Response time in the emergency services. Systematic review[1]

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Abstract

The growth of the urban population raises concern about municipal public managers in the sense of providing emergency medical services (EMS) that are aligned with the needs of prehospital emergency medical care demanded by the population. The literature review aims at presenting the response time of emergency medical services in several parts of the world and discussing some factors that interfere in the result of this indicator such as GDP (Gross Domestic Product) percentage spent on health and life expectancy of countries. The study will also show that in some of the consulted articles, authors suggest to EMS recommendations for decreasing the response time using simulations, heuristics and metaheuristics. Response time is a basic indicator of emergency medical services, in such a way that researchers use the descriptive statistics to evaluate this parameter. Europe and the USA outstand in the publication of studies that present this information. Some articles use stochastic and mathematical methods to suggest models that simulate scenarios of response time reduction and suggest such proposals to the local EMS. Countries in which the response time was identified have a high index of human development and life expectancy between 74.7 and 83.7 years.

Key words: Emergency Medical Services. Ambulances. Emergency Responders.

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■ Introduction

Growth of the urban population raises the concern of municipal public managers in the sense of providing emergency medical care services that are aligned with the needs of prehospital emergency medical care demanded by the population. There are estimates indicating that by 2050, urban areas should have a contingent of 6.29 billion people, equivalent to 69% of the world's total population[1]. With population growth in large cities, it is natural that there is a significant increase in the number of traffic accidents and other serious occurrences such as heart attack, drowning, drilling by firearm and disasters (floods, landslides, earthquakes, for example).

This increase in such occurrences is reflected in the proportional growth in costs of health systems worldwide. In 2010 prognoses show that this value reached 17.6%. Among these health expenditures, 5 to 10% are with emergencies[2-3]. Furthermore, the increasing number of inhabitants in an urban area will challenge the resources already in place. The traffic density in many metropolitan areas of the world causes severe car congestion[4].

The World Health Organization has defined provision of basic life support to all risk situations involving people and goods as a main objective of Emergency Medical Services (EMS)[5]. EMS is included in this discussion as they are responsible for the provision of acute prehospital care for patients with illnesses and injuries and have a key role to providing quality services to people, minimizing the degree of lesions and even the death toll[6]. The response time of EMS is a fundamental factor for prehospital care to be successful and, therefore, must be controlled in order to increase the chances of survival[7].

Response time is the main indicator of this service. It is defined as the time between notification of an occurrence and the ambulance arrival at the scene. According to the WHO, an ideal response time is equivalent to less than 8 minutes[5]. Regarding the definition of response time, Lawner *et al.*[7] consider secondary outcomes, which include changes in other main ambulance time metrics such as average ambulance response interval (time from ambulance dispatch to arrival at the scene) and overall out-of-service interval (the amount of time that an ambulance is not available to respond to another incident). Vile *et al.*[8] further stresses that response times are one of WEST's Key Performance Indicators (KPIs) since they are believed to provide a good indication of the quality and timeliness of care provided by the service.

Worldwide, this parameter is quantified because of its relevance in the evaluation of quality of service. Examples identified in cities with more than one million inhabitants in Brazil and in the world explain the average response time for urgent care: in the UK, it should be a maximum of 8 minutes in 75% of calls and 19 minutes in serious, but not urgent, calls.

In Vienna, Austria, the average response time recorded in 2015 was 15 minutes considering a 10% dispersion of this value to more or less due to the restrictions of intense traffic of vehicles and climatic conditions. In Brazil, in Belo Horizonte, the average response time in 2010 was approximately 21 minutes[9]. In the city of São Paulo, in 2007, the best response time found for emergency medical services was 27 minutes[10].

Takeda *et al.*[11] discussed in their article the US EMS Act, which sets some standards: 95% of the emergency requests should be served within 10 min in urban areas and within 30 min in rural areas. Similar regulations are found in other parts of the world; for example, in London and Montreal, the regulation states that 95% of the requests should be served within 14 to 10 min, and 50% and 70% of the requests should be served within 8 to7 min,

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respectively[6-8]. Throughout the time, there was a tendency of growth of the publications that addressed in its scope the time of response of EMS. Figure 1 represents the continents with a larger number of publication of the selected studies for data extraction[12].
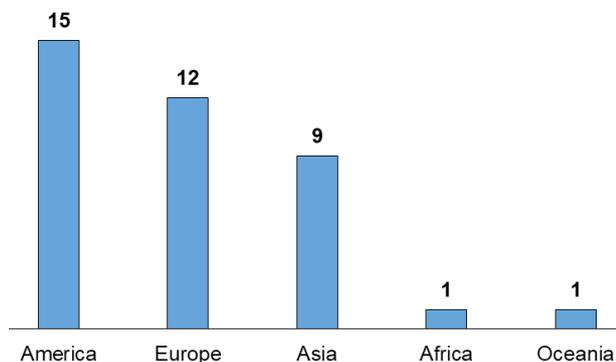

Figure 1 - Continents that outstand in the publication of response times and EMS.

It is clear that America and Europe outstand in this classification. It is necessary to point out that the figure in discussion refers to the articles that were selected by this review for presenting the information initially discussed by the authors.

The keywords identified in the articles consulted in this literature review are interrelated and allowed the meeting of technical materials that were aligned with the objective described in this review. In Figure 1, the diameter of each node representing these words is proportional to the number of articles located regarding them. The representativeness of nodes emergency medical services, prehospital emergency care, ambulances, emergency responders, reaction time and emergency health service are significant in the contribution to studies that deepen the discussion of this review.

In order to quantify the response time of emergency medical services and, in some cases, to contribute with suggestions to reduce

this indicator, the articles consulted were based on Statistical Methods and Operational Research. The objective of statistical methods is to make processes efficient as much as possible[12]. Statistical methods are used to understand variability. By variability, it is understood that successive observations of a system or phenomenon do not produce exactly the same result. In the search for this goal, statistic uses some tools: descriptive statistics, statistical inference, regression, correlation and multivariate analysis of the data.

Descriptive statistics, measures of central tendency; dispersion measures; measures of asymmetry and flatness; and measures of association and graphical representation of results. Also, according to, statistical inferences cover some functions of probability density that are used more frequently in statistical analysis[13]. The functions are *Normal distribution; Distribution of the Chi-square (x^2); Student's t-distribution; F Distribution and Binomial Distribution*[12,13].

Regression is a valid method to understand the influence that one or more predictive variables have in relation to a regressive variable. Through it, it is possible to construct an equation that accurately predicts the future behavior that one wishes to evaluate, if parameters such as correlation coefficient between variables, *F-test* and *p-value test*, are satisfactory[13].

Operational Research also contributes to the fact that the models developed in the articles consulted for this review reach their objectives, since one of the strategies used by EMS management to reduce response time is to use algorithms, heuristics and metaheuristics to the definition of the routes of the vehicles involved in the provision of this service[10-12].

Operational Research attributed to the military services early in World War II. Due to of the war effort, there was urgent need to allocate scarce resources to the various military operations. Another characteristic

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of operations research is its broad viewpoint, encompassing Linear Programming, Dynamic Programming and Queuing Theory[14].

Inserted in this context, this literature review aims to present the response time of emergency medical services (EMS) in several parts of the world and to discuss some factors that interfere in the result of this indicator such as GDP percentage spent with health as well as life expectancy of Countries. Our study will also show that in some of the articles consulted the authors suggest to the EMS recommendations to decreasing the response time using simulations, heuristics and metaheuristics.

■ Methods

Scopus/Embase, NCBI (PubMed) and Science Direct were searched on 5 May 2017 for English-language papers from 2007 to 2017. The following search terms were used: "Emergency Medical Services" and "Response Time". Titles and abstracts were reviewed independently by four reviewers. The time interval considered for the evaluation of articles was from 2007 to 2017. The Lilacs database was not queried because it is indexed in SciELO, which in turn is indexed in PubMed. Google Scholar was not considered due to the preference of the review authors for the use of peer reviewed databases. It used in this research is showed in Figure 2. Disagreements between reviewers were resolved in a meeting with the rest of the research team. During the full text review, studies were excluded if they did not meet the criteria, response time availability and the referring cities. Studies were not excluded on the basis of methodological quality. The final sample size for the analysis was 205 articles, these came from 864 studies. A recent bibliometric review of scheduling routing presented relevant information regarding response time in emergency medical services with a broader number of selected articles, the mentioned review though, approached the applied methodology aiming at improving the response time. While the present study focus on the descriptive statistical analysis of the response time around the world. The reason of which the aforementioned review differs in searched articles, can be explained by the requirement of the proposition mathematical methods, demand of which is not applied in the present study.
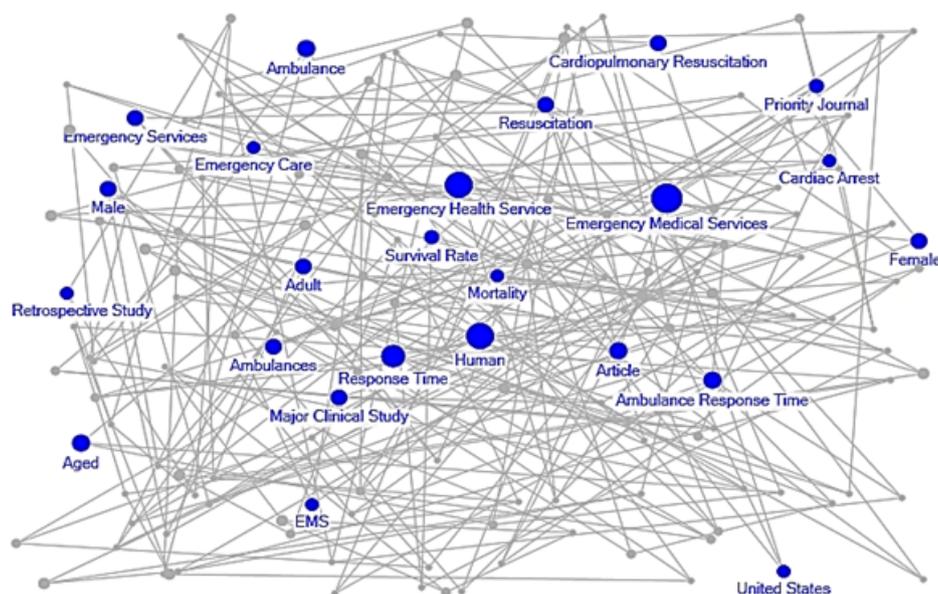

Figure 2 - Keyword found in database search.

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The research was done in the following order: the country and city where the study was carried out, the methods used to provide the reduction of the response time of the EMS, the journal that published it, year of publication of the article, country's GDP, public health expenditure percent to GDP and nationality life expectancy. Based on these data, an analysis of the elements of descriptive statistics was developed and the graphical representations of this evaluation were positioned within the scope of this study, in such a way that the conclusions expressed in it are evaluated numerically.

■   Results

According to the articles listed, an international concern is observed in the measurement and optimization of response time in attending emergency occurrences that require the presence of qualified medical staff[15-17]. Technical work has been found in this sense in all the habitable continents with emphasis on America and Europe. The largest portion of the articles comprise statistical analysis of the data provided by the medical emergency management agencies of the region aiming at presenting indicators of these services[18,19].

In general, local organizations that manage the emergency medical service provide the information necessary for research centers to make this assessment[20]. Other study will not only make basic statistical descriptions related to the EMS, but also make recommendations that will influence the performance of routine operations impacting, in particular, the service response time[21-23]. Figure 3 summarizes that a significant portion of the studies dealing with problems related to emergency medical services in order to contribute to decreased response time, resources, coverage and routes, for example, make use of simulation, algorithms and data analysis through descriptive statistics[24,25].
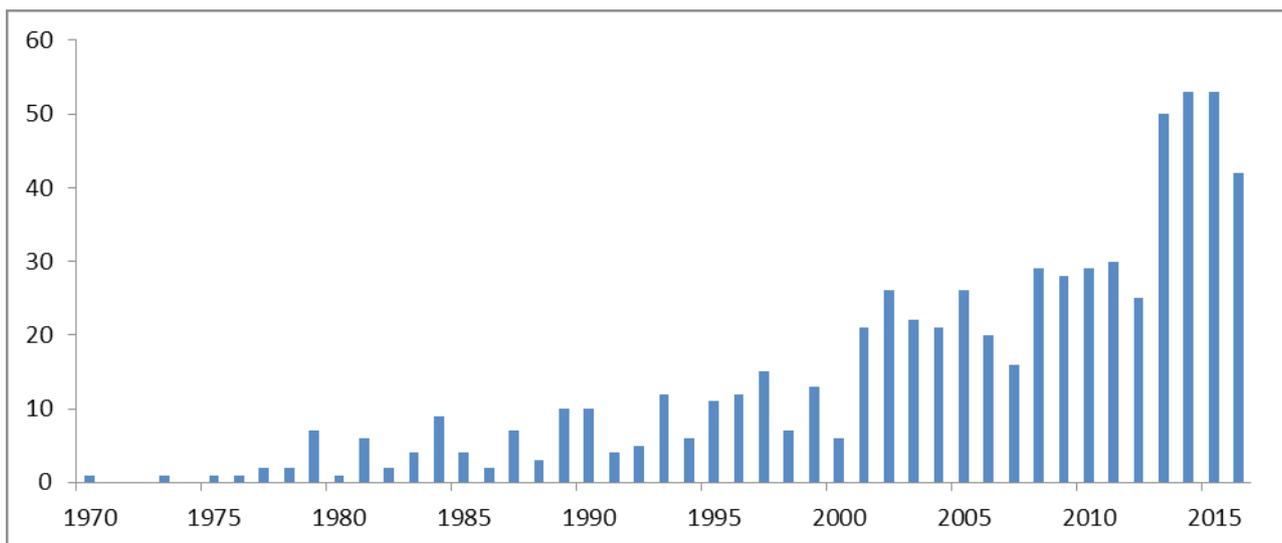

Figure 3 - Evolution of publication related to responses times and EMS.

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The use of algorithms and simulations allow scenarios to be developed and evaluated. Hence, it is possible to make changes in the characteristics of the scenarios, such as resources, variables and planning horizons, for example[26-28]. Non-significant methods for usability in articles related to Figure 4 (Queue Theory, for example) are more complex in the construction of scenarios and are descriptive, which makes their recurrent use unfeasible in the articles consulted[29].
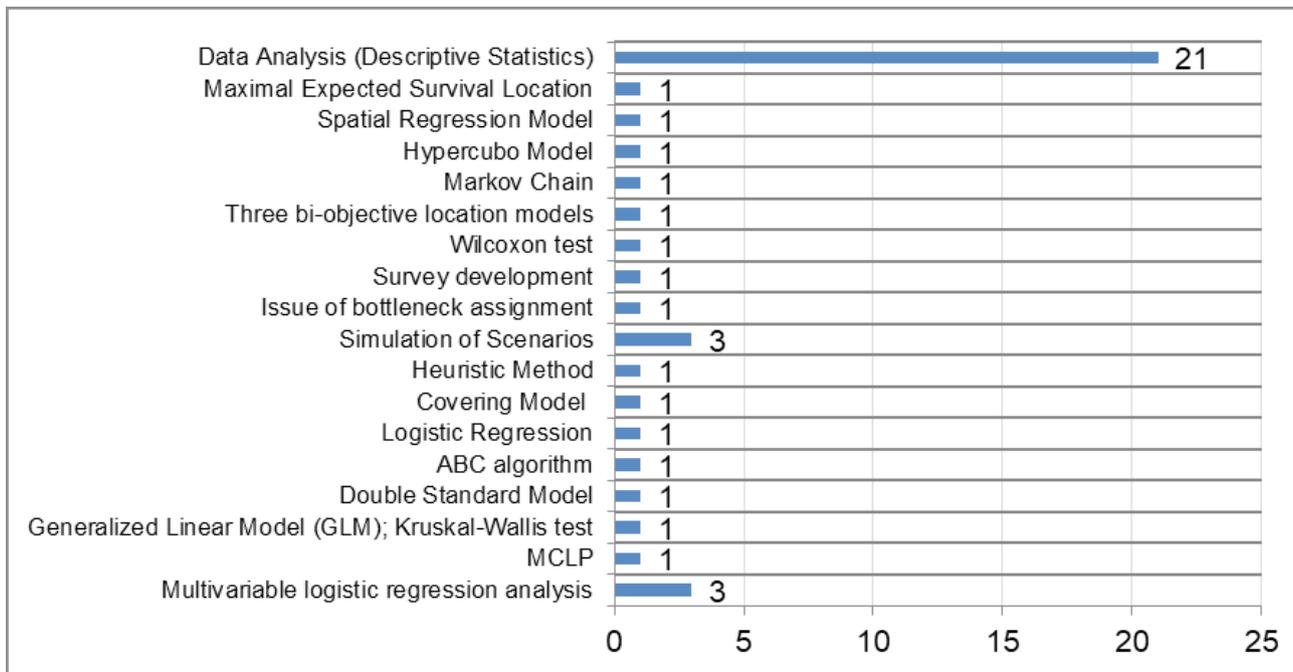

Figure 4 - Methods used in the article searched.

Data evaluation shows that the localities found, positioned mainly in Europe and North America, present a response time in accordance with what is expected for this type of service, having an estimated time of approximately 8 minutes according the WHO[2,30-33].

Locations in Asia, Latin America and Africa showed response time higher than 8 minutes. Economic development and access to health influence these numbers as well as the operational conditions of the emergency medical services of those countries of the aforementioned places[34-36]. Table 1 shows that the localities with the shortest response time in emergency medical services were Salt Lake City (United States) and Taoyuan (Taiwan). In these cities, the use of information technology (mobile applications), significant GDP percentage spent on public health by the country and high level of schooling of the population (which could provide prehospital medical care before the arrival of ambulances), ensure that the indicator is lower than that of other countries and cities[37]. The locations with the longest response time were Athens and São Paulo[10-12].

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Table 1 - Information listed in the articles evaluated.

Year of publication	Countries	City. Region and State	Response Time (Minutes)	HDI	Life expectancy (Years)	Public Health Expenditure (% to GDP)
2014	Taiwan	Taoyuan[15]	5	0.738	76.0	3.1
2016	United States	Salt Lake City[16]	5	0.920	79.2	8.3
2017	Republic of Korea	Seoul [17]	7	0.901	82.1	7.4
2015	United Kingdom	Wiltshire,Glouceste-rshire and Avon in Southwest England[18]	6	0.909	80.8	7.6
2016	United States	Seattle[19]	6.1	0.920	79.2	8.3
2015	Singapore	Singapore[20]	7.25	0.925	83.2	2.1
2015	Sweden	Stockholm[21]	7.8	0.913	82.3	10.0
2012	Australia	Melbourne[22]	8	0.939	82.5	6.3
2016	Netherlands	Nijmegen, Gelderland Zuid[23]	8	0.924	81.7	9.5
2015	Netherlands	Amsterdam [24]	15	0.924	81.7	9.5
2015	Finland	Southern and Eastern Finland[25]	8	0.895	81.0	7.3
2016	United States	Charlotte[26]	8.59	0.920	79.2	8.3
2011	Portugal	Lisboa[27]	9	0.843	81.2	6.2
2012	Canada	Edmonton[28]	9	0.920	82.2	7.4
2014	United States	Hanover[29]	9	0.920	79.2	8.3
2016	United States	Chicago[30,31]	10	0.920	79.2	8.3
2015	Norway	Bergen[32]	11	0.949	81.7	9.7
2013	Switzerland	Berna[33]	11.5	0.939	83.1	7.7
2017	Mexico	Tijuana[34]	14	0.762	77.0	3.3
2013	United States	Alabama[35]	6.4	0.920	79.2	8.3
2016	Netherlands	Flevoland[36]	15	0.924	81.7	9.5
2014	Spain	Galícia[37]	15	0.884	82.8	6.4
2014	Iran (Islamic Republic of)	Tabriz[38]	17.87	0.774	75.6	2.8
2016	Ghana	Kumasi, Accra and Tamale[39]	19.5	0.579	62.5	3.6
2016	Brazil	Belo Horizonte[5]	21	0.754	74.7	3.8
2014	United States	Dallas[40]	24	0.920	79.2	8.3
2016	United States	Baltimore[41]	25.1	0.920	79.2	7.8
2013	Spain	Navarre[42]	26	0.884	82.8	6.4
2015	Brazil	São Paulo[10]	27	0.754	74.7	3.8
2007	Brazil	Campinas[11]	13	0.754	74.7	3.8
2014	Turkey	Eskisehir[43]	6.5	0.767	75.5	4.2
2015	Iran (Islamic Republic of)	Shiraz[4]	8.83	0.774	75.6	2.8
2016	Japan	All of Japan [44,45]	7.5	0.903	83.7	10.2
2013	United States	Durham[46]	6.8	0.920	79.2	8.3
2015	Taiwan	Taipei[47]	6.5	0.738	76.0	3.1
2015	United States	Colonial Heigths[48]	4.09	0.920	79.2	8.3
2016	Finland	Turku[49]	11.6	0.895	81.0	9.7
2016	Austria	Styria, Tyrol[49]	8.2	0.893	81.6	11.2
2016	Croatia	Slavonski Brod, Zadar, Zagreb[49]	26.9	0.827	77.5	7.8
2016	Croatia	Koprivinica, Rijeka, Split[49]	11.1	0.827	77.5	7.8
2016	Czech Republic	Hredec Kralove[49]	8.4	0.878	78.8	7.4
2016	Greece	Athens[49]	28.9	0.866	81.1	8.1
2016	Poland	Cracow. Poznan[49]	16.5	0.855	77.6	6.3
2016	Serbia	Novi Sad[49]	9.2	0.78	75.0	10.4

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Factors contributing to these figures concern the heavy traffic of vehicles on public roads those cities, which hinders the circulation of ambulances and is an impediment to achieving adequate response times as prescribed by the WHO.[2] In Brazil, there is no specific regulation that specifies limitations for response times in EMS[11-13,38].

Another indicator evaluated by the United Nations Development Programmer is the proportionality of health spending relative to the GDP and the life expectancy of the countries[38-40]. Evaluating this indicator, it was observed that there is no significant correlation between the GDP percentage allocated to health spending and the response time of the service under discussion (Table 1). That is, the performance of the response time of emergency medical services does not depend on the amount of resource available for health in a country[41]. The idea that arises the present from this discussion is centered on the management of the resource derived from the

GDP, that is, if it is being used to promote the operational efficiency of emergency medical assistance services.

Furthermore, other factors that should influence the response performance of medical teams are demographic density, localities (size), public health policies and traffic conditions in public roads. Figure 5 represents a summary of the median of the indicators presented in Table 1 per continent[11,18].

The choice of the median for the development of this graph was due to sensitivity, which allows the adequate understanding of the indicators from the continental point of view, according to our review[42]. Figure 5 shows that there is a predominance of response time in significant nonconformity with what is prescribed by the World Health Organization (8 minutes) in places where there is low life expectancy, low public investment in health and follow average human development index (HDI)[43].
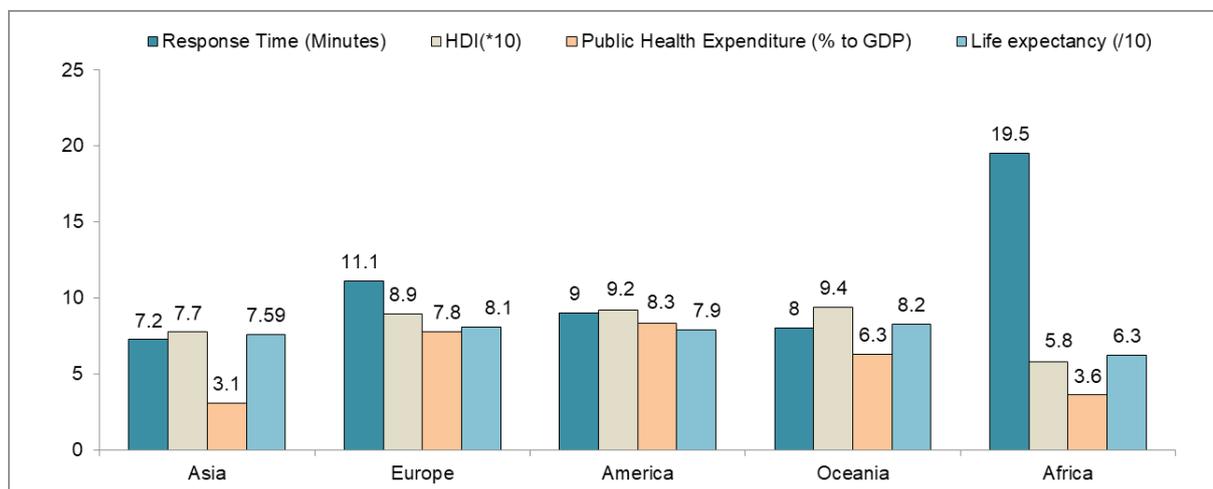

Figure 5 - Median of Response Time, Public Health and HDI.

In locations where response time happens within the WHO's determined their conformity, can be seen high life expectancy, higher GDP percentage, more public investment

in the area, expenditure, very high human development index and high life expectancy were identified[42-44].

The exceptional case of Asia presents

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a median response time lower than that registered in other continents, although the GDP percentage spent on health is the lowest recorded value, which raises the discussion of the public policies used by the governments of the countries of that continent and the distribution of resources for the provision of these policies and their alignment with the efficiency of routine EMS operations[45].

Asia has a shorter mean response time (7.3 minutes), followed by Oceania (8.0 minutes). In this continent was identified only one country (Australia) that presented city (Melbourne) whose emergency medical service measures indicator response time[46-48]. In Africa only one country (Ghana) presented cities (Kumasi, Accra and Tamale) where in emergency medical service measures indicator response time (19 minutes). America and Europe have a median response time of 9 to 11 minutes, respectively[49]. Due to the representativeness of North American cities in the measurement of the response time of emergency medical services, a median human development index for the Americas was equivalent to 0.920, value corresponding to the US HDI. This does not reflect the HDI reality of the entire American continent[50].

■ **Conclusions**

In conclusion, this review has shown that, in several countries around the world, there is an interest of health institutions responding urgently and in an emergency to the quantification of response time, and there is a consensus that this indicator is fundamental to understanding routine EMS.

Due to the importance of the topic, it is necessary to stimulate the development of other studies that seek to understand the factors correlated to the response time, which will allow a scientifically validated understanding of what can be done to reduce it.

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