Development of health sensity indicators in South Africa using GIS

by Tholang Mokhele, Gina Weir-Smith and Demetre Labadarios, Human Sciences Research Council

Abstract

The scope and emphasis of a public health program are necessarily influenced by the changing characteristics of the population it serves. In South Africa, population growth between 2004 and 2009 has outstripped the availability of health facilities. GIS provides ideal platforms for decision makers to easily visualize problems in relation to existing health services as well as distribution of health facilities and their surrounding populations. Therefore this research was aimed at developing health density indicators in South Africa at a sub-provincial level using GIS in order for decision makers to target appropriate populations and areas for intervention. This research used the existing (5043) public health facilities data (2010) together with some additional data from the Department of Health and Stats SA Community Survey 2007 population estimates at municipality level to develop two health facilities density indicators. The first indicator, health facilities per population, was calculated by dividing the number of health facilities by the total population (per 10 000) at a municipal level. The second indicator was calculated by dividing the number of health facilities by square kilometre (1000 km²). Findings showed that most municipalities that had a low coverage in terms of the number of health facilities per 10 000 population are located in the eastern part of the country as well as in urban areas even though there are more health facilities in these urban areas as the total population is also much higher due to migration. Results also indicated that the density indicator per 1000 km² is useful for large areas so that the distribution do not get skewed by the size of a municipality. Therefore, the combination of the two indicators is of high importance in final decision making in prioritizing areas for health care interventions for large municipalities characterized with low populations.

Keywords

South Africa, GIS, health facilities, population, indicators

Introduction

The scope and emphasis of a public health program are necessarily influenced by the changing characteristics of the population it serves. The rate of population growth affects long term planning of community health and medical facilities. Alterations in age composition, internal migration, changes in population density and urban-rural movement are all factors that need to be considered [1].

Preparing the health workforce to work towards the attainment of a country's health objectives represents one of the most important challenges for its health system. According to the World Health Report [2], South Africa is one of the few countries in Africa which does not have a critical shortage of health service providers (doctors, nurses as well as midwives). However, inequities exist in access to health services between public and private sectors, as well as within the public sector itself, especially between urban and rural areas [2 – 4]. Thus, even though the constitution states that everyone has the right to essential health care services, many South Africans still do not have adequate access to quality health care services.

South Africa faces colliding epidemics through explosive HIV/Aids and TB, a high burden of chronic illness, mental health disorders, injury and violence-related deaths as well as a silent epidemic of maternal, neonatal and child mortality. South Africa's per capita health burden is the highest of any middle-income country in the world [5]. Population growth between 2004 and 2009 has outstripped the availability of health facilities. For example, the country's population per clinic is 13 718, which is inconsistent with the WHO norm of 10 000 people per clinic [6]. Furthermore, Day and Gray [7] indicate that the population density in most provinces increased between 1996 and 2010 (see Table 1). This means an enlarged burden in terms of the number of people that require access to health care services. An extremely high increase occurred in Gauteng, while KwaZulu-Natal and Western Cape also experienced significant increases.

Year/Province	EC	FS	GP	KZN	LP	MP	NC	NW	WC
1996	38,4	21,0	448,4	95,1	41,7	36,7	2,3	29,9	31,5
2010	39,9	21,8	615,7	112,8	43,3	47,3	3,0	30,5	40,4

Table 1: Population density (persons per km²) in 1996 and 2010 (Source: [7]).

In order to properly plan, manage and monitor any public health programme, it is vital that up-to-date and relevant information is available to decision-makers at all levels of the public health system. As every disease or health event requires a different response and policy decision, information must be available that reflects a realistic assessment of the situation at local, national and global levels. This must be done with the best available data and taking into consideration disease transmission dynamics, demographics, availability of and accessibility to existing health and social services as well as other geographic and environmental features such as natural barriers, e.g. mountains and rivers.

Access to health care is an important component of an overall health system and has a direct impact on the burden of disease that affects many countries in any developing world. Therefore measuring accessibility to health care contributes to a wider understanding of the performance of health systems within and between countries which facilitates the development of evidence based health policies. Geographic accessibility often is concerned with the complex relationship between the spatial separation of the population and the supply of health care facilities and thus has a strong underlying geographic component [8]. GIS provides an ideal platform for the convergence of disease-specific information and their analyses in relation to population settlements, surrounding social and health services and the natural environment [9]. It is highly suitable for analysing epidemiological data, revealing trends and interrelationships that would be more difficult to discover in tabular format. Moreover GIS displays can help inform proper understanding and drive better decisions, and GIS allows policy makers to easily visualize problems in relation to existing health services and so more effectively target resources.

Since 1993, the WHO's Public Health Mapping and GIS programme has been leading a global partnership in the promotion and implementation of GIS to support decision-making for a wide range of infectious disease and public health programmes [10]. GIS has proven to be core to epidemiological analysis (person, time and place), analysing spatial trends, planning and targeting of resources, stratifying risk factors, identifying populations at risk, monitoring programmes over time and advocacy [11]. It has also been used by health services researchers and epidemiologists to study populations to better understand cancer epidemiology, disease outbreaks and even the impact of distance on care. Therefore, the aim of this research was to develop density indicators of health facilities in South Africa at a sub-provincial level with GIS functionality.

Data and methods

This research used the existing public health facilities data (2010) together with some additional data from the Department of Health to develop two health facilities density indicators, namely the number of health facilities per population in a municipality and the number of health facilities per square kilometre in a municipality. For the total population (denominator), the Stats SA Community Survey 2007 population estimates at municipality level was used. The total number of health facilities for the whole country was 5043. Both datasets were originally in an Excel spreadsheet and were converted to .dbf format to link them with the 2005 local municipality boundaries data. Atlas GIS 4.0 was used for the area calculation of each municipality in kilometres. Thereafter the data were exported back to .dbf format, linked to the spatial data and opened as shapefile in ArcMap where the two health density indicators were calculated. The first indicator, health facilities per population, was calculated by dividing the number of health facilities by the total population at a municipality level. The denominator was standardised to 10 000 people, which is the WHO norm [6, 12]. The second indicator was calculated by dividing the number of health facilities by square kilometre and the denominator was standardised to 1000 km^2 based on the spatial level of analysis.

Results and discussions

Fig. 1 presents the estimates of the density of health facilities per 10 000 population at municipality level in South Africa. The national average for this indicator is two health facilities per 10 000 population, even though there is no clear threshold, this might be close to the WHO norm of 10 000 people per clinic [6]. One should note that the WHO norm considers clinics only whereas the developed indicator did not consider the type of health facilities as it included all types of public health facilities such as clinics, hospitals, mobile clinics, community health centres as well as satellite clinics. Most municipalities that have a low coverage in terms of the number of health facilities per 10 000 population are located in the eastern part of the country. The reason for this is that in the western part of the country, the total population is low in most municipalities and therefore the low number of health facilities could be enough. Similar instances of low coverage per population were also found in urban municipalities. Even though there are more health facilities in these urban areas, the total population is also much higher due to migration (rural-urban movement) of people in search for jobs and better services. All six the metropolitan municipalities also had low coverage of health facilities with between 0,01 and 1,00 health facilities per 10 000 population. The majority (70%) of the District Management Areas (DMAs) had no health facilities as illustrated in Figs. 1 and 2.

In the Western Cape, the majority of municipalities had a good coverage of 2,01 to 13,20 health facilities per 10 000 population. Only two municipalities had a low coverage (0,01 to 1,00 health facilities per 10 000 people) and these were the City of Cape Town Metro and Stellenbosch municipalities, with 0,66 and 0,90, respectively (see Table 2). Four

municipalities (Drakenstein, Breede Valley, Mossel Bay and George) had 1,01 to 1,50 health facilities per 10 000 population.
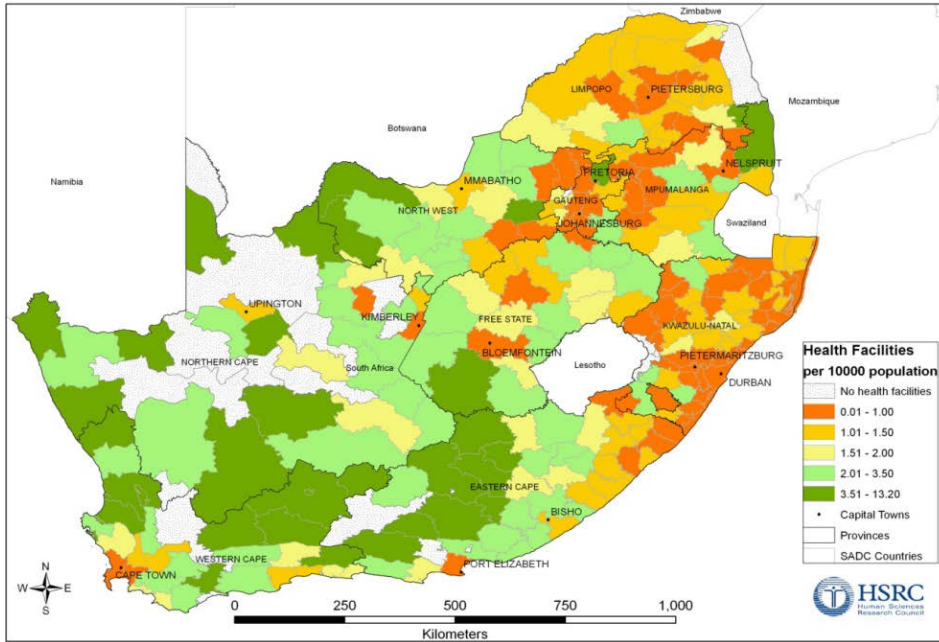

Fig. 1: Number of health facilities per 10 000 population.

In the Eastern Cape, about six municipalities had a low coverage (0,01 to 1,00 health facilities per 10 000 people) and five of these municipalities were located close to the border of KwaZulu-Natal. These included Nelson Mandela Bay Metro, Nyandeni, Qaukeni, Mbizana, Matatiele and Umzimkhulu local municipalities. All municipalities that had 1,01 to 1,50 health facilities per 10 000 people, except Buffalo City, were located in close proximity to the above mentioned municipalities. The municipalities with a good coverage of health facilities per population were located in the north-western part of the province.

KwaZulu-Natal is the province with the lowest coverage in terms of health facilities per population and is the only province where none of the municipalities fell in the highest category (3,51 to 13,20 health facilities per 10 000 population). Across the country, 60% of the 10 lowest covered municipalities in terms of health facilities per 10 000 population is from this province (see Table 2). Only six municipalities were in the higher category of 1,51 to 3,50 health facilities per 10 000 population. These were Nkandla, Mooi Mpofana, Utrecht, Ubuhlebezwe, Kwa Sani, and Greater Kokstad local municipalities. The rest of the municipalities were in the low coverage categories, with the majority (60%) in the lowest category of 0,01 to 1,00 health facilities per 10 000 population.

In the Free State, there were three municipalities that had very low coverage (0,01 to 1,00 health facilities per 10 000 population), namely Metsimaholo, Matjhabeng and Mangaung local municipalities. Three municipalities (Maluti a Phofung, Mqhaka and Nala) were in the category of 1,01 to 1,50 health facilities per 10 000 population. The majority (42%) of municipalities had good coverage of 2,01 to 3,50 health facilities per 10 000 population. Only the Kopanong local municipality was in the highest category of 3,51 to 13,20 health facilities per 10 000 population scoring 3,84.

Municipality	Province	Population	Health facilities	Health facilities per 10 000 population	Health facilities per 1000 km²
				Highest 10	
Kamiesberg	NC	12 117	16	13,20	1,35
Laingsburg	WC	5154	5	9,70	0,56
Mier	NC	7328	5	6,82	0,42
Khâi-Ma	NC	12 568	8	6,37	0,95
Inkwanca	EC	14 285	9	6,30	2,50
Richtersveld	NC	14 614	9	6,16	0,94
Molopo	NW	6508	4	6,15	0,32
Prince Albert	WC	8378	5	5,97	0,61
Tsolwana	EC	27 662	16	5,78	2,64
Ventersdorp	NW	36 531	19	5,20	5,02

				Lowest 10	
Mbonambi	KZN	118 078	7	0,59	5,75
Indaka	KZN	101 555	6	0,59	6,02
City of Tshwane Metro	GP	2 345 909	130	0,55	59,39
Impendle	KZN	39 403	2	0,51	2,10
uMhlathuze	KZN	332 154	16	0,48	20,08
eThekwini Metro	KZN	3 468 087	165	0,48	71,55
Kgatelopele	NC	21 501	1	0,47	0,40
Emalahleni	MP	435 226	17	0,39	6,30
Imbabazane	KZN	140 753	4	0,28	4,82
Ntambanana	KZN	94 187	2	0,21	1,84

Table 2: Ten highest and ten lowest covered municipalities in terms health facilities per 10 000 population.

In the Northern Cape, only two municipalities (Sol Plaatjie 0,74 and Kgatelopele 0,47, which is among the 10 lowest covered municipalities across the country as shown in Table 2) were in the lowest category of 0,01 to 1,00 health facilities per 10 000 population. This province is characterised by sparsely populated municipalities and a lot of parks and reserved areas and therefore there were many municipalities with no health facilities at all while the majority of municipalities (65%) had more than 2,01 health facilities per 10 000 people. This is also supported by the fact that four of the ten highest covered municipalities are from Northern Cape (see Table 2).

In the North West, the five municipalities that had a low coverage of health facilities per population were located close to the border of Gauteng. These included Bela-Bela, Madibeng, Rustenburg, Potchefstroom and Matlosana local municipalities. These municipalities represent the highest concentrations of people in the province. There were three municipalities (Merafong City, Mafikeng and Maquassi Hills) that had between 1,01 and 1,50 health facilities per 10 000 people. The majority of municipalities (57%) in this province had a good coverage with more than 2,01 health facilities per 10 000 people.

In Gauteng, which has three metros, the majority of municipalities (58%) had a low coverage of health facilities per population. This might be due to the fact that almost all municipalities in Gauteng are urban or semi-urban areas and subject to fluctuating population numbers due to migration. The West Rand DMA had no health facilities at all. Nokeng tsa Taemane and Lesedi local municipalities were the only municipalities with a good coverage of more than 2,01 health facilities per 10 000 people, with 3,64 and 2,26, respectively.

In Mpumalanga, the majority of municipalities (72%) had a low coverage of health facilities per population and were located in the western part of the province, mostly towards the border of Gauteng. Only four municipalities were in the good coverage category of 2,01 to 3,50 health facilities per 10 000 people. These included Dipaleseng, Mkhondo, Umjindi and Highlands local municipalities.

Limpopo was the province with the second lowest coverage after KwaZulu-Natal and is the only province with only one municipality (Mookgopong with 2,97) in the good coverage category of 2,01 to 3,50 health facilities per 10 000 population. Only four municipalities were in the middle category of 1,51 to 2,00 health facilities per 10 000 population and these were Mutale, Maruleng, Modimolle and Thabazimbi local municipalities. The majority of municipalities (70%) had less than 1,50 health facilities per 10 000 people.

In general, although the standardised density (per 10 000 population) does not indicate the exact number of health facilities in a municipality, it provides a clearer picture of the distribution of health facilities in relation to the population. Therefore the results from this health density indicator can help the government, NGOs and international agencies to prioritize municipalities in terms of health facilities in order to provide better health care for all citizens.

The concentration of health facilities per square kilometre (Fig. 2) shows that high concentrations (more than 20 health facilities per 1000 km²) occurred in all metropolitan areas (Cape Town, Port Elizabeth, Durban, Johannesburg, Pretoria and Germiston) as illustrated in Table 3. These areas have high populations and cover small areas. Other municipalities which had high concentrations (>20) of health facilities included are in Buffalo City with in the Eastern Cape as well as The Msunduzi with 65,93, Hibiscus Coast with 26,07 and Umhlathuze with 20,08 in KwaZulu-Natal. In Gauteng, eight of the 13 municipalities had more than 20 health facilities per 1000 km². One municipality in Mpumalanga, namely Dr JS Moroka, also fell in this category with 20,37 health facilities per 1000 km².
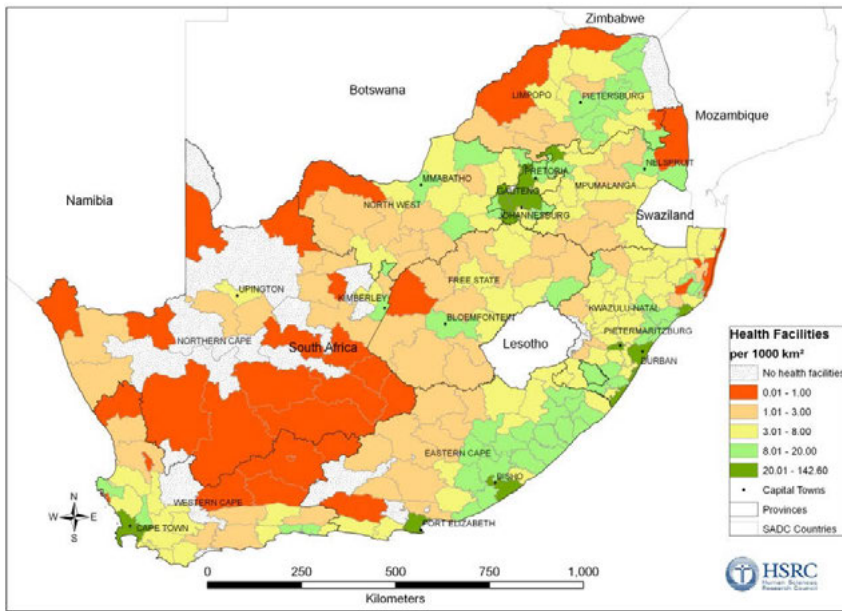
Fig. 2: Number of health facilities per 1000 km².

Municipalities that had between 8 and 20 health facilities per 1000 km² were located around major towns in the Western Cape, e.g. Saldanha/Vredenburg, George, Knysna and Paarl. The municipalities in the eastern part of the Eastern Cape were also in this category while the Northern Cape had two municipalities in this category, namely Sol Plaatjie (Kimberley) and Phokwane, with 14,32 and 9,52, respectively. In the Free State the Mangaung and Maluti a Phofung municipalities had more than eight health facilities per 1000 km², with 11,53 and 10,35, respectively. In the remainder of the country, municipalities in this category were distributed across the provinces. Nine out of the 26 municipalities in Limpopo had between eight and 20 health facilities per 1000 km².

The municipalities that had an extremely low concentration of public health facilities tend to be those that are very large in area and usually with a very low population density. In the Northern Cape most municipalities had between 0 and 1 public health facility per 1000 km², this is also indicated by the fact that eight out of ten municipalities with lowest health facility densities per 1000 km² across the country are in this province (see Table 3). Although these municipalities might in reality have more than one public health facility, the standardized indicator (per 1000 km²) indicates a number between 0 and 1. There was also no distinction between the type of facility, i.e. mobile, tertiary hospital, clinic, etc., but the analysis agglomerated all types of facilities. Many municipalities in other provinces with a low number of public health facilities per 1000 km², were located in border areas, e.g. in the west and north of Limpopo, east of Mpumalanga and northern parts of North West.

The average number of public health facilities per 1000 km² was eight and the number of municipalities that had more than eight facilities was the exception rather than the rule (75 out of 257). Since this indicator considers only area (km²) it provides an indication based on a standardised area. When interpreting this indicator, it is therefore expected that the distribution of public health facilities will not be affected by the size of large municipalities (e.g. in the Northern Cape), however this might bring some challenges to health facilities management such as low supervision visit rates due to long distances between health facilities.

Municipality	Province	Population	Health facilities	Health facilities per 10 000 Pop	Health facilities per 1000 km²
					Highest 10
City of Johannesburg Metro	GP	3 888 182	236	0,61	142,60
Ekurhuleni Metro	GP	2 724 227	192	0,70	99,12
City of Cape Town Metro	WC	3 497 101	232	0,66	93,62
eThekwini Metro	KZN	3 468 087	165	0,48	71,55
The Msunduzi	KZN	616 733	42	0,68	65,93
Emfuleni	GP	650 872	61	0,94	62,76
City of Tshwane Metro	GP	2 345 909	130	0,55	59,39
Mogale City	GP	319 633	53	1,66	47,96

Nelson Mandela Metro	EC	1 050 934	76	0,72	38,58
Buffalo City	EC	724 308	95	1,31	37,42
					Lowest 10
Lephalale	NP	80 141	11	1,37	0,55
Renosterberg	NC	9186	3	3,27	0,54
Siyathemba	NC	20 121	4	1,99	0,48
Mier	NC	7328	5	6,82	0,42
Kgatelopele	NC	21 501	1	0,47	0,40
Molopo	NW	6508	4	6,15	0,32
Hantam	NC	21 235	7	3,30	0,25
Ubuntu	NC	16 148	5	3,10	0,24
Kareeberg	NC	9868	4	4,05	0,22
Karoo Hoogland	NC	10 419	4	3,84	0,13

Table 3: Ten highest and ten lowest covered municipalities in terms health facilities per 1000 km².

The two health density indicators seem to compensate the weakness of one another. For instance, the health facilities density indicator per km² is useful for large areas so that the distribution do not get skewed by the size of a municipality whereas the health facilities density indicator per population indicates the proportion of health facilities in relation to the surrounding population. South Africa is characterized by a number of large municipalities but with a low population (e.g. in the Northern Cape) and therefore the density indicator per population might be a more useful one. Even though municipalities with lower coverage of health facilities per 1000 km² might have some challenges when it comes facilities management such as low supervision visit rates due to long distances between health facilities, these are municipalities with good coverage in terms of health facilities per 10 000 population (see Table 3). There were few cases where the figures of the two indicators (health facilities per 10 000 population and per 1000 km², respectively) were close to the national averages in the same municipalities, these included Saldanha Bay (2,03 and 9,03) in Western Cape, Lukanji (1,78 and 8,63) and Emalahleni (2,31 and 8,13) in Eastern Cape, Mutale (1,85 and 8,49) in Limpopo as well as Umjindi (2,31 and 7,98) in Mpumalanga. Even though these national averages are documented targets, but they give a general picture that these municipalities are well balanced.

Conclusions and recommendations

This research has shown that municipalities with low numbers of public health facilities are predominantly located in the western part of the country. However, many of these municipalities also have low population densities and the distribution of public health facilities might therefore be adequate for the population. In addition, the results from this research can help the government, NGOs and international agencies to prioritize municipalities in terms of health facilities in order to provide better health care for all citizens.

Since there is seemingly no internationally accepted standard in terms of access to health facilities, it is difficult to indicate municipalities which have inadequate coverage of health facilities. The study has aimed to set a base for future research in this field. The density indicator per km² is useful for large areas so that the distribution do not get skewed by the size of a municipality. South Africa is characterized by a number of large municipalities but with a low population (e.g. in the Northern Cape) and therefore the density indicator per population might be a more useful one. This is probably also the indicator that will assist decision-makers better in prioritising areas for health care interventions since such interventions are aimed at reaching the people. The density indicator per km² is useful for large areas so that the distribution do not get skewed by the size of a municipality while the density indicator per population might be a more useful one for targeting large municipalities characterised with low populations. Therefore, the combination of the two indicators is of high importance in final decision making in prioritising areas for health care interventions for large municipalities characterised with low populations.

Future research should ideally include practice management data which could be geo-coded and mapped to reveal variation between actual clinical service areas and the medically underserved areas [13]. In addition, population penetration analyses could also be performed to depict patterns of utilization. Such analysis would provide a far more detailed indication of the utilisation of public health facilities in South Africa. Knowledge of the utilisation of such facilities will inform more detailed spatial planning and effective service delivery. It will also assist in achieving the Millennium Development Goals (MDG) to reduce child mortality (goal 4), improve maternal health (goal 5) and combat HIV/Aids, malaria and other diseases (goal 6). The availability of data on health workers from the Department of Health will also add great value in the development of health density indicators in South Africa. Further analysis of the location of each health facility in relation to public transport routes is also recommended to ensure the accessibility of these health facilities.

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Contact Tholang Mokhele, Human Sciences Research Council, Tel 012 302-2521, tamokhele@hsrc.ac.za