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Access to Emergency Medical Services,

Time of Response Analysis.

Case Study: Manizales – Colombia

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Abstract

The relationship between transport and health have been taking a large place in academic agendas, even more in low and middle income countries which have a marked social gaps caused by an unequal access to facilities and services as health care. Hence, this research makes a retrospective database review with which is elaborated a methodology to assess the coverage of emergency medical services (emergency service facilities and ambulance dispatches). Using socio-demographic and economic secondary data, also primary information of emergencies occurred in the city between 2010 and 2015 from Fire Brigade and analyzed by GIS (Geographic Information System).

Keywords: Ambulance dispatch, emergency service facility, equity, travel time, life threatening emergencies

1 Introduction

The equity has always been an important subject to study, but in recent decades has been associated to many researching areas such transport and health, just to mention two [7]. In last years, movement pro-health has been increasing. Looking for improvements health outcomes through actions which should be taken in many areas, such as planning and transport that prompt decreasing of social and health inequity [16]. This paper proposes a methodology to encourage coverage of Emergency Service Facilities (ESF) and Ambulance Dispatches (AD). Attempting to reduce health and social inequity in attention of different types of medical emergencies. Using a city of the global south as a case of study such as Manizales – Colombia. First, this research takes concepts of health equity, geographic accessibility and attention of medical emergencies. Second, it identifies some of those concepts to diagnose and gives an overview of the case of study. As a final part, discussion and conclusions which indicates causes and consequences to apply this technique. Knowing that exist many methods to find the best alternative to improve the accessibility to health care facilities [21]. The first tool that health system has for avoided fatal outcomes and the lifelong disabilities is the prehospital care, in which time has an important role.

Violent deaths are an important public health problem in Colombia, has reached the five leading causes of death, being road traffic injuries a preventable cause. Low income and middle income countries have reported the majority rates of road traffic mortality (around 90%) and only have the 48% of the world's registered vehicles [22]. Even, road traffic injuries have an huge impact in economic development, people aged within 15 and 44 years presents highest percentage of road traffic fatalities that means the loss of potential years of productivity life [1]. The pre-hospital attention in trauma is estimated in 60 minutes after injury occurs; it is named "The golden hour" and a meta-analysis of prehospital care times for trauma in urban areas was averaged in 5.25 minutes [4]. Another study calculated a reduction around of 30% in the mortality indexes in road crashes with the decrease of 10 minutes in the response time [21]. An analysis in the transport time and scene time in trauma patients, found a relation in scene time longer than 20 minutes and a higher odds of mortality, compared to a scene time lower than 10 minutes [17].

¿How long has to spend the response time for prevent fatal outcomes and lifelong disabilities? Some studies have tried to answer this question, a retrospective cohort study evaluated the response time, level of illness severity and the survival to hospital discharge, found that 8 minutes was not associated to a decrease in the mortality, however a response time within 4 minutes showed a favourable impact in survival to hospital discharge [24]. Another observational study concluded an improved survival in response times less than 5 minutes than longer response times [3]. Furthermore, an investigation has demonstrated that inequity has influence in the agility of response time. Finding, a correlation between living in a low income neighbourhood and a longer prehospital delay [10]. However, actually the world

suffers significant health inequalities, even an ex-director of WHO sentenced that poverty is the principal issue to health development [20]. The cities of the global south have many aspects prompting modifications in health care. Even, in Latin America and poorer countries when the inequality decreases the gross domestic product has a positive effect on public health due to better distribution of wealth [2]. In the unequal societies the health services are more inappropriate in terms of quality of service and treatment [23]. In urban areas, as local as national governments should develop new strategies of territory planning and health systems. Seeking healthy cities with equity, with access to resources (facilities, medical, nurses, healthy food, among others), and public policy which tends to enhance social and physical environment [15]. The methodologies framed by theories of accessibility are fairly used to measure the strategies of land use and transport. For instance, determine the best location to health care services looking for equity is one those strategies [11]. Hence, these methodologies have been collaborating to improve in planning for health care through accessibility methods [18]. Nevertheless, a few papers have studied inequalities in access to health care facilities [21]. Also, health inequalities are a consequence of inadequate distribution of resources [14]. Furthermore, there are some authors who have researched emergency service facilities to diagnose and improve the response attention of urgencies [13]. For this research, we use minimum travel time as method due to factors emergencies [6] and is a key for physical accessibility to hospitals in low and middle income countries [26].

Manizales has approximately 391,640 inhabitants. This city is situated in northwest of South America, exactly in Department of Caldas Colombia as shown in Fig. 1. This city has been developed in abrupt topography. Also, its urban planning has been poor. Hence, the informal settlements have been characteristic along the city, which have a few resources (facilities and road infrastructure), even with a depraved quality of basic services [5]. Population in Colombia is distributed by six strata. Stratum 1 belongs to areas where poorest people live and stratum 6 is for areas where richest people reside. In Manizales, 39% of population live in areas stratum 3, and 80% of people reside in areas between stratum 1 and 3 [8]. It indicates that citizens of low and middle income predominate in this city as other Latin America cities.

Furthermore, elder inhabitants are increasing between 1% and 3% per year, while population growth is around to 1% [12]. This means that health system would have more pressure in next years and decades. In Manizales there are 12 ESF. Although, between 2010 and 2013 there were 14 ESF and between 2014 and 2015 there were 13 ESF. The spatial distribution of this facilities along the city is a sample of social inequalities, due to areas stratum 5 and stratum 6 (richest) have highest density of ESF, while sectors stratum 1 and stratum 2 have lowest density. According to Ambulance Dispatches (AD) for medical emergencies, there are 5 entities that provide the services. Civil Defence, Fire Brigade, GER (Special Group of Rescue for its acronym in Spanish). These ones depend of the local government. Red Cross

and BYR (Search and Rescue for its acronym in Spanish) and these ones are NGO's. As regards to the location, 4 of the 5 entities have one facility and only Fire brigade has two locations where ambulances are dispatched.

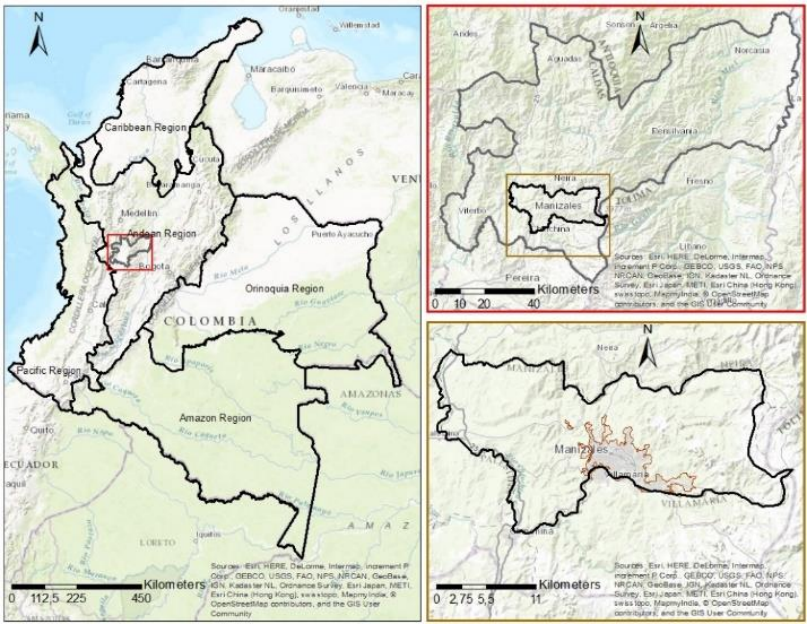

Fig. 1. Geographic location of the city of Manizales. Source: Authors.

2 Methodology

This methodology finds zones with failures in attention between AD and event. And second, find zones with failures in attention between event and EFS facilities through analysis of following variables: i) Average minimum travel time to attend a LT emergency in each zone as AD – event as event - ESF through the algorithm Djkstra in software ArcGis 10.2.1, due to this type of events should be analysed by minimum travel time [6]; ii) Average actual travel time to attend a LT emergency in each zone as AD – event as event - ESF through the algorithm Dijkstra in software ArcGis 10.2.1.; iii) Quantity of LT emergencies in each zone; iv) Quantity of deaths in each zone; and v) Population of each zone.

It is important to clarify, that transport time (event - ESF) has not influence in mortality [24] is important define a time boundary. This limit is defined due to a study which defined that patients attended in 4 minutes of respond time (AD – event) has an advantage to survive [24]. First step, find zones with mean minimum travel time and actual travel time less than 5 minutes [3] in journey between ambulance dispatch and event, and less than 6 minutes between event and ESF. Identifying the zones which fulfil requirements in attention of emergencies. Second step, find zones with mean minimum travel time less than 5 minutes and 6 minutes in journeys AD – event, and event – ESF respectively, but mean actual travel time greater than 5

minutes and 6 minutes respectively. Identifying the zones which need improvements in logistic of attention of emergencies. Third step, find zones with mean minimum travel time and real travel time in both journeys greater than 5 minutes and 6 minutes, respectively. To identify the zones which need AD or ESF, we used an assessment of three variables (fatalities, LT emergencies and population) between zero (0) and ten (10), being zero (0) for zones where the variable has none quantity and between one (1) and ten (10) the value is given by decile, being one (1) for the first decile and successively for the rest of values. To be a zone which requiring an AD or ESF, the value of any variable must be greater than five (5). Fourth step, identify zones of analysis where can be localized a facility (AD or ESF). These great zones have many characteristics: i) Have at least one zone that requiring AD or ESF; ii) Have less than 3.0 km of diameter (this distance can be changed, it depends of the speed observed and permitted in zone of study); iii) Have a significant road connectivity between zones that conform the great zone. Fifth step, make an analysis of accessibility to each great zone. Identifying the location where AD and ESF could be settled.

This analysis is made through Kriging method, which has been used in the same area, studying the accessibility to mean university of the city and its relation to social inequalities [27], regarding students and professors. Also, it has been used for plan of mobility in Manizales [9]. For this method, it needs coordinates of each node that conform the road network (each link is shaped by two nodes, setting the road network) of the great zone, also needs the average travel time that each node would take to every another node of the great zone. To forecast the average travel time in whole great zone it is necessary weight (λ) the sampled points. The sum of all weights must equal to one. Each λ is multiplied by the value of the variable in this case average travel time. Finding the average travel time of a zone where there were not travel time observed through this equation:

$$T_{vi}^{*}(X_0) = \lambda_1 T_{vi}(X_1) + \lambda_2 T_{vi}(X_2) + \lambda_3 T_{vi}(X_3) + \lambda_4 T_{vi}(X_4) + \cdots + \lambda_n T_{vi}(X_n) \quad (1)$$

$$T_{vi}^{*}(X_0) = \sum_{i=0}^{n} \lambda_i T_{vi}(X_i) \quad (2)$$

3 Results

3.1 Minimum and actual travel time by zone between AD – event and event - ESF

As a first input, the average minimum travel time by zone between AD – event and event – ESF (as shown in Fig.2a and Fig.2b), expose that zones which are near to a facility take less time than zones which are in the peripheries. While, as a second input, the average actual time by zone and journey (as shown in Fig.3a and Fig.3b), reveal that if a zone is close to a facility, it does not mean that travel time will be minimum.

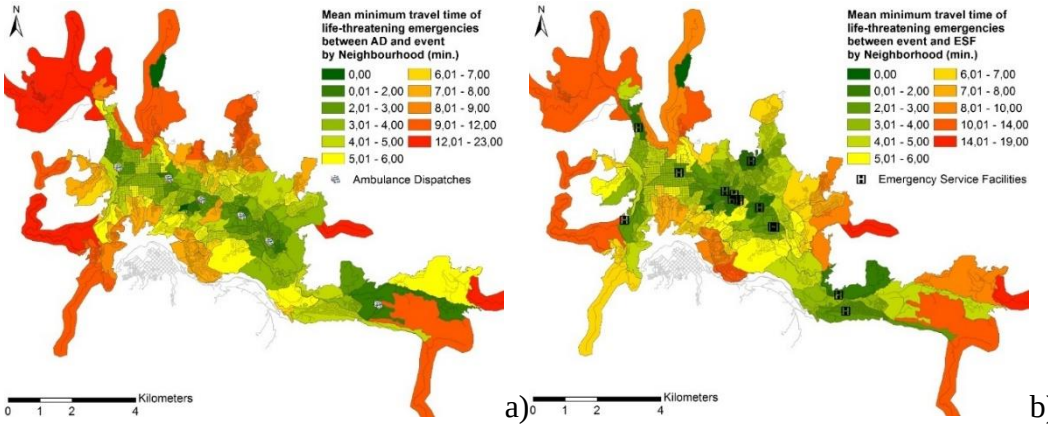

Fig. 2. Mean minimum travel time of LT emergencies occurred between 2010 and 2015 excluding 2012; a) Between AD and event; b). Between event and ESF.

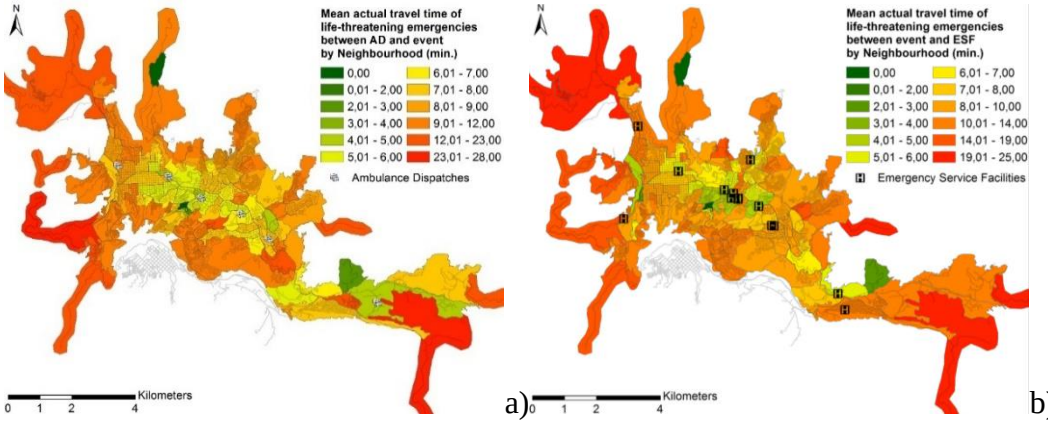

Fig. 3. Mean actual travel time of LT emergencies occurred between 2010 and 2015 excluding 2012; a) Between AD and event; b). Between event and ESF.

The Fig. 3a and Fig. 3b imply that majority of the zones that fulfil the travel time to arrive to an event (5 minutes) or an ESF (6 minutes). When, they are analysed with actual time those neighbourhoods non- fulfil optimal time range. Hence, it demonstrates that a high percentage of neighbourhoods present loss of time in attention of emergencies.

3.2 Life-Threatening emergencies and fatalities

As was mentioned, the principal variable to identify the necessity of AD and ESF is time, also is supported with LT emergencies, fatalities occurred in attention of emergencies and population. NLT emergencies are not taken in account due to these

do not need a quick response time or transport time. However, it does not mean that this type of emergencies must not be attended in the same range of time as life-threatening events. The zones where are located the most life-threatening events (as shown Fig.4a) and fatalities (as shown Fig.4b), are characterized by flow pedestrian, high speed or high index of murders. The first two causes are observed in Central Business District (CBD) and the peripheries where road are designed for higher speed or drivers of vehicles take more risks.

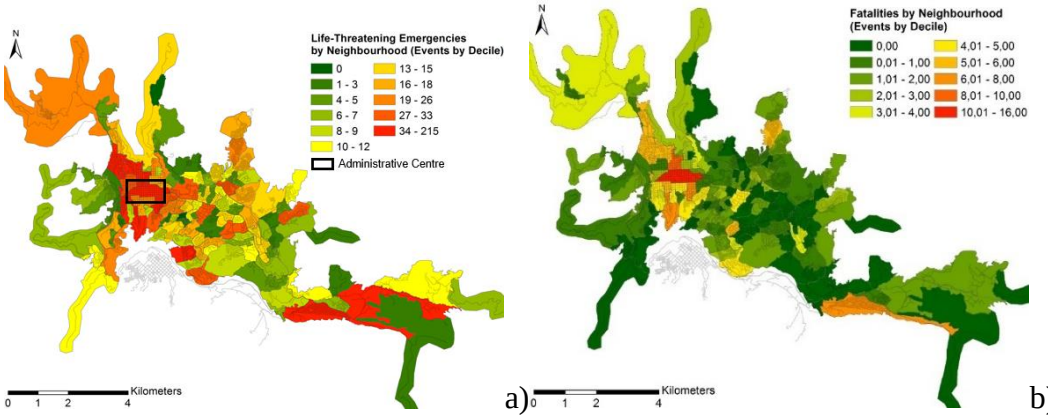

Fig. 4. Event occurred between 2010 and 2015 excluding 2012 by neighbourhood; a) LT emergencies; b) Fatalities.

Hence, this shows that national government and local government must take policies that looking for decreasing the road traffic accidents, and the principal action ought to be focused in behaviour of users.

3.3 Fulfil and non-fulfil requirements of time in attention of emergencies from AD to event and from event to ESF

Nine of one hundred and twenty-four sectors satisfy the requirements of time in the journey AD – event (5 minutes) (as shown in Fig.5a) and just two of the zones fulfil the optimal range of time are neighbourhoods due to did not happen LT emergencies (as shown in Fig.2a). While, in the journey event – ESF nineteen sectors comply with optimal range of time. It is expected due to there are more ESF than AD. However, it is critical. Because, less than 15% of the neighbourhoods fulfil this requirement of time. Hence, it is evidence for this city, where is needed improvements as urban planning and emergency medical services. The most zones near to AD or ESF, comply with requirements of time if the emergencies occurred inside of each sector are attended by the nearest facility (AD or ESF). But it is not happening (as shown in Fig.5b). For instance, the 45% (55 zones) of the neighbourhoods satisfy this condition in the journey AD – event. While, between event and ESF the 55% (65) zones fulfil this condition. The peripheral neighbourhoods are characterized for non-fulfil neither average minimum time nor average actual time. For journey AD – event the 48% (60) of the zones do not meet

any time. And for journey event – ESF the 30% (37) of the sectors are in the same condition as AD. Hence, AD requires more work by policy makers, because almost the half of the city has not a quality service in respond time. While, ESF are better than AD, it needs consideration to enhance quality of life through accessibility to health services. Regarding these zones, it does not mean that each one needs an AD or ESF, these sectors must fulfil other requirements as population, life-threatening events and fatalities in the process of attention.

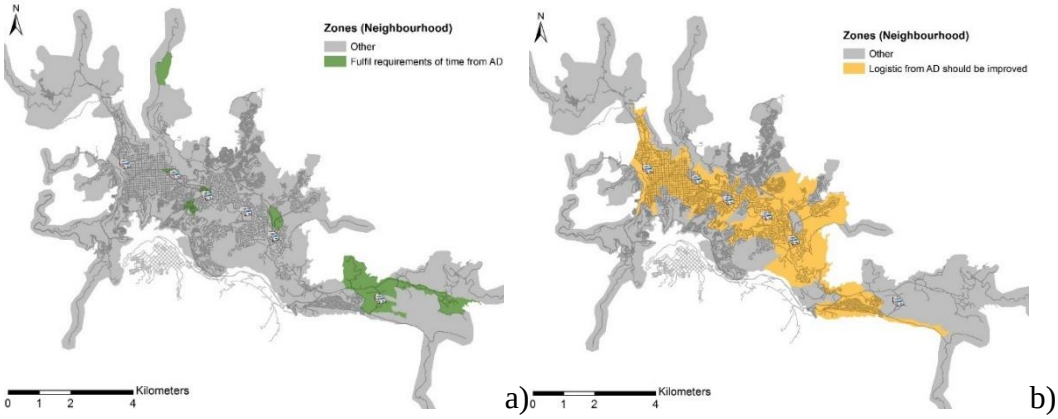

Fig. 5. a) Neighbourhoods which fulfil requirements of time from AD to event; b) Neighbourhoods where the logistic of attention of emergencies must be improved in the journey AD - event.

4 Conclusions

In response time, it is a good standard five minutes as an optimal limit. Due to some authors inferred respond time to reduce mortalities [3, 17], close to this boundary time. Therefore, this research would help to reduce mortalities in medical emergencies. According to the results, to generate equity the cities need an enhanced spatial coverage of AD and ESF. Knowing, that proximity to facilities arrays many factors which influence the health outcomes [26].

With this methodology, the correlation between living in a low income neighborhood and a longer pre-hospital delay [10] is determinate. Ensuring equity in access to emergency medical services.

In accordance with WHO, road traffic accident is a public health issue. Therefore, national government has developed actions to reduce this type of deaths through national plan for road safety. Prompting to reduce the 26% of deaths caused for road traffic accidents [19]. Hence, this methodology collaborates to that aim, providing an appropriate emergency attention. If the aim is generate healthy cities with equity [15], this will be a great step to begin the construction, quitting health inequalities with an adequate distribution of resources as an AD and ESF [14].

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