Quantity and Quality of Healthcare Professionals, Transfer Delay and In-hospital Mortality Among ST-Segment Elevation Myocardial Infarction: A Mixed-Method Cross-Sectional Study of 89 Emergency Medical Stations in China

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Research

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Abstract

Background: The purpose of the present study was to explore the influence of the quality and quantity of healthcare professionals at emergency medical stations on transfer delay and in-hospital mortality among patients with ST-segment elevation myocardial infarction (STEMI).

Methods: A cross-sectional study using mixed methods was conducted at 89 emergency stations in 9 districts in China's Shenzhen province. Based on a sample of 31 hospitals, 1255 healthcare professionals, and 3131 patients with STEMI, a generalized linear model was used to explore the associations between the quality and quantity of healthcare professionals and transfer delay and in-hospital mortality among patients with STEMI. Qualitative data were also collected and analyzed to explore the reasons for the lack of quantity and quality of healthcare professionals at emergency medical stations.

Results: The analysis of the quantity of healthcare professionals showed that an increase of one physician per 100,000 individuals was associated with decreased transfer delay for patients with STEMI by 5.087 min (95% CI −6.722, −3.452; P<0.001). An increase of one nurse per 100,000 individuals was associated with decreased transfer delay by 1.471 min (95% CI −2.943, 0.002; P=0.050). Analysis of the quality of healthcare professionals showed that an increase of one physician with an undergraduate degree per 100,000 individuals was associated with decreased transfer delay for patients with STEMI by 8.508 min (95% CI −10.457, −6.558; P<0.001). An increase of one nurse with an undergraduate degree per 100,000 individuals was associated with decreased transfer delay by 6.645 min (95% CI −8.218, −5.072; P<0.001). Qualitative analysis illustrated that the main reasons for low satisfaction of healthcare professionals at emergency medical stations included low income, limited promotion opportunities, and poor working environment.

Conclusions: The quantity and quality of emergency healthcare professionals are key factors influencing transfer delay in patients with STEMI. The government should increase the quantity of healthcare professionals at emergency medical stations, strengthen the training, and improve their performance by linking with clinical pathways to enhance job enthusiasm among emergency healthcare professionals.

Introduction

ST-segment elevation myocardial infarction (STEMI) is a severe subtype of coronary heart disease and is a significant cause of mortality worldwide. The hospitalization rate of patients with STEMI in China increased nearly four-fold between 2001 and 2011. The rate of STEMI among male patients increased from 4.6 to 18 per 100,000 individuals[1]. Most STEMI-related deaths occur in the first few hours of disease manifestation, with 40–65% occurring in the first hour[2]. It has also been shown that every 30 min delay in reperfusion reduces a patient's life expectancy by 1 year[3]. Therefore, the duration of time from symptom onset to reperfusion therapy, which includes patient delay, transfer delay, and in-hospital delay, is a crucial factor determining mortality in STEMI patients. The primary cause of delay in reperfusion is system delay[4], which mainly comprises transfer delay. Compared with door-in-door-out patients, the door-to-

balloon time for patients who are directly transferred to emergency medical stations with in-hospital percutaneous coronary intervention capabilities is shorter and their prognosis is better[5].

In China, the patterns of pre-hospital emergency medical services (EMS) are stand-alone type, dependent type, and directive type. Ambulances can be directed to an emergency center (stand-alone type) or hospital (directive type), and EMS are provided by the emergency center (pre-hospital type) or hospital (dependent type). The pre-hospital EMS supported by Shenzhen in Guangdong Province, China, belongs to the directive type. The Shenzhen Emergency Medical Center is a command center for unified communications, and is responsible for coordinating EMS across the city[6]. After receiving an emergency call, the emergency medical center dispatches an ambulance staffed with healthcare professionals from the nearest emergency medical station to the emergency scene according to the patient's condition. This strategy aims to facilitate rational use of medical resources, shorten response time, and improve rescue efficiency[7].

Shenzhen currently has a sufficient number of ambulances. All ambulances are well equipped with medical supplies including monitoring apparatus for the resuscitation of critically ill patients[8], such as electrocardiograph (ECG), ventilator, and cardiopulmonary resuscitation device. Sufficient healthcare professionals are needed to provide patients with available and sustainable healthcare services[9]. The physician and nurse are responsible for pre-hospital diagnosis and treatment; they need to identify symptoms immediately, transmit ECG results to the hospital as soon as possible, and rapidly communicate with physicians in the hospital emergency department. Therefore, the quantity and quality of physicians and nurses affect pre-hospital emergency response time, which in turn influences clinical outcomes[10].

Most previous studies focused on the association between transfer modes[11], delay time, and mortality among patients with STEMI[3,12–14]. Although some researchers explored the role of general practitioners/primary healthcare physicians in treating patients with STEMI in remote areas[15], the influence of the quality and quantity of healthcare professionals on transfer delay and in-hospital mortality have received little attention. Currently, China is facing problems associated with scarcity and uneven distribution of healthcare professionals for pre-hospital EMS. A major constraint is the shortage of healthcare workers, which means it is not possible to increase the number of operating ambulances because the basic personnel allocation for ambulances cannot be met[16].

The purpose of the present study was to explore the influence of the quality and quantity of healthcare professionals at emergency medical stations on transfer delay and in-hospital mortality among patients with STEMI in China. The results of this study could provide a implication for the allocation of emergency healthcare professionals in developing countries with the similar EMS systems.

Methods

Data collection and patients

This study used data from two sources: China Chest Pain Center Data, and regular report data on the allocation of healthcare resources at emergency medical stations. The China Chest Pain Center Data contained case data for patients with STEMI from 31 hospitals in nine districts of Shenzhen in 2019. The regular report data at emergency medical stations comprised the quantity and quality data for physicians and nurses at 89 emergency medical stations in nine districts of Shenzhen in 2019. The two databases were merged based on district coding, and patients were excluded if they were transferred to other hospitals. Finally, 31 hospitals, 1255 healthcare professionals, and 3131 patients with STEMI were included in our analyses.

Quantitative data

Measurement

Independent variables

The numbers of physicians and nurses per 100,000 individuals in each district of Shenzhen were used to measure the quantity of healthcare professionals. We used the number of physicians holding undergraduate degrees and nurses holding college degrees per 100,000 individuals to measure the quality of healthcare professionals.

Dependent variables

We used transfer delay and in-hospital mortality of patient with STEMI as the dependent variables. Transfer delay referred to the total time from calling 120 to hospital admission for each patient with STEMI. In-hospital mortality was based on the discharge diagnosis (death or not).

Covariates

The covariates used in this study were: patients' age, gender, hypertension or not, normal heart rate or not (normally between 60–100 bpm), clinical stage of heart failure caused by acute myocardial infarction (Killip class I–IV), and emergency risk stratification (low risk = 0, moderate risk = 1, and high risk = 1).

Qualitative data

A semi-structured interview was conducted to explore the reasons for the lack of quantity and quality of healthcare professionals at emergency medical stations. All interviews were entirely voluntary. Two physicians, two nurses, and one director from each emergency medical station were selected, giving a total of 445 interviewees. This selection was based on occupation, gender, age, and educational attainment to ensure the interview results were representative of the responses of all healthcare professionals and directors in these emergency medical stations. The interview questions for physicians and nurses explored job enthusiasm, job satisfaction, and preferences for different incentive factors. Questions for directors included management of emergency medical dispatch, personnel incentive

mechanism, and reasons for lack of healthcare professionals. Each interview lasted for 30 min with on-site recording and audio recording. The interviews ended when data saturation was reached.

Statistical analyses

We described the basic characteristics of patients with STEMI and the quantity and quality of physicians and nurses. The transfer delay and in-hospital mortality of patients with STEMI were descriptively analyzed using analysis of variance and chi-square tests ($P < 0.05$). A generalized linear model was used to explore the association between the quality and quantity of healthcare professionals and transfer delay and in-hospital mortality among patients with STEMI. Covariates were included in all models, and a 95% confidence interval (CI) for the regression coefficient was provided. All statistical analyses were performed using Stata V.15.1 (Stata Corp., College Station, TX, USA).

Results

Participants' characteristics

The mean age of the 3131 patients with STEMI was 56.98 years, and 17.18% were women. Most patients had normal heart rate (75.98%), low emergency risk (77.93%), and were classified as Killip class I (78.25%) (Table 1).

There were 4.444 physicians and 5.073 nurses per 100,000 individuals in Shenzhen. The highest physicians density was those with undergraduate degrees (3.238 per 100,000), which was far higher than the density of physicians with other degrees. The highest nurse density was observed for those with undergraduate degrees (2.525), followed by those with college degrees (2.229) (Table 2).

Table 3 shows the transfer delay and in-hospital mortality for patients with STEMI in districts with differing densities of healthcare professionals. We divided the density of physicians and nurses equally into three levels by district (low, middle, and high). The least transfer delay for patients with STEMI was found in the three districts with high physician density (medians 38 min, 26 min, and 60 mins; $P<0.001$). The greatest median transfer delay for patients with STEMI was found in the three districts with low nurse density (48 min, 32 min, and 70 min; $P<0.001$).

Association between quantity and quality of healthcare professionals and transfer delay and in-hospital mortality

The analysis of the quantity of healthcare professionals showed an increase of one physician per 100,000 individuals decreased transfer delay for patients with STEMI by 5.087 min (95% CI −6.722, −3.452; $P<0.001$); an increase of one nurse per 100,000 individuals decreased this transfer delay by 1.471 min (95% CI −2.943, 0.002; $P=0.050$). Analysis of the influence of quality of healthcare professionals showed that an increase of one physician with an undergraduate degree per 100,000 individuals

decreased the transfer delay for patients with STEMI by 8.508 min (95% CI −10.457, −6.558; $P<0.001$); an increase of one nurse with an undergraduate degree per 100,000 individuals decreased this transfer delay by 6.645 min (95% CI −8.218, −5.072; $P<0.001$) (Table 4).

Reasons for lack of quantity and quality of healthcare professionals

In most cases, healthcare professionals at emergency medical stations had a low level of job satisfaction. The main reasons for this low satisfaction included low income, limited promotion opportunities, and poor working environment, which led to high job mobility and low attractiveness to highly educated professionals. The interviewees indicated that their total income at emergency medical stations was lower than the average level for the city and did not match the high workload. Performance bonuses accounted for a low proportion of their total income. The salary gap between individuals with the same professional title was also relatively small, and did not reflect the difference in working competence.

The channels for promotion for healthcare professionals were limited. Unlike physicians and nurses in hospitals, those working at emergency medical stations had reached the ceiling for promotion if they held an intermediate professional title, regardless of their educational level and working competence. This mean that for healthcare professionals with the same advanced medical education, emergency medical stations were far less attractive than hospitals.

Working in an emergency center also requires night shifts, which demanded a high level of vigilance as emergency patients may need to be rescued at any time. Moreover, the family members of emergency patients were usually irritable, which was likely to intensify the doctor–patient relationship.

Discussion

The present study quantitatively explored associations between the quantity and quality of healthcare professionals at emergency medical stations and the transfer delay and in-hospital mortality of patients with STEMI, and qualitatively analyzed the reasons for the lack of quantity and quality of healthcare professionals at emergency medical stations.

First, our study demonstrated that the density of healthcare professionals was negatively associated with transfer delay for patients with STEMI. In China, each ambulance is usually equipped with a physician, a nurse and a stretcher-bearers[17]. These professionals are responsible for providing EMS and treatment to patients during the transfer process, and monitoring patients before they are admitted to hospital[18]. Our findings were consistent with previous studies, which showed that sufficient healthcare professionals are essential for providing basic health services and improving health outcomes[19,20]. High-quality healthcare professionals are widely recognized as the prerequisite for effective healthcare, and a critical factor that

determines healthcare system performance[21]. Pre-hospital EMS is an integral part of the healthcare system[22]. In 2009, China initiated a comprehensive healthcare system reform, which included a goal of solving the lack of healthcare professionals. However, Shenzhen, as a first-tier city with a relatively high economic level, still faces a lack of emergency healthcare professionals. Therefore, the quantity of healthcare professionals at emergency medical stations should be increased to ensure the quality of pre-hospital EMS.

Second, we found that a higher density of physicians with undergraduate degrees and a higher density of nurses with college degrees were associated with shorter transfer delay for patients with STEMI. For the emergency medical care of patients with STEMI, healthcare professionals are required to recognize the symptoms immediately, take ECG quickly, and rapidly transmit ECG results to the hospital emergency and cardiology departments, so that the hospital can complete the necessary preparations before patient arrival. This means the patient can bypass the emergency and cardiology departments after arriving at the hospital, and go directly to the catheterization laboratory for rapid treatment, thereby reducing transfer delay and in-hospital delay[23]. The wrong decision by healthcare professionals that results in the patient not being sent to the catheterization laboratory in a timely manner can endanger the patient's health and even lead to death[24,25]. The professional competence of healthcare professionals is crucial in pre-hospital emergency medical care. A previous study showed that competent healthcare professionals are essential for providing healthcare services and determine the degree to which the services meet healthcare demand[26]. A higher education level and participation in education programs can also improve competence among healthcare professionals[27]. Therefore, the quality of healthcare professionals and the quality of healthcare services can be improved through on-the-job training for healthcare professionals, and skills in emergency medicine should be cultivated through appropriate medical education and skills training.

Third, although the quantity and quality of healthcare professionals are directly associated with transfer delay, they did not influence in-hospital mortality of patients with STEMI for multiple reasons. For example, the allocation of healthcare professionals at emergency medical stations mainly affects transfer delay, which accounts for approximately 25% of the total delay; in-hospital delay also affects treatment time and further influences in-hospital mortality. In addition, many factors influence the mortality of patients with STEMI, such as basic demographic characteristics[28], medical history[29], and delay caused by patient-level factors[30].

Fourth, our qualitative analysis revealed that the workload of these healthcare professionals was not proportional to their income, meaning incentive mechanisms failed to promote their motivation to work.. The equalization of basic public health services (EBPH) policy implemented in 2009 expanded the coverage of public health services in China, and governments at all levels allocated funds for these services. However, the EBPH policy indicates special funds can only be used to support operating costs such as medical resource consumption and transportation, and cannot compensate for personnel expenses. Therefore, the input of healthcare professionals and the corresponding increase in workload do

not receive sufficient rewards. The explanation for this phenomenon was consistent with previous studies; that is, healthcare workers are unwilling to provide medical services because they are concerned about the rapid increase in workload without corresponding financial returns[31–33]. Furthermore, the performance of emergency medical stations is only evaluated by the number of ambulances dispatched, and not the quality of treatment. Thus, healthcare professionals may be motivated to drive the ambulances out, but not to provide treatment. There is also a growing trend not to transport patients in many Western European countries[34,35]. In addition, there are complex and multifactorial factors affecting the motivation for healthcare professionals in an ambulance not to treat patients. This decision is influenced by healthcare professionals, patients and their relatives, the healthcare system (referral or general physician), and auxiliary tools, such as a patient's refusal to accept therapy, disease severity of the patient, and the ability of healthcare professionals[28,36], which results in prolonged transfer time. Therefore, the performance of emergency medical stations should be linked to service quality. As well as covering in-hospital mortality, service quality but should also cover clinical pathways, such as whether the healthcare professionals on the ambulance identified patient symptoms correctly, completed an ECG immediately, and transmitted the ECG results to the hospital emergency and cardiology departments in a timely manner.

Conclusion

Ensuring sufficient quantity and quality of healthcare professionals at emergency medical stations is a top priority to reduce the delay in treatment of patients with STEMI. The government should increase the quantity of healthcare professionals at emergency medical stations, strengthen the training of professional personnel, and improve their performance by linking with clinical pathways to enhance job enthusiasm among emergency healthcare professionals.

Abbreviations

STEMI: ST-segment Elevation Myocardial Infarction; EMS: Emergency Medical Services; ECG: Electrocardiograph; CI: Confidence Interval; EBPH: Equalization of Basic Public Health Services

Declarations

Ethics approval and consent to participate

This project was approved by the Peking University Health Science Center Institutional Review Board (IRB00001052-21020). Informed consent was obtained from all participants prior to questionnaire administration.

Consent for publication

Not applicable.

Availability of data and materials

The data used and/or analyzed during the study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contribution

Qiang Zhou and Wenya Tian: drafting the manuscript, data analysis and interpretation. Rengyu Wu: field investigation, data collection and critical revision of article for important intellectual content. Chongzhen Qin, Hongjuan Zhang and Haiyan Zhang: critical revision of article for important intellectual content. Shuduo Zhou: data analysis and critical revision of article for important intellectual content. Siwen Li: critical revision of article for important intellectual content. Yinzi Jin: study concept and design, data analysis and critical revision of article for important intellectual content. Zhi-Jie Zheng: critical revision of article for important intellectual content. All authors gave final approval of the version to be published.

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Tables

Table 1 Patient-level characteristics of study participants

	N	%
Patient-level characteristics		
Number of hospital admissions	3131	-
Age (years)*	56.98	13.71
Female	538	17.18
Heart rate		
Normal	2,379	75.98
Arrhythmia	752	24.02
Emergency risk		
Low	2440	77.93
Medium	380	12.14
High	311	9.93
Hypertension	1,463	46.73
Killip class		
I	2,450	78.25
II	181	5.78
III	54	1.72
IV	130	4.15

* mean (SD)

Table 2 District-level characteristics of health care professional

	Physicians	**Nurses**
	Mean (SD)	Mean (SD)
Number of health care professionals per 100,000 individuals	4.444 (4.348)	5.073 (5.771)
Number of health care professionals with graduate degrees per 100,000 individuals	0.516 (1.667)	0.023 (0.231)
Number of health care professionals with undergraduate degrees per 100,000 individuals	3.238 (1.638)	2.525 (4.206)
Number of health care professionals with junior college degrees per 100,000 individuals	0.675 (0.397)	2.229 (3.515)
Number of health care professionals with technical secondary degrees per 100,000 individuals	0.053 (0.311)	0.311 (1.004)
Number of health care professionals with high school degrees per 100,000 individuals	0.023 (0.943)	0.008 (0.104)
Number of health care professionals with age under 25 per 100,000 individuals	0.045 (0.528)	0.811 (1.709)
Number of health care professionals with age between 25 and 34 per 100,000 individuals	1.327 (1.906)	3.117 (4.004)
Number of health care professionals with age between 35 and 44 per 100,000 individuals	1.926 (2.614)	1.046 (2.035)
Number of health care professionals with age over 45 per 100,000 individuals	1.160 (1.952)	0.121 (0.407)

Table 3 Relationship between density of health care professionals at district level and transfer delay and in-hospital mortality in STEMI individuals

	Transfer delay, minutes (median, q1 q3)	*P*	In-hospital mortality, n (%)	*P*
Total				
Districts with low physician density	46 (30, 72)	<0.001	71 (4.38%)	0.768
Districts with middle physician density	44 (32, 60)		39 (4.13%)	
Districts with high physician density	38 (26, 60)		24 (4.66%)	
Districts with low nurse density	48 (32, 70)	<0.001	26 (5.95%)	0.164
Districts with middle nurse density	40 (29, 56)		93 (4.08%)	
Districts with high nurse density	32 (24, 42)		15 (3.64%)	

Table 4 Associations between health care professional at district level and transfer delay and in-hospital mortality in STEMI individuals

	Transfer delay (minutes)			In-hospital mortality (%)		
	Coeffect	95% CI	*P*	Coeffect	95% CI	*P*
Physicians						
Number of physicians per 100,000 individuals	-5.087	[-6.722, -3.452]	<0.001	0.001	[-0.007, 0.008]	0.930
Number of physicians with undergraduate degrees per 100,000 individuals	-8.508	[-10.457, -6.558]	<0.001	-0.001	[-0.010, 0.008]	0.801
Nurses						
Number of nurses per 100,000 individuals	-1.471	[-2.943, 0.002]	0.050	0.003	[-0.004, 0.010]	0.385
Number of nurses with junior college degrees per 100,000 individuals	-6.645	[-8.218, -5.072]	<0.001	0.009	[0.001, 0.016]	0.022