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Professional firefighter and trained volunteer first responding units in emergency medical service

Joonas I Tamminen[1], Sanna E Hoppu[2], Antti JJ Kämäräinen[2]

1 Medical School, University of Tampere, Tampere, Finland

2 Emergency Medical Service, Tampere University Hospital, Tampere, Finland

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Corresponding author

J Tamminen, Medical School, Tampere University Hospital, PO Box 2000, FI-33520 Tampere, Finland; Tel. +358 50 350 5057; Email: tamminen.joonas.i@student.uta.fi

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Abbreviations

ALS=advanced life support; BLS=basic life support; CPR=cardiopulmonary resuscitation; EMS=emergency medical service; EMT=emergency medical technician; FHQ=first hour quintet (cardiac arrest, severe respiratory failure, chest pain, severe trauma and stroke); FRU=first responding unit; ROSC=return of spontaneous circulation.

Keywords

Emergency first responders; Emergency medical services; Resuscitation; Firefighters; Volunteers.

Abstract

Background: Although widely used, there is a lack of published data on the performance of prehospital first responding units.

Methods: In this retrospective, descriptive study, the general performance of 44 first responding units in Pirkanmaa County, Finland, were examined. A subgroup analysis compared the first-responding units made up of professional firefighters and laypeople.

Results: First responding units were dispatched to patients during 1,622 missions between 1 January 2013 and 31 December 2013. The median time to reach the scene was 9 minutes in any mission. In presumed cardiac arrest missions, a first responding unit reached the patient within a median time period of 4 minutes before the arrival of the ambulance. Overall, first responders evaluated 1,015 patients and provided treatment or assisted ambulance personnel in 793 cases. The most common treatment modalities were assistance, such as carrying (22%) and the administration of an oxygen supplement (19%). There were 83 resuscitation attempts during the time period. In 42 of these, first responding units initiated basic life support prior to the arrival of ambulance personnel. Return of spontaneous circulation was achieved in 20% of cases. The subgroup analysis showed no clinically significant differences between the professional and volunteer units' general performances.

Conclusion: First responding units provided initial treatment or assistance to ambulance personnel in approximately half of the missions. No clinically significant difference between the professional and volunteer units' performances was observed.

Introduction

First-responding units (FRUs) are used in many countries as a means of bringing trained help to the victims of prehospital emergencies before ambulances. There are variations on the concept of FRU organization ranging from trained volunteer laypersons to professional firefighters and emergency medical technicians (EMTs) who are dispatched as one tier of emergency response.[1–7]

In some centres, the primary goal of FRUs is to reach cardiac arrest patients within the first minutes of the onset of arrest[4] but FRUs also respond to all other types of emergencies. Generally, FRU personnel perform initial, potentially lifesaving procedures prior to the arrival of the first ambulance. These procedures include, but are not limited to, cardiopulmonary resuscitation (CPR) with or without defibrillation; the opening of the airway with or without the use of simple airway methods, such as an oropharyngeal airway or a supraglottic device; and the control of external haemorrhage.[7]

To our knowledge, there are no previous reports on the general performance of FRUs. This study aims to evaluate the types of missions FRUs complete and the procedures performed prior to ambulance arrival, as well as whether these procedures have any effects on the clinical state of the patient. Given that within the study area FRUs are staffed with both professional firefighters, EMTs, and trained volunteers depending on a given FRU's location, it was possible to compare the performance levels of FRUs in terms of personnel composition.

Methods

The county of Pirkanmaa, Finland, (population circa 500,000) is covered by an emergency medical service (EMS) system coordinated by the Pirkanmaa Health District and consisting of 38 advanced life support (ALS) level ambulances operated by both the Pirkanmaa Fire Services and several privately owned companies. In addition to the ALS-level ambulances, which are mainly used for immediate response, there is one extended ALS-level field commander unit, one physician-staffed helicopter emergency medical service unit and 44 FRUs. The FRUs are coordinated and trained by Pirkanmaa Fire Services. Fourteen of the FRUs operate from regional rescue stations and are staffed with professional firefighters, some of which work also as EMTs on the basic life support (BLS) level. These units respond to FRU dispatches within 90 seconds of the alarm. Twenty-seven of the FRUs are staffed with trained laypersons responding from home or work on a volunteer basis. By contract, these units respond to an emergency within 5 minutes of the associated dispatch. Three layperson-staffed units are available for immediate response during daytime, and during the night, these units will respond within 5 minutes of a dispatch. Approximately 400 civilians participate as first responders in the EMS system and they are allowed to use lights and sirens. All FRUs respond to fire and rescue dispatches, which are categorized as their primary missions in the case of simultaneous dispatches to both a rescue mission and a first-response mission.

The principal means an FRU uses to help a victim of a prehospital emergency include the provision of CPR and automated external defibrillator (AED)-based early defibrillation, opening the airway using a supraglottic device or an oropharyngeal airway, supporting breathing with bag-mask ventilation and/or oxygen administration, wound dressing and the control of external haemorrhage, and the administration of rectal diazepam, subcutaneous glucagon, oral nitroglycerin or acetylsalicylic acid depending on the symptoms. There are several programs available for the initial FRU training of volunteer laypersons, mostly comprised of a BLS course and an additional 30–40 hour FRU course. The basic training of a professional firefighter is 1.5 years in duration,

approximately one-third of which consists of emergency care. This training is provided via identical curricula at two colleges in Finland.

During the study protocol, an FRU was dispatched to an emergency by the Central Dispatch Centre when it was estimated to reach the patient 5 minutes prior to an ambulance in A-level emergencies (the most urgent, including sudden severe unconsciousness or presumed cardiac arrest) or 15 minutes prior to an ambulance in B-level emergencies (urgent mission, potential need for life support measures). In cases of witnessed cardiac arrest, high-energy fall trauma or presumed ischemic stroke, the FRU was always dispatched, regardless of the expected time advantage over ambulance units. In cases of road traffic accidents, the units are dispatched per rescue service protocol and do not perform as FRUs for the EMS, thus excluding trauma cases due to motor vehicle accidents and fires from the study.

Of each mission, the FRU personnel filled out specific documentation. Based on this documentation, all FRU missions between 1 January 2013 and 31 December 2013 were analysed. The mission characteristics were analysed, focusing on the treatment provided by the FRUs and whether a clinical impact could be observed based on this treatment.

The primary endpoint was an improved or normalised vital function. A vital function was considered abnormal if systolic blood pressure < 100 mmHg, heart rate > 150 or < 40 beats per minute, respiration rate > 30 or < 10 breaths per minute, oxygen saturation ≤ 90%, Glasgow Coma Scale ≤ 13 or an impaired level of consciousness on the AVPU scale, hypoglycaemia (< 4 mmol/l) or shortness of breath was recorded in the documentation. In addition, the primary endpoint also included the relief of pain. The data were further stratified into professionally and layperson-staffed unit groups to compare their performances, specifically focusing on the five symptoms termed the ‘first-hour quintet’ (FHQ; cardiac arrest, severe respiratory failure, chest pain, severe trauma and stroke).[8]

Author JT manually transferred the data from the paper documentation to Microsoft Windows Excel. SPSS software version 23 (SPSS Inc, Chicago, IL, USA) was used to perform the statistical calculations. Continuous variables were reported as medians and their respective interquartile ranges and categorical variables were reported as frequencies and proportions. The comparison between the groups was performed using a Mann-Whitney U-test for the continuous, nonparametric data and a two-tailed Fisher's exact test for the categorical data. No systematic pattern regarding unreported patient and mission characteristics was observed, and no imputation method was applied to address missing data. Because the study was a retrospective chart review, no power calculation was performed, and the need for patient consent was waived. The study protocol was approved by the institutional review board of the Pirkanmaa Health District (R14148, 4.11.2014).

Results

During the 12-month study period, FRUs were dispatched on a total of 1,894 medical first-response missions, yielding an incidence of 379 FRU missions per 100,000 citizens annually. Of these, the FRU mission was cancelled en route in 272 cases, and thus, FRUs attended to patients during 1,622 (86%) missions (324/100,000/year). The study population is shown in Figure 1.

Patient and mission characteristics and time intervals are presented in Table 1 and Table 2, respectively. The median response time from dispatch to scene was 9 minutes, and an FRU was the first unit on scene in 878 (54%) missions. An individual, professional FRU attended to a median of 44 patients per year (range 20 to 90), and a volunteer-staffed FRU attended to a median of 27 patients per year (range 2 to 66; p=0.003).

Table 3 summarises the treatment characteristics and treatment response. Overall, the FRUs evaluated 1,015 out of the 1,622 encountered patients and provided treatment or assisted ambulance personnel during 793 (49%) missions. CPR was attempted in 83 missions, and an FRU was the first to initiate CPR in 42 cases, which occurred a median of 4 minutes prior to the arrival of the ambulance (range 1 to 18 minutes). Consequently, the return of spontaneous circulation (ROSC) was achieved in 17 (20%) of the missions during which CPR was performed.

Oxygen supplementation was administered to 309 patients, whose shortness of breath was improved in 126 cases (41%). Medication was provided to 64 patients, which resulted in the relief of chest pain in 16 of these 64 patients (25%), the correction of hypoglycaemia in three patients (5%), and the cessation of convulsions in one patient (2%). The FRU assisted ambulance personnel during 351 missions, notably by carrying the patient to the ambulance. No clinical evaluation or treatment was recorded in 607 cases (37%) during which a patient was encountered.

The performance of the professional- and trained volunteer layperson-staffed units during FHQ missions is shown in Table 4. Statistically significant differences were observed in attempted

resuscitation rates (professional 46 attempts per 79 presumed cardiac arrests [58%] vs layperson 37 attempts per 43 presumed cardiac arrests [86%]; p=0.002) and oxygen administration rates during ischemic stroke and chest pain missions (stroke: professional 9 per 236 cases [4%] vs layperson 26 per 181 cases [14%], p<0.001; chest pain: professional 16 per 78 cases [21%] vs layperson 77 per 159 cases [48%], p<0.001). Respiratory state was reported to improve more often during chest pain missions treated by laypersons as compared to professionals (4 vs 24 cases; p=0.031).

Discussion

In this study, the general performance of 44 first-responding units in the county of Pirkanmaa, Finland, was evaluated during a 1-year period. As a part of the evaluation, the performance of fourteen professional fireman- or EMT-staffed FRUs and thirty layperson-staffed FRUs were compared in FHQ missions. To our knowledge, there are no extensive reports concerning the general performance or clinical impact of first-responding units. Additionally, no previous study has compared the performance of volunteer layperson- and professionally staffed first-responding units.

The mainstay of a first-responding unit is that it truly is the first responder or otherwise a rapid responder, especially in time-critical emergencies such as cardiac arrest. In our data, the median time needed for an FRU to reach the scene after dispatch was 9 minutes. Compared with this study, the existing literature has described shorter response intervals ranging from 3.5 to 8 minutes, most importantly in the time-critical context of out-of-hospital cardiac arrests.[1,4–6] According to our data, this was achieved more often by professional FRUs, with the specific response times in cases of cardiac arrest being 6 and 9 minutes for the professional and layperson units, respectively. A theoretical model describing the performance of EMS in Stockholm suggests that the shortest achievable interval from time of incidence to defibrillation is 6.5 minutes if the driving time to the scene is one minute.[9]

In cardiac arrest, every minute CPR and defibrillation are delayed increases mortality, and thus, every minute saved by the use of an FRU is important.[10,11] However, in this study, the FRU was the true first responder initiating CPR in only 42 cases (51%), and ROSC was achieved in 17 of the 83 cardiac arrests cases (20%) in which CPR was attempted. A previous study of firefighter first responders showed that an FRU was first on the scene in 41% of 1,961 out-of-hospital cardiac arrest missions in Stockholm, Sweden.[5] The same study reported that FRUs and EMS achieved ROSC in

29% of missions. Furthermore, in a Danish study, firefighter FRUs achieved ROSC in 7 of 29 cases (24%) when an AED was attached.[1]

Among presumed cardiac arrest missions, volunteer FRUs were more likely to be involved in CPR attempts as compared to professional FRUs. This may reflect the capability of EMT-staffed professional FRUs to critically evaluate the potential futility of a resuscitation attempt and also their stronger adherence to pre-existing guidelines when resuscitation is not attempted. Lay rescuers may also initiate CRP more frequently when no legal consequence is followed.[12] Furthermore, resuscitation attempts may result in psychological stress, especially to non-professional rescuers.[13] Both professional and volunteer first responders were able to participate in debriefing sessions during the study period.

Regarding the form and the clinical impact of FRU-provided treatment other than resuscitation and oxygen administration, medicinal or procedural treatment by FRUs was uncommon, occurring in less than 5% of attended cases. Oxygen supplementation appears to be the most common and effective modality according to our data. Oxygen was supplied to 309 patients, and relief of shortness of breath was reported in 41% of these cases. In cases of presumed ischemic stroke and chest pain, oxygen was administrated by layperson FRUs more often than by professionals although the units had no different treatment protocols in this regard.

The potentially toxic effects of oxygen in myocardial ischemia have been under strict evaluation during the past years, and currently, the routine administration of oxygen is not recommended unless signs of hypoxia, dyspnoea or heart failure are present.[14,15] Therefore, the more liberal administration of oxygen by laypersons and the indications for oxygen use in this study warrant further evaluation and clinical guidance.

Based on these results, the background of a given FRU does not affect its performance to a significant degree. Indeed, the initial treatment of an emergency patient must focus on the priorities

of providing basic life support measures. Thus, the provision of early FRU care by trained laypersons seems to be sufficient.

This study has several inherent limitations because it is a retrospective chart review. First, the exact interval between patient evaluation, physiological measurements and treatment responses could not be determined. Second, the outcome measures may have been affected by EMS. The FRUs are advised to describe only the assessment and treatment provided by the FRU in their documentation, whereas for the EMS units, there is a separate form of documentation. In cases of the simultaneous arrival of the FRU and the EMS unit at the scene, some of the procedures performed by the EMS personnel may have also been documented on the FRU forms. Indeed, during certain missions, the FRU was always dispatched, regardless of the time benefit as compared with the EMS ambulance. The arrival of the FRU and the initial treatment during these missions (witnessed cardiac arrest, high-energy fall trauma and presumed ischemic stroke) may well have occurred simultaneously or even after that of the ambulance. Nevertheless, the magnitude of these procedures (eg, airway management, medication) is small in relation to the entire material, suggesting that the role of the FRU, in this sense, is not strong. Third, a large degree of heterogeneity in terms of FRUs' skill level makes the comparison between professional vs volunteer units difficult to quantify with statistics. Finally, the paper mission forms were often incompletely filled yielding a large amount of missing data. A future prospective study is warranted to provide more complete data.

Conclusion

In conclusion, first responding units initiate treatment or assist ambulance personnel in approximately half of the cases attended. The most effective treatment modality in terms of symptom relief is oxygen administration in patients presenting with dyspnoea. Professional and volunteer-based first-responding units perform similarly in general, excluding the shorter response time of the professional units, a higher tendency on the part of volunteer units to be involved in

resuscitation attempts in presumed cardiac arrest and a higher rate of oxygen supplement provided in ischemic stroke and chest pain missions by volunteer units.

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Conflicts of interest

The authors have no conflicts of interest to declare.

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Table 1. Mission characteristics*

	Patient encounter	
Characteristics	*n* = 1622	%
Age, median (IQR); years	67 (52–81)	
Missing	527	32
Gender		
Male	779	48
Female	552	34
Missing	291	18
Mission type/reason for dispatch		
Ischemic stroke	417	26
Chest pain	237	15
Trauma	132	8
Arrhythmia/collapse	130	8
Cardiac arrest	122	8
Confirmed cardiac arrest	114	7
Shortness of breath	114	7
Sudden unconsciousness	96	6
Other medical	345	21
Missing	29	2
First unit on scene		
FRU	860	53
BLS/ALS	363	22
Simultaneous arrival	82	5
Missing	96	20

IQR, interquartile range; FRU, first responding unit; BLS/ALS, basic or advanced life support. *272 (14%) of total 1894 missions were cancelled *en route*.

Table 2. Time intervals on missions when a patient was encountered.

Patient encounter *n* = 1622	Median	IQR	Missing, %
Delay from dispatch, min			
to mobile	2	1–5	13
to scene	9	6–13	11
to patient	10	7–14	18
FRU before BLS/ALS on scene, min	9	5–13	20

IQR, interquartile range.

Table 3. Treatment modalities and responses.

	Patient treated by the FRU	
Treatment modalities and responses	*n* = 793	%
Clinical response recorded	223	
Resuscitation	83	
ROSC	17	20
ROSC by FRU alone	1	1
Airway management excl. CPR	7	
Respiratory compromise resolved	4	57
Oxygen administration	309	
Respiratory state improved	126	41
Chest pain relief	20	6
Medication	64	
Chest pain relief	16	25
Anticonvulsive or normoglycaemic effect	4	6
Spinal immobilization/splinting	32	
Pain relief/prevention	3	9
Recovery position/postural treatment	34	
Respiratory state improved	4	12
Pain relief	4	12
Other clinical response*	17	

ROSC, return of spontaneous circulation; FRU, first responding unit; CPR, cardiopulmonary resuscitation. *Other clinical response includes e.g. improved haemodynamic state.

Table 4. Comparison of professional vs. trained volunteer first responding units' performance in first hour quintet (FHQ) missions.

	Professional		Volunteer		
Treatment modality/response	*n* = 489	%	*n* = 533	%	*p*-value
Cardiac arrest					
Dispatches	79		43		
Resuscitation by the FRU	46	58	37	86	0.002
ROSC	8	10	9	21	0.110
Median time from dispatch to scene, min (IQR)	6	(5–9)	9	(7–16)	<0.001
Severe respiratory failure					
Dispatches	38		76		
Airway management	0		0		
Oxygen supplement	16	42	35	46	0.842
Respiratory state improved	12	32	25	33	1.000
Chest pain					
Dispatches	78		159		
Oxygen supplement	16	21	77	48	<0.001
Medication	10	13	24	15	0.697
Oxygen and medication	5	6	18	11	0.254
Chest pain relief	5	6	23	14	0.087
Shortness of breath improved	4	5	24	15	0.031
Severe trauma					
Dispatches	58		74		
Immobilisation/splinting	13	22	14	19	0.667
Pain relief/prevention	1	1	1	2	1.000
Stroke					
Dispatches	236		181		

Carrying/assistance for ambulance	94	34	36	27	0.213
Oxygen supplement	9	4	26	14	<0.001

FHQ, first hour quintet; FRU, first responding unit; ROSC, return of spontaneous circulation; IQR interquartile range.