based on the availability of investigators, resulting in a convenience sample. Data collection was done during various hours of the day and night, and on various days of the week. The study period ran for 21 months to include data collected under a variety of seasonal driving conditions in the extreme climate of northern Minnesota. Data were collected on calls within the city limits of the base station, as well as throughout the rural parts of the county included in the primary service area. All EMS personnel were instructed on the use of the stopwatches, which were placed in each code 3 ambulance and the chase vehicle. The crews were instructed to respond to all calls in a usual code 3 fashion, using lights, siren, and emergency driving techniques. The non-driving crew person was responsible for timing the call.

All calls were timed after the ambulance was dispatched from a stationary location. The crews were instructed to start the stopwatch when the ambulance transmission was placed into "drive." They stopped timing the event when the ambulance arrived at the scene, and the transmission was placed into "park." The investigator in the chase vehicle started the timing procedure from the same stationary location, and followed the same timing parameters.

The ambulance crews in this rural service are not required to remain at the station during their shift and thus respond to calls from an "out-of-house" location, picking up the ambulance at the base station and going to the scene. The responding crew and the investigator discussed the exact route to be taken for the call at the station or on the two-way radio transceiver while en route. The ambulance responded code 3 and the chase vehicle responded code 2 from the same location. Any deviations from the predetermined route were communicated to the investigator by radio, and the chase vehicle followed the identical route, complying with all posted signs, speed limits, and traffic signals. If the code 3 ambulance arrived at the destination of the call, administered patient care, and left the scene for the hospital before the chase vehicle arrived, a crew person placed a yellow traffic cone at the sight where the code 3 ambulance had placed the transmission into "park." The chase vehicle then was instructed to use the cone location as the stopping point for timing the event.

The information recorded included code 3 time intervals, code 2 time intervals, distance traveled, visibility, road condition, day of week, time of day, and unusual occurrences, such as an ambulance or chase vehicle's being delayed by a train. Data were entered into a Lotus format database and analyzed by an outside statistician utilizing SYSTAT software (Systat, Inc., Evanston, IL). (There were no pre-determined exclusion criteria; however, the statistician did exclude five records because of outlying factors such as train crossing delays, extremely heavy traffic, or unusually long distance.) The primary variable of interest was the percent of time saved by responding code 3 rather than code 2. Other variables (distance traveled, visibility, road surface conditions, time of day, and day of the week) were evaluated individually and in combinations to determine whether they explained statistically significant time savings. In addition to descriptive statistics, a paired Student's t-test and analysis of variance (ANOVA) were used when appropriate for comparison between the code 3 and code 2 data points with a significance set at $p < 0.05$. When ANOVA was used, the logs of run times and mileage were used as covariates and analyzed against each variable.

RESULTS

A total of 72 runs were timed during the prescribed 21-consecutive-month data collection period. Five runs were excluded from analysis, three because of train crossing delays, one due to exceptionally heavy traffic, and one as an outlier in distance (47 miles). These five runs were excluded by the statistician because they overly influenced the statistical data and were not representative of typical runs in this service area. Data were collected in rural northwestern Minnesota under a variety of extreme weather and driving conditions. Road conditions included dry pavement on 45 runs, wet pavement on 14 runs, and icy/snowy or slippery roads on 13 runs. Weather conditions included clear visibility on 58 runs, decreased visibility due to rain on nine runs, and blowing snow or fog with decreased visibility on five runs. Run distance ranged from 0.30 miles to 26.8 miles, with an average value of 7.90 miles (SD ± 7.34 miles). During code 2 operation, the time range recorded was 1.25 minutes to 38.33 minutes. The mean code 2 response time was 12.14 minutes (SD ± 9.28 minutes). The 95% confidence interval was between 9.86 minutes and 14.40 minutes. During code 3 operation, the range of time recorded was 0.77 minutes to 26.18 minutes. The mean code 3 response time was 8.51 minutes (SD ± 6.64 minutes). The 95% confidence interval was between 6.89 minutes and 10.13 minutes. The mean speed of the chase vehicle during code 2 operation was 32.50 miles per hour, with a 95% confidence interval between 29.45 miles per hour and 35.54 miles per hour. The mean speed of the code 3 ambulance was 46.85 miles per hour, with a 95% confidence interval between 42.55 miles per hour and 51.15 miles per hour. The average speed of the chase vehicles was 39.04 miles per hour. The average speed of the ambulances was 55.72 miles per hour. Speed was derived by dividing the total distance by the total time.

The total time saved during code 3 operation ranged from 0.12 minutes to 13.77 minutes. The average time saved by operating code 3 versus code 2 was 3.63 minutes (SD ± 2.97 minutes). This represents a mean time savings of 30.9%, with a 95% confidence interval between 28.3% and 33.4%. For the 67 runs, the time saved per mile of run under code 3 was 0.70 minutes (SD ± 0.53 minutes), when the shorter runs are weighted equally with the longer runs. The time saved by code 3 operation was significant when compared with code 2 ($p < 0.01$).

Run distance was the only variable that was statistically significant in affecting time saved during a code 3 response (Fig. 1). Statistical analysis of lighting conditions, prevailing visibility, road surface conditions, and city versus rural runs showed no significant impact on the difference in run times.

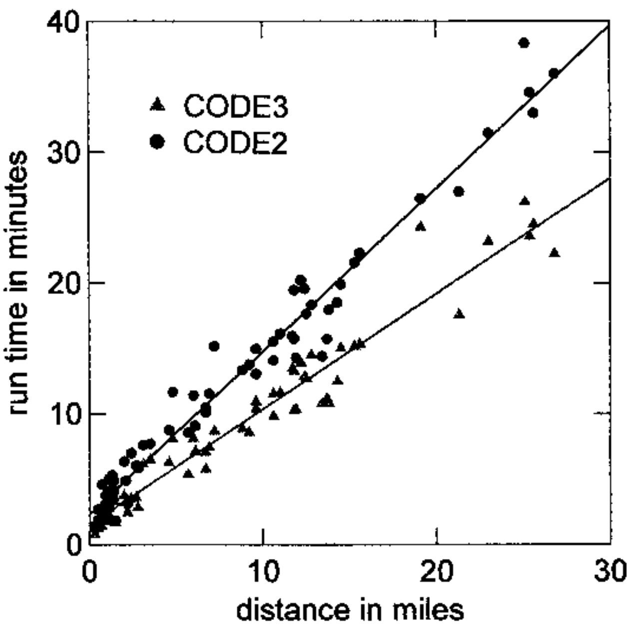

FIGURE 1. Code 2 and code 3 run times by distance.

DISCUSSION

To date, few published studies have prospectively measured the time saved by responding to ambulance calls code 3 versus code 2. In a study conducted in metropolitan Hennepin County, Minnesota, Ho and Casey reported a 3.02-minute time savings, representing a 38.5% decrease in response time on runs ranging from 0.20 miles to 8.0 miles ($p < 0.01$).[10] Other sources, including a position paper from the National Association of EMS Physicians, indicate that responding code 3 is a privilege granted to emergency vehicles, but one that compromises public and crew safety.[14,15] Neither source addresses the issue of whether a code 3 response saves time.

There has been some information published on warning lights and siren usage during ambulance transport back to the hospital. Hunt et al. found an average of 43.5 seconds saved with the use of lights and siren and concluded that this small time savings did not warrant their use during ambulance transport, except in rare circumstances.[5] O'Brien et al. found a mean of 3 minutes and 50 seconds saved with the use of lights and siren during ambulance transport and concluded that their use significantly shortens transport time, but was generally not clinically significant.[16] We would concur with these findings; however, we would caution others that saving time during the ambulance transport interval is very different from saving time during the ambulance response interval.

It is our belief that the time interval between dispatch and arrival at the scene is the most crucial period in the prehospital provider intervention. This is the time that elapses before rescue personnel are able to perform potentially lifesaving interventions and is the most critical in determining the effectiveness of these interventions. In the case of ventricular fibrillation, defibrillation success declines by 10% per minute for every minute of delay to the first defibrillation attempt.[17–19] We believe that a reduction of this time interval could have a clinically significant impact on the medical outcome of some critically ill patients.

There are numerous differences in traffic, road surface conditions, hazards, and even weather between rural and urban environments. In addition, distances to the destinations of ambulance requests tend to be longer in the rural setting. Because of these and other differences, we prospectively evaluated the time savings of code 3 operation during this critical time interval.

The low *n* and short sampling period of this study are limitations. While the ambulance runs chased for the study were randomly selected, certain factors influenced the choices. The primary factor was the availability of a crew person to operate the code 2 chase vehicle. Because the ambulance service participating in the study normally staffs only two ambulances per shift, during periods of higher call volume when additional crews were called in, chase vehicle operators were not available. The study community is a popular tourist destination, and high-call-volume periods tend to coincide with periods of higher traffic in the city and parts of the county. Thus, these higher-traffic periods were probably undersampled. The low *n* and relatively short study period may have artificially reduced the overall effect of traffic on the study findings.

Crew members were encouraged to chase ambulance calls at various times of the day and night. Because the ambulance service is staffed by out-of-house crew members, chasing a call at night generally meant the code 2 operator had to get out of bed and respond to the station. An early analysis of time of day for studied runs showed a preponderance of day and evening runs, so crews were asked to respond to more night calls for a period of time. This selection process was not truly random, but rather resulted in a convenience sample.

The "wake effect," heavier traffic experienced by a chase vehicle resulting from cars pulling over to allow the code 3 vehicle to pass through, has been well described in the literature and has been identified as a contributing factor in emergency vehicle collisions.[1] This effect was not felt to be a limitation in this study. Because both the code 3 crew and the code 2 chase operator responded to the ambulance headquarters from home or elsewhere, only rarely did both vehicles leave the garage at the same time. Though the vehicles followed the same route, most often the chase vehicle was several minutes behind the code 3 ambulance, and therefore the "wake effect" did not contribute to differences in times.

Another potential limitation to this study is the possibility that the operators of both the code 3 and code 2 vehicles displayed enhanced driving performance as a result of being observed, the "Hawthorne effect." The crew members and the chase vehicle operators were aware of the study and its purpose. It is possible that the code 3 driver may have driven with more intensity, while the code 2 driver may have actually driven more slowly than would be the normal case, (i.e., 55 miles per hour instead of the customary 2 to 4 miles per hour over the posted limit, as most other non-emergency traffic does). However, for the purposes of future studies, a "gold standard" of compliance with all traffic laws was necessary, even though such compliance is certainly not the standard for civilian traffic. All employees of the ambulance service drove the code 3 vehicles, and the code 2 operators were rotated in order to sample numerous driving styles.

Last, we did not look at the issue of when it is necessary to save time during ambulance responses to requests for medical aid. Several literature reports identify the inappropriate and unnecessary use of code 3 driving, and very few address how or when to use it.[2,4,15] We advocate further study in this area.

CONCLUSION

Code 3 operation in this rural environment resulted in a mean time savings of 30.9% of the response interval when compared with code 2 response. The time saved during code 3 operation was significantly altered only by the distance of the run. Larger prospective studies performed in various types and sizes of systems are needed to identify which patients are benefited by significant time savings.

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