

THE INFLUENCE OF THE TRANSPORT NETWORK ON THE ACCESSIBILITY DEGREE OF AMBULANCES. CASE STUDY: CHISINAU.

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Rezumat: Reformele implementate în Sistemul de Asistență Medicală (SAM) în țara noastră impun noi abordări și ridică noi cerințe față de modul în care se realizează și se asigură asistența medicală a populației. O componentă importantă a SAM este Serviciul de asistență medicală urgentă.

Localizarea stațiilor SAMU determină costurile (distanță și timp) de acces a serviciilor medicale spre populație. Buna funcționare a SAMU presupune un nivel mare de accesibilitate și mobilitate, care condiționează menirea principală a serviciului. Nivelul înalt al accesibilității poate fi obținut prin localizarea corectă a stațiilor de intervenție în cadrul zonei deservite cât și prin eficientizarea rutelor de la stații spre populație, dar și de la populație spre centrele medicale, ultimele fiind în multe cazuri și punctul final al rutelor.

Key words: road network, accessibility, access zones, isochrones.

Introduction

The implemented reforms in the System of Medical Assistance (SMA) in our country impose new approaches and submit new demands towards the way it is achieved and assured the medical assistance of the population. An important part of the SMA is the Service of Medical Emergency Assistance (SMEA). In the city of Chisinau SMEA represents a territorial structure formed on the hierarchical system of a principal station and 4 secondary stations endowed with 61 specialized motor vehicles (MSRM, 2005).

The localization of SMEA stations establishes the price (distance and time) of the accessibility of the medical services for population. The good functioning of SMEA supposes a high level of accessibility and mobility that determine the main aim of the service. The high level of accessibility can be obtained by correct localization in the zone and both by making more efficient the routes from stations towards population, and from population towards the medical centres, the last ones being in many cases the final point of the routes.

The form of the territory of the city of Chisinau represents a polygonal structure elongated from south-east to north-vest with a surface over 120 km². This polygonal structure is covered by 5 SMEA stations. The uniform territorial covering of the residential zones in the city districts with operative medical services and the improving of SMEA's access represent the goal of this study.

The population's acces to services is very important and is connected to working of a well organized and effectively managed healthcare system. The existing studies (Penchansky,1981; Guagliardo,2004; Brans,1981) distinguish five

levels of population's access¹: availability, accessibility, accommodation, affordability and acceptability. In this study we report only on the accessibility represented by the location, time of access and distance.

Methods and Materials

On the first stage it was formed the linear network of the system of motor vehicles in Chisinau. The network was obtained by digitizing 1:10 000 the topographical maps and the visual rectifying according to Ikonos satellite images of Chisinau. The satellite pictures were of a great utility especially in renewing and actualizing the information about roads. Also due to satellite pictures there were established the portions with the highest motor traffic.

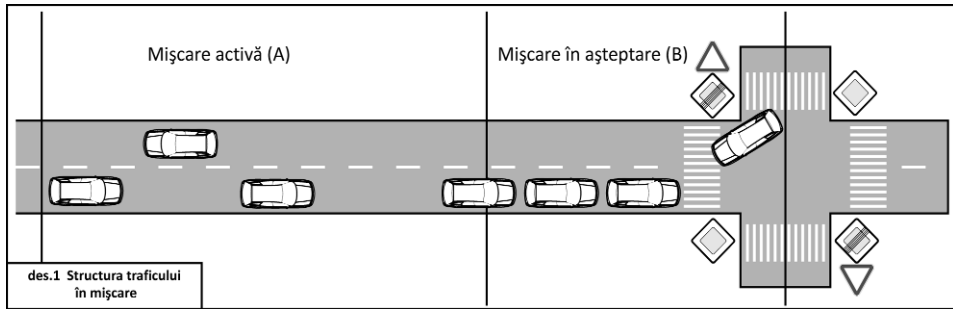
A special role in the investigation is played by the route measurements of the road portions in the network. There were done ten measurements for each road category. It is to mention that this stage was one of the most difficult, implying work on the territory, GPS measurements and high fuel consumption. The measurements pointed out several sections with the highest traffic pressure on the road network. These sections have a very important role on the functioning of the whole road network. Their influence is decisive in increasing the access speed in network and in its diminishing.

To generalize the measurements on road sections we started from the idea of speed homogenizing on the whole segment. The average speed of the section was determined as the average speed of the active motion (A) and the pending motion (B). The first one is conditioned by the speed settled by the Traffic Rules and the type of road wear and the second by the existence of traffic-lights, intersections, and traffic jams (fig.1).

The following stage represented the indexation of the vectors (roads) with random data and network contents, such as: main roads, secondary roads and neighborhood roads, one way or two-way traffic roads etc. For each network segment, which in fact represents a road section, there were calculated lengths (meters), average speed (km/h) and time of travel (minutes) (Butler, 2008).

¹ În articolul "The Concept of Access. Definition and Relationship to Consumer Satisfaction" Penchansky R. și Thomas J.W. evidențiază cinci nivele de acces - **Availability**, the relationship of the volume and type of existing services (and resources) to the clients' volume and types of needs. **Accessibility**, the relationship between the location of supply and the location of clients, taking account of client transportation resources and travel time, distance and cost. **Accommodation**, the relationship between the manner in which the supply resources are organized to accept clients (including appointment systems, hours of operation, walk-in facilities, telephone services) and the clients' ability to accommodate to these factors and the clients' perception of their appropriateness. **Affordability**, the relationship of prices of services and providers' insurance or deposit requirements to the clients' income, ability to pay, and existing health insurance. **Acceptability**, the relationship of clients' attitudes about personal and practice characteristics of providers to the actual characteristics of existing providers, as well as to provider attitudes about acceptable personal characteristics of client'."

In the study as tools there were used specialized software from GIS-T (geographical information systems in transport) group: TransCad 4.5 and ArcGIS 9.1 (module Network Analyst). They allowed the reduction of calculation time and the simplification of case situations' modeling.



Results and Comments

Geographical location of the SMEA stations.

Analyzing the location of SMEA stations throughout the districts of the city we can mention that their location is more or less uniform. All the stations are situated in residential zones of the city. The SMEA stations of Riscani, Centru and Botanica are situated inside the residential zones, excepting those of Buiucani și Ciocana which are located at the edge of residential zones.

It is difficult to highlight the favourability of stations' location. It can seem that their central location in the district is the best solution, but if taking into account the form of the motor transport network and the traffic pressure on the network, it makes possible the short time entrances of the ambulances from the boundaries of residential zones towards inside without staying in traffic jams. A totally different situation is recorded in the case of SMEA stations of Centru, Buiucani and Rascani. Their location inside the residential zones requires direct entrances in the transport network even in the segments where it is the highest traffic. This conditions the diminishing of the route speed in the incipient phase.

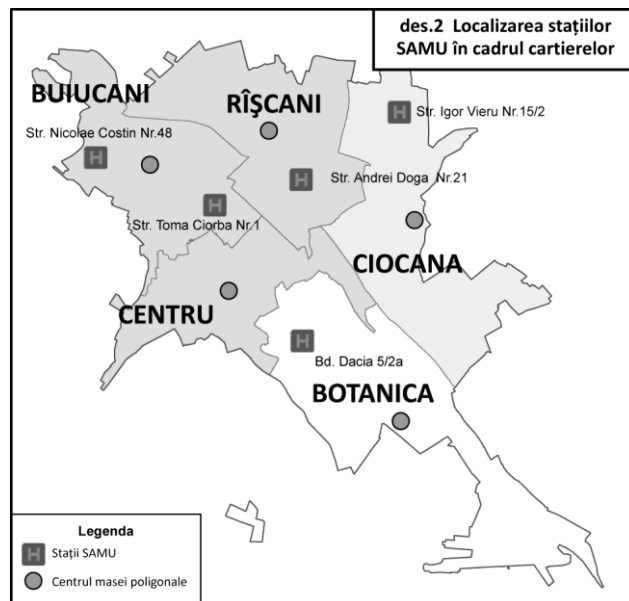
To identify the position of the stations concerning the centres of the districts it was calculated the centre of polygonal mass for each district (Jeness, 2006) (fig.2). The calculations show the location of SMEA stations compared to the centres of the districts. In the case of the Buiucani station it is situated 1,6 km towards north-west, the Riscani station is 1,8 km towards south-east, the Ciocana station is 3,2 km

towards north, the Botanica station is 3,9 km towards north-west. In the case of the Centre station it is situated 2,7 km northward, being located even in another district (Buiucani).

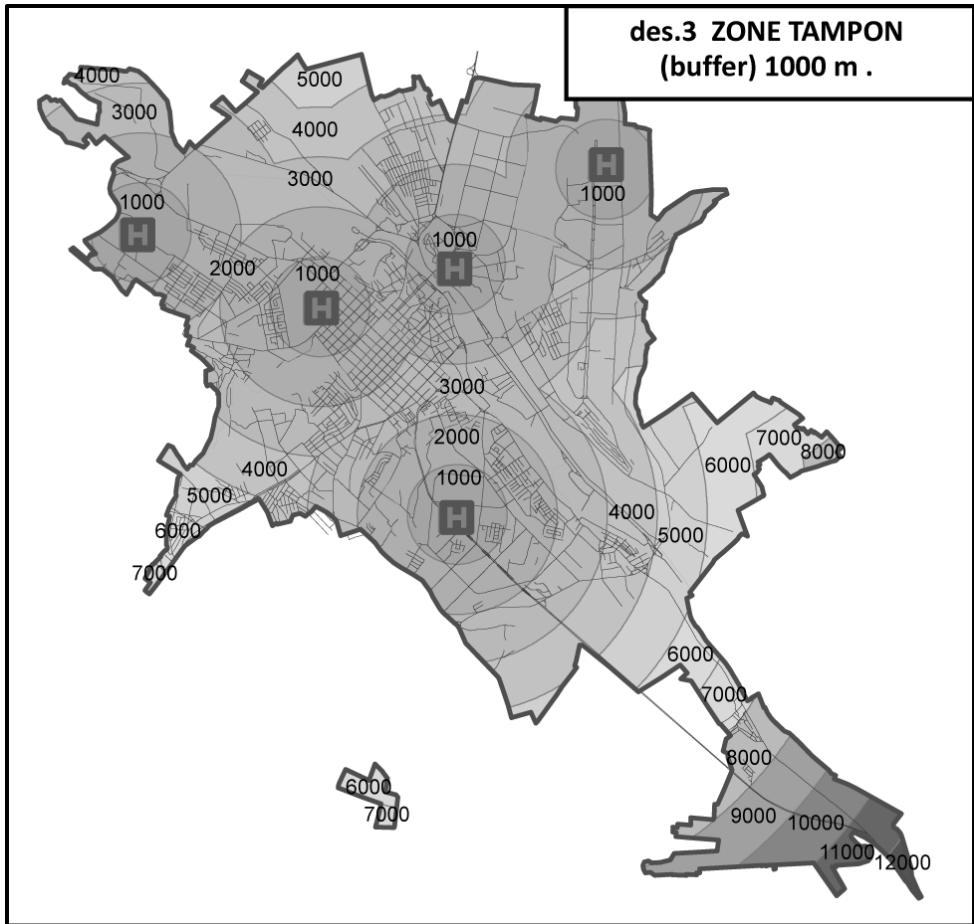
Buffer zones.

An important role in the efficient functioning of the SMEA plays the area of the territory which the service can cover. There were formed several buffer zones marked over 1000 metres. When the zones were formed it was paid attention to the fact that all the stations work as a system. The formed zones represent the territorial overcast of the city by all the stations altogether (fig.3).

The furthest zone is that of 9000 -12000 metres that comprises the south-east part of the city (the region of the airport). Most of the city's residential zones are around 1000 - 4000 metres from the SMEA stations.



It must be mentioned that the buffer zones don't exactly reflect the coverage index, because it doesn't take into account the form and the content of the road network. The formation of buffer zones reflects more a generalizing index of territorial coverage. Eventually the ambulances don't circulate on straight lines, but on roads that can take different configurations and have different cross time.



Time and Distance.

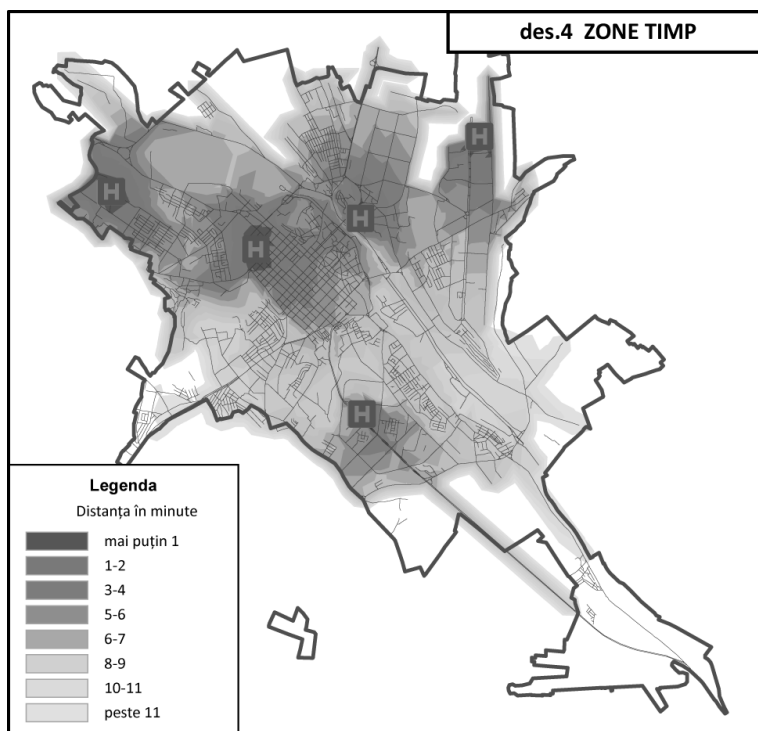
Time and distance in network are two measure indicators that demonstrate the efficiency of network. They are the values that can measure the accessibility of SMEA services to the population and vice versa. The calculations refer primarily to the measurements in the road network in Chisinau city. In order to determine the time and distance zones 135 ambulance calls were modeled. The points for calls

were placed arbitrarily all over the city, but taking into account the distance from the main road lines, the location of SMEA stations, the location within the residential zones of the districts.

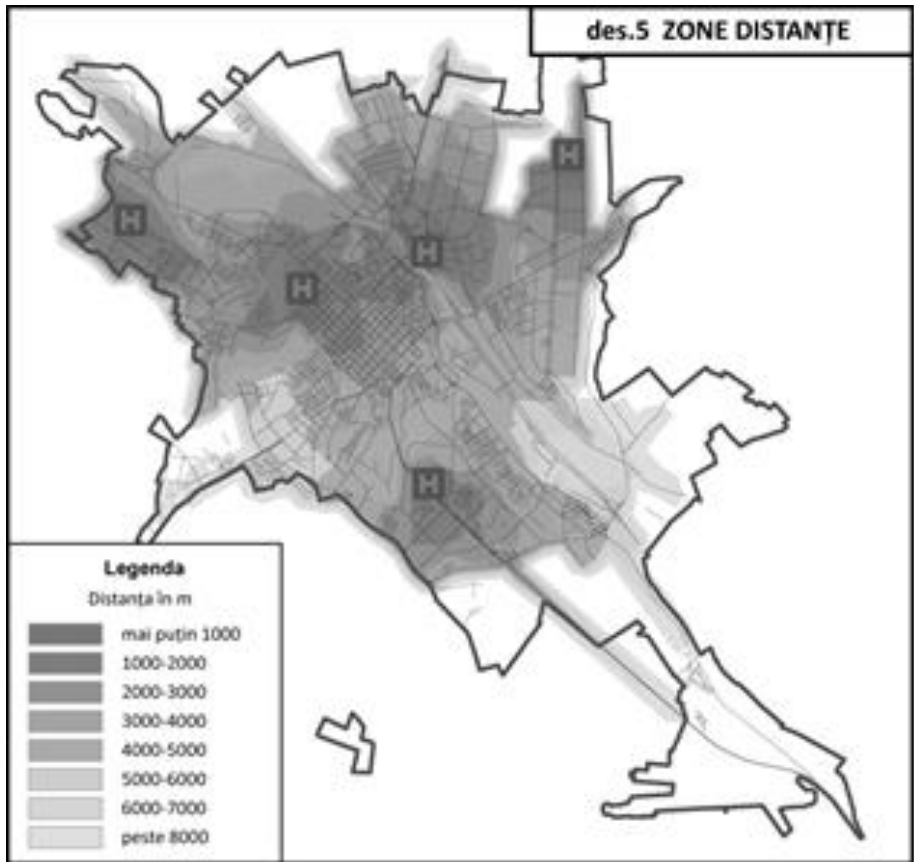
Time. The time indices are in direct correlation to the location and extension of the five city districts and the location of SMEA stations.

Nr. rd	ZONES minute s	BUIUCANI		CIOCANA		BOTANICA		CENTRU		RÂȘCANI	
		km ²	%	km ²	%	km ²	%	km ²	%	km ²	%
1	0 - 1	0,78	9,50	0,22	4,95	0,07	0,77	0,00	0,00	0,10	1,15
2	1 - 2	1,37	16,75	0,49	10,71	0,14	1,59	0,00	0,04	0,71	7,88
3	2 - 3	2,02	24,71	0,72	15,77	0,46	5,44	0,58	6,37	2,35	26,11
4	3 - 4	2,52	30,90	0,58	12,85	1,54	18,10	0,92	10,21	2,84	31,54
5	4 - 5	1,16	14,23	0,64	14,06	1,76	20,67	0,89	9,85	1,91	21,24
6	5 - 6	0,19	2,28	0,70	15,34	0,87	10,30	1,22	13,54	0,60	6,67
7	6 - 7	0,10	1,17	0,29	6,44	1,96	23,08	1,63	18,05	0,19	2,16
8	7 - 8	0,01	0,13	0,21	4,55	1,00	11,72	1,59	17,60	0,04	0,43
9	8 - 9	0,01	0,10	0,33	7,26	0,11	1,24	0,80	8,88	0,03	0,36
10	9 - 10	0,01	0,07	0,13	2,95	0,05	0,64	0,34	3,79	0,02	0,28
11	10 - 11	0,00	0,05	0,12	2,57	0,05	0,64	0,08	0,92	0,02	0,24
12	11 - 12	0,00	0,03	0,04	0,81	0,07	0,88	0,12	1,32	0,02	0,18
13	12 - 13	0,00	0,00	0,02	0,44	0,14	1,59	0,41	4,51	0,01	0,16
14	13 - 14	0,00	0,00	0,01	0,29	0,13	1,57	0,29	3,23	0,01	0,15
15	14 - 15	0,00	0,02	0,01	0,20	0,03	0,32	0,04	0,41	0,01	0,15
16	15 - 25	0,00	0,06	0,04	0,82	0,12	1,44	0,12	1,28	0,12	1,32
			100,00		100,00		100,00		100,00		100,00

The obtained indices are the result of a complex modeling that takes into account the system's operation for the simultaneous serving of all the districts by all the SMEA stations. In our modeling, the serving is not directly connected to the affiliation to a well defined district. Through aggregation were distinguished the polygons of the districts that represent the residential zones of the city. Afterwards, overlapped through „overlay” - „intersect” with attributes' transfer with time zones. There were stabilized 16 zones within the districts with different time of acces of the ambulances (fig.4, tab.1).



The district of Buiucani, according to the obtained data, has the best covering. Over 99% or 8,13 km² of the residential zones area is comprised by the zones 1 – 7. The most remote limits of the district can be reached in 7 minutes. Over 97% (4,42 km²) of Ciocana district are covered by 11 zones, i.e. 11 minutes. The big number of time zones is explained by the big extension of Ciocana district and by the insular shape of the residential zone. Approximately 90% (6,84 km²) of the residential zone of Botanica district is comprised by 6 time zones. In case of Botanica district the closest zones of 1-2 minutes cover only 2,3%. This fact is explained through the location of SMEA station regarding the district, through configuration of transport network and through the traffic direction in the immediate vicinity to the SMEA station of Botanica. 98 % (8,92 km²) of residential zone of Centru district is covered by most of time zones, except only zones 1, 2, 11, and 15. The lack of 1-2 minutes zones is explained by the fact that in this district there are no SMEA stations. The residential zone of Rascani district making 98% (8,83 km²) is covered by eight time zones: 1-7 and 16.



Distance. Distance indices offer another view over the covering of city's residential zones with SMEA services.

.ord	ZONE										
	km	BUIUCANI		CIOCANA		BOTANICA		CENTRU		RÂȘCANI	
		km ²	%	km ²	%	km ²	%	km ²	%	km ²	%
1	0 - 1	1,38	16,87	0,41	8,99	0,21	2,45	0,00	0,01	0,67	7,43
2	1 - 2	2,56	31,38	0,90	19,83	1,49	17,50	0,34	3,73	2,95	32,77
3	2 - 3	3,32	40,62	1,01	22,38	2,26	26,57	1,31	14,55	3,57	39,67
4	3 - 4	0,87	10,66	1,16	25,65	1,92	22,65	1,86	20,56	1,33	14,78
5	4 - 5	0,01	0,17	0,28	6,12	1,87	21,99	2,77	30,69	0,21	2,36
6	5 - 6	0,01	0,15	0,31	6,93	0,12	1,43	1,54	17,01	0,05	0,58
7	6 - 7	0,01	0,07	0,30	6,60	0,03	0,31	0,27	2,95	0,04	0,47
8	7 - 8	0,00	0,00	0,10	2,16	0,06	0,72	0,06	0,66	0,03	0,35
9	8 - 9	0,00	0,03	0,02	0,53	0,27	3,15	0,62	6,85	0,03	0,30
10	9 - 10	0,00	0,01	0,02	0,40	0,20	2,35	0,23	2,55	0,04	0,48
11	10 - 11	0,00	0,01	0,01	0,11	0,03	0,32	0,02	0,24	0,02	0,24
12	11 - 12	0,00	0,02	0,00	0,11	0,02	0,27	0,01	0,10	0,02	0,27
13	12 - 13	0,00	0,02	0,01	0,21	0,03	0,30	0,01	0,12	0,03	0,32

The distance values aren't connected to the traffic and to its intensity as time indices are. They depend only on the remoteness of call points from the SMEA station and on the presence of a road with a geometry closer to a straight line.

There were established 13 zones that cover all districts of the city. All zones as well as the time zones start from the SMEA stations to the districts' outskirts.

The zones were traced over 1 km (fig.5, tab.2).

Over 98% (8,33 km²) of Botanica district are covered by 8 zones. 98,8% (8,94 km²) of Centru district are included in 8 zones (2 – 7 and 9 – 10), among which, the zones 3 – 6 cover 82,8%. Five zones (1 – 5) cover over 97% (8,73 km²) of the area of residential zone of Rascani district.

Conclusions

- 1..SMEA stations' location is more or less successful.
- 2..The stations can cover with services the largest part of the city, taking into account the possible growth zones of the city.
- 3..The accessibility of ambulances is hampered by several factors:
4. Inadequate movement of traffic members;

- 5 Violation of traffic rules by the traffic members;
- 6 Damaged road coverage, which reduces the call time and speed;
- 7 The incorrect algorithm of route covering etc.
- 8 Neutralization of the statement that in Chisinau city the ambulances can not reach all the calls together for less than 10 minutes.
- 9 The extension of the districts and the peripheric location of SMEA station complicate the access and speed of the call (in case of Ciocana, Buiucani and Botanica, with reference to microdistrict „Airport”).

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