Situational analysis for health facility planning

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Abstract

Modern times call for innovative ways to understand and plan for healthcare facilities. How does one determine where the gap lies in current provision of healthcare facilities in order to plan for the provision of healthcare facilities in future? How can one provide a platform with GIS from where politicians and senior management can make informed decisions in this regard? The key lies in the modeling of supply versus demand for different levels of healthcare. Quantifying the different levels of building blocks in conjunction with current base data from the GIS such as road infrastructure as accurate as possible is critical for this process. Emergency Medical Services (EMS) will be used as an example in this process. A careful identification and allocation process needs to be followed to clearly define current supply and current demand before further analysis on future supply and future demand can be considered. This process can become challenging when different administrative levels of authority exists within an organisation. Applying of appropriate datasets available from the census in conjunction with the gathering of appropriate administrative records need to be applied in the context of realistic norms and standards for both supply and demand. Further quantification of key results can then assist in identifying proposed areas of focus. Different approaches can be taken once the current gap has been identified for further facility allocation modeling. The main objective of this paper is to look at Emergency Medical Services (EMS) as an example of one of these processes as a situational analysis. In this example the process of modeling current healthcare provision as a base for further long term planning gets explored.

Keywords

situational analysis, health, facility planning

Introduction

The healthcare industry has many challenges in providing adequate healthcare services to the people of Gauteng. Although Gauteng is geographically the smallest province in South Africa, it has the highest population numbers and densities in South Africa. It is perceived by many people in South Africa and Africa as the main economic engine and therefore as the ideal destination to fulfill their socio-economic and healthcare needs. For this reason it is vital to use innovative ways in planning for the provision of healthcare in Gauteng and the rest of the country.

Project background

A team of specialists was tasked to look at best ways to model the provision of healthcare in Gauteng, to identify where the current gap in service delivery exists. This would then establish a base from where further analysis can be done to identify possible future gaps in service delivery in order to assist current long term planning processes. The project was therefore divided in different phases of which the first phase was a situational analysis on the current gap in service provision. Due to the extent of the project not all sections of this phase will be discussed in here, but Emergency Medical Services (EMS) will be used as an example of one section in this process.

Methodology and approach

Supply vs demand

In this study the first step was to identify both the supply and demand in the case with EMS services. Therefore the demand was quantified as uninsured population from the Census 2011 Small Area Layer (SAL) and allocated proportionally to a uniform tessellated surface of hexagons which was around 1.3 km² in size. The SAL population was projected proportionally based on the 2014 midyear estimates from Statistics South Africa.

Various factors can play a role on this demand in healthcare. The project team also started doing some work on determining a deprivation index, to also keep in consideration the impact of factors such as the burden of disease. More work needs to be done on this, but this is something which can play an important role in future analysis.
The supply was identified as number of ambulances per EMS station and then also allocated accordingly to the tessellated surface. The tessellated surface was used within Flowmap in conjunction with the road network to model where the supply does not meet the demand for both a single and double constraint scenario. The single constraint scenario per definition considered only drive time from each EMS station and the double constraint scenario per definition considered both drive time and capacity from and at each EMS station. This will be discussed in more detail later in this paper.

Fig. 1: Public population per hexagon.

A map with the allocated uninsured population per hexagon can be seen in Fig. 1 which was used to represent the demand in the modeling. Due to the proportional allocation of population to equal sized hexagons, this map also represents uninsured population densities per hexagon. The light green, orange and red hexagons represent pockets of areas where high number of uninsured population exists. This means that the lowest density of people will be in the dark green areas and progress in density to light green, then orange and then eventually the red areas which represent the most densely populated areas.

The typical character of Gauteng can be seen here where a high concentration of people exists in the three metro areas of City of Tshwane, City of Johannesburg and Ekurhuleni. Typically one sees a very big difference between the high density and low density areas within Gauteng. This emphasises the fact that capacity of EMS stations should also vary accordingly to represent the spread in concentration of people.

Fig. 2: EMS stations per sub-district.
The EMS stations for Gauteng can be seen in Fig. 2 which were used as a measure of supply. Again one can see that more EMS stations exist around the city centres of the three metro areas. This map represents both provincial and local government EMS stations in order to have a complete picture of government supply and therefore not to skew the picture.

**Norms and standards**

The next step in the modeling process was to determine acceptable norms and standards for EMS. The National norm for P1 response time for ambulances is 15 minutes. This norm was used as a drive time response norm on the standard road network. The road network available for the study was procured from a reputable private vendor who also provides their data to some of the commercial Global Positioning Systems (GPSs).

The second norm, also from the National Department of Health, is the number of population needed for one ambulance. The available norm here is one ambulance for every 10 000 people. This norm was used to determine the capacity available at each EMS station. It is also important to note that although this norm was used, more work is in progress to look at adjusting this norm to compensate for high population densities within Gauteng. The possibility for a norm of 30 000 or 45 000 people per ambulance is currently under discussion.

**Assumptions/concerns**

The following assumptions were made:

- All projections were based on uninsured population only, although 21% of the population has medical insurance.
- Around 30% of the uninsured population do not use public sector primary healthcare facilities and services.
- Insured population may use public sector for some services.
- The denominator does not include people from other provinces. (The analysis depends on census figures per province at the night of the count.)
- The denominator does not include people from other countries. (The analysis depends on census figures per province at the night of the count.)
- It is assumed that the majority of public population in lower income brackets will make use of public ambulances and that private population in higher income brackets will make use of private ambulances. However it is known that this might not always be applicable.

**Software used**

A variety of software was used, but the main GIS modeling software was Flowmap and Esri’s ArcGIS 10.2.

**Results**

The results from the above modeling provided the number of people not covered by the EMS stations within the 15 minute norm (the gap in EMS provision). This result was obtained for both a single constraint scenario as well as a double constraint scenario as mentioned before, which was again used to model best placement for possible new EMS stations.

**Single constraint gap**

With the single constraint analysis, the population was identified that fall outside of the 15 minute norm from each of the EMS base stations without considering capacity at each station.
Fig. 3: Population outside catchment (single constraint).

Fig. 3 illustrates the results from the single constraint analysis. The green and blue areas indicate the areas which fall outside the 15 minute drive time norm. In this case only the drive time gets used in the modeling without considering the capacity at each EMS station. The grey hashed areas indicate the combined 15 minute drive time from each EMS station.

It is clear in this scenario that it seems as if most of the population in Gauteng is covered with the existing EMS stations. If one quantifies the results from the modeling then it appears that around 522 734 people are not covered by the existing EMS stations. In the next scenario we will see how drastically the situation changes when one brings the capacity at each EMS station into the equation.

Double constraint gap

With the double constraint analysis, the population was identified that fall outside of the 15 minute norm from each of the EMS base stations with consideration of capacity at each station.

Fig. 4: Population outside catchment (double constraint).

Fig. 4 illustrates the results from the double constraint analysis. The green and blue areas again indicate the areas which fall outside the 15 minute norm. In this case both the drive time and capacity at each EMS station are being used in the modeling. The grey hashed areas again indicate the combined 15 minute drive time from each EMS station.
In this scenario one can clearly see that many more people now fall outside of the 15 minute norm with the consideration of capacity at each EMS station. What this means in reality is that the 15 minute catchment area of some EMS stations are saturated by the immediate demand before the actual catchment area can be reached. The lack in capacity at some stations therefore has the effect of shrinking the actual catchment area before it can be reached. If one quantifies the results from this modeling then it appears that around 6,948,402 people are not covered by the existing EMS stations.

The above modeling results make it now possible to model possible proposed EMS station allocation points with a certain capacity. An expansion model was used to model maximum customer coverage. Additional EMS sites were allocated where the highest population share would be covered. Three scenarios were modeled which will be further discussed next.

Facility allocation scenario 1

![Fig. 5: Possible new stations with three ambulances each (scenario 1).](image)

In the first scenario the allocation of EMS stations with three ambulances each were done as illustrated in Fig. 5. This resulted in the identification of 28 possible sites with three ambulances each. Therefore a total of 84 ambulance allocations were identified here.

Facility allocation scenario 2

![Fig. 6: Possible new stations with five ambulances each (scenario 2).](image)
In the second scenario the allocation of EMS stations with five ambulances each were done as illustrated in Fig. 6. This resulted in the identification of 20 possible sites with five ambulances each. Therefore a total of 100 ambulance allocations were identified here.

Facility allocation scenario 3

![Fig. 6: Possible new stations with seven ambulances each (scenario 3).](image)

In the last scenario the allocation of EMS stations with seven ambulances each were done as illustrated in Fig. 7. This resulted in the identification of 18 possible sites with seven ambulances each. Therefore a total of 126 ambulance allocations were identified here.

Discussion

It is a known fact that the majority of analysis time is spent on gathering and cleaning of data before any analysis can be started. In this case the situation was no different. A lot of time had to be spent on checking, cleaning and geo-coding the EMS station list. The EMS unit assisted in this process to get final verification on usable ambulances per EMS station with their physical addresses. This process was preceded by a lengthy comparison of different lists from sources such as fleet management services as well as from routine data available on the District Health Information System Software.

Government bureaucracy is another factor which complicated the process further. The reality is that both provincial and local government has EMS stations with ambulances. The challenge then was to make sure that all the EMS sites from both sides were covered and to get the actual number of ambulances at each site. Although EMS stations exist in both provincial and local government spheres, it is important to use the combined picture when doing modeling for planning purposes. A further reality is that although a certain number of ambulances might be available on paper; this might be significantly less due to breakdowns or other reasons for unavailability. This is why it was important in this study to take some extra effort to try and obtain the number of actual usable ambulances.

Data considerations also play an important role in this study. Future improvements in this analysis can be made as technology progresses and more sophisticated road datasets become available that cater for actual road speed based on user feedback. This will have to then cater for both an average actual speed and a maximum actual speed. The fact is that we know that an ambulance can drive faster than the speed limit, if the road condition permits it or he might in some cases only be able to drive much lower than the speed limit if factors like road congestion play a role. This will therefore affect the size of the 15 minute catchment and therefore also the results from the model. In this study we used the data available to the department which only uses road speed per road segment which should at least provide a good indication of reality.

Another important factor to bear in mind is the type of model to be used when allocating possible new sites. The DPSA’s guideline to improving geographic access to government service points [1] was used as a guide in considering the type of model to use. According to this document the following models exists:
Expansion model

This model is used to increase service points and therefore the identification of optimal points. In the study this is what we wanted to achieve so we opted for this model. Although the other models will be discussed briefly, more focus will be placed on sub categories within the expansion model. Two different approaches can be taken here, namely a Greenfields and Brownfield’s approach.

- **Greenfields approach**

This approach defines the optimum location of service points and keeps in consideration number of target demand reachable, capacity, access standards defined as well as road network. Existing stations are not considered in this approach.

The model starts where the largest concentrations of beneficiaries are located. Stations get added until all optimal located sites have been identified. These stations will then be placed as close as possible to where the demand exists.

Competition between EMS stations gets considered for nearby demand to ensure demand gets allocated to the closest station.

Possible new stations will not be identified where the demand falls below the minimum demand parameter for the establishment of a new station. In these cases other ways must be explored to access those areas, like for instance deploying ambulances at certain locations in these areas periodically as mobile stations.

- **Brownfield’s approach**

This approach takes in consideration the location of existing stations in order to determine the optimum location of new EMS stations. Besides this, all the rest of the modeling gets implemented in exactly the same way. At this stage closing down of existing EMS stations was not an option in this project, so the Brownfield’s approach was used in modeling possible placement of new EMS stations.

Reduction model

This model reduces the number of facilities and will be used in cases where more facilities exist than what can be identified through applying the access norms and standards.

Relocation model

This model optimises the location of existing service points in cases where current facilities are not located optimally and more optimal locations are needed.

The results generated from the EMS modeling formed part of a bigger modeling process in order to compile the first phase of a long term plan (LTP) for the department and therefore should at the end be seen in context with the other components of the plan.

Further initiatives also included integrating the findings from this phase with critical initiatives from other organisations such as The Human Settlements Department. It is therefore important to realise that analysis like this needs to be brought into context with other realities such as budget constraints, other existing development initiatives from other departments, availability of land at proposed locations etc. In the case with EMS, the fact that EMS vehicles are mobile, provide an ideal opportunity to consider sites for re-deploying vehicles in areas close to the identified optimum locations. The same can be done in areas which fall below the minimum demand level, in order to create a type of mobile EMS station.

The impact of innovative planning with specific focus on EMS can have much greater impact than just improved service delivery on the ground. It is important for us to remember the importance of sustainable development with the focus on reduced pollution in its totality (ecological footprinting) from better placement and distribution of ambulances [2]. In this way both man and nature can benefit from this through lower operational cost as well as less pollution in the long run from EMS vehicles. The ripple effect of this together with other similar improved planning initiatives will then hopefully eventually assist in a healthier nation with less dependence on the healthcare system.
Conclusion

The situational analysis based on spatial modeling of where the current gap in EMS services exists enabled the planning team to get a solid understanding of where the current needs in EMS services are. This enabled the planning team to make tangible proposals to senior management on current need and to then start the second phase on possible future needs. It is very important to realise that these analyses still only provide a guideline and that this must be looked at in conjunction with other planning initiatives as well as with other external influencing factors.

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References


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