8 Developing an approach to accounting for need in resource allocation between urban and rural district hospitals in South Africa

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The South African public health system has struggled to deal with persistent structural inequities in the resourcing and provision of care in the post-apartheid era. A significant challenge in this regard is that the allocation of resources from the provincial level to districts and facilities does not adequately account for need.

This chapter explores an approach to accounting for need in the assessment of equity in resourcing the country's public health system. Using Principal Components Analysis, we develop and test an approach to the creation of a rural index that explicitly accounts for differences in rural and urban contexts with regard to healthcare need, and the demographic, geographic and socio-economic factors that play a role in determining relative resource needs.

Having tested this approach on an assessment of the allocation of resources to district hospitals in KwaZulu-Natal Province, we found that while there is merit in developing a rural index for assessment purposes, in practice it should be used in conjunction with a broader analytical framework that allows for assessment of a facility's performance against key input, utilisation and resourcing outcome indicators.

In this way, the index should become a component of a performance management framework that seeks to not only address issues of equity (between rural and urban settings), but also efficiency and effectiveness as an outcome of resource allocation processes.

Accepting inevitable 'inefficiencies' due to diseconomies of scale and inherently lower levels of utilisation at rural facilities, trends in the analysis were generally advancing towards equity between urban and rural facilities as a social good.

We develop and test an approach to the creation of a rural index that explicitly accounts for differences in rural and urban contexts with regard to healthcare need, and the demographic, geographic and socio-economic factors that play a role in determining relative resource needs.

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Healthcare expenditure in South Africa: historical context

When the African National Congress (ANC) came to power in 1994, it faced the mammoth task of reforming every sector of the state to undo the effects of segregationist and apartheid legislation and policy regulating access to land, the economy and basic social goods.

The structural inequity of the health system and the fragmentation of healthcare provisioning had been promoted in a number of ways.[1,2] Vertical fragmentation resulted from largely curative hospital-based care being given clear priority over a primary health care (PHC) approach rooted in prevention and health promotion at the local level and typically within communities. By the end of the apartheid era, only 11% of total public sector expenditure in South Africa was allocated to PHC services.[2]

Fragmentation also occurred as a corollary of separate development through the creation of discrete health systems in each of the 'Bantustans' or ethnic homelands, resulting in 14 separate health departments, each with their own administrations, lines of authority and access to resources. These were largely structured around under-resourced missionary-led hospitals that supported some primary health care services in underserved outlying rural areas.[3] Health care for South Africa's white minority, on the other hand, was offered in a well-developed and richly resourced network of urban public hospitals or within private facilities.[1] Inequities in resourcing were stark, and by the late 1980s there was as much as a tenfold difference in per capita funding between homeland and provincial health systems.[4] Increasingly, the private health system drew resources away from the public sector and by the end of apartheid accounted for 65% of all health care expenditure in South Africa, accessible to only 17% of the population.[5]

Healthcare expenditure post-1994: progress towards equity

Healthcare provisioning was one of the first areas of government responsibility to receive attention from the new democratically elected government. In line with the introduction of the Reconstruction and Development Programme (RDP),[6] the ANC published its National Health Plan for South Africa in 1994[7] which envisioned the total transformation of the health system based on a PHC approach to service provision.

The plan was given substance in the government's White Paper for the Transformation of the Health System in South Africa, which delineated a unified public health system built around planning and service provisioning at the district level.[5] Underpinning reforms was a commitment to progressive shift towards greater equity in the resourcing and provision of services.[2]

Fiscal federalism and intra-provincial equity

Following the introduction of South Africa's Constitution in 1996,[8] greater responsibility for decision-making around the allocation of resources between government agencies and line departments was given to provincial governments. Other than conditional grant funding for priority health programmes, which were allocated directly to provincial health departments from the national level, the bulk of departmental funding would be apportioned at provincial level and allocated from the provincial equitable share.[2]

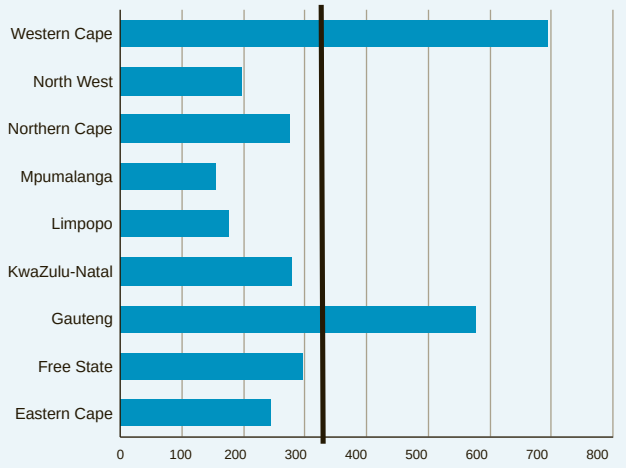
The Equitable Share Formula (ESF) became the primary mechanism for promoting equity in budget allocations, using population size in combination with measures of relative need for key services – such as health care and education – to determine the relative proportion of government revenue to be allocated to each province.

Following its introduction, the facility of the ESF to meaningfully promote inter-provincial equity in healthcare expenditure came into question for a number of key reasons.[9] The formula does not adequately account for historical backlogs in social and economic infrastructure.[10] While a poverty component which is meant to strengthen its redistributive bias is included,[11] it accounts for only 3% of the formula and is diminished by the economic output component that favours more economically active provinces.[10]

The formula also has limited capacity to promote intra-provincial equity in allocations between line departments, districts and local municipalities because provinces have discretion in the division of revenue. So, even if provinces receive an equitable share of resources, there is no obligation to allocate them equitably and no guarantee that health care would receive its fair share of revenue.[12]

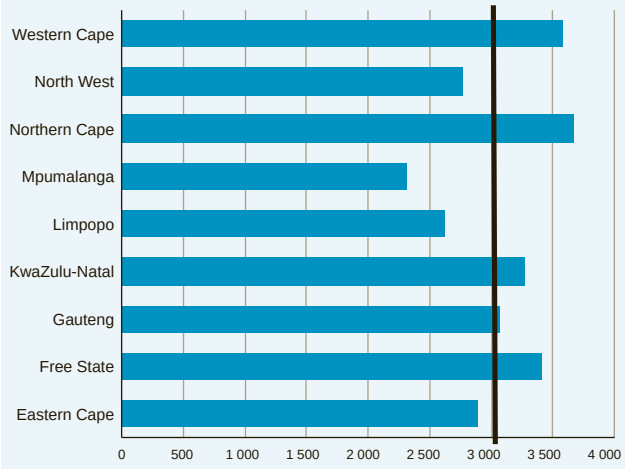
Despite these limitations, there is evidence that inter-provincial equity within public health care is making positive, albeit slow, progress. As Figure 1 and Figure 2 reveal, since 1992/93, inter-provincial expenditure on health care has started to equalise and by 2013/14, most had expenditures near to the average for all provinces.

Figure 1: Per capita (uninsured) provincial health expenditure 1992/93 (Rand nominal)



Source: McIntyre, 2012.[9]

Figure 2: Per capita (uninsured) provincial health expenditure 2013/14 (Rand)

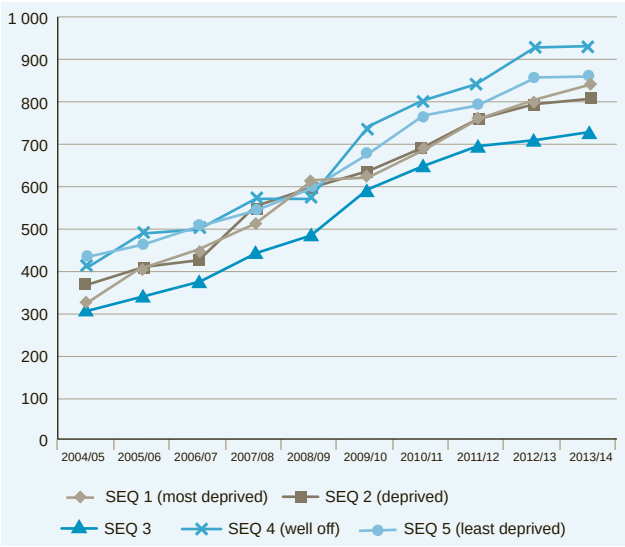


Source: National Treasury, 2015.[11]

While this trend has demonstrated commitment on the part of provincial governments to ensure that provincial health departments receive a fair allocation from their equitable shares, progress in achieving intra-provincial equity (between districts and facilities) has been less consistent.

Recent data[13] show that per capita PHC expenditure tends to be highest in the least-deprived quintile health districts (4 and 5), and lowest in the most-deprived quintile health districts (1, 2 and 3) (Figure 3). Thus PHC expenditure is greatest in districts where the need is lowest and lowest in districts where need for health care is expected to be greatest.[12]

Figure 3: Per capita (uninsured) PHC expenditure by deprivation quintile 2004/05–2013/14 (nominal terms)



Source: Massyn et al., 2014.[13]

Achieving equity between districts has been more difficult primarily because there is no obligation placed on provincial health departments to allocate budgets to districts based on any determination of need.[2] In the absence of regulations, processes and guidelines fostering needs-based allocations, allocations to and within provincial departments of health are determined historically and incrementally.[1,10,14,15]

Historical and incremental budgeting has sustained what Stuckler et al.[10] have referred to as an "infrastructure inequality trap", where pre-existing hospital infrastructure and a relatively high proportion of healthcare workers are often the primary factors in determining allocations rather than an assessment of need.[10] In this way, structural inequities that have their roots in apartheid are allowed to persist more than two decades into democracy.

Exploring the development of a rural index

One of the challenges in promoting equity in allocations for service delivery (not only in health but in all social sector departments) has been the complexity in accounting for differences in need for care and resource-needs service provisioning. This has created the perception that needs-based budgeting is too technically daunting and resource-intensive to be used in government budget processes.[16]

In recent years, the government has tried to introduce Performance-based Budgeting (PBB)[a] as a workable alternative to needs-based budgeting, but capacity constraints and the questionable quality of performance data have limited its use, and government departments still rely largely on historical and incrementalist approaches to budgeting.[16]

In this chapter, we explore one possible approach to overcoming some of the complexities associated with assessing differences in resource needs between units of analysis in the pursuit of needs-based budgeting. While similar approaches have been developed with varying degrees of complexity,[10,12,18–21] ours is unique in that we attempt to account explicitly for differences in resource needs between urban and rural contexts.

Why 'rural'?

There are good data indicating that rural areas do tend to have a greater need for health care than do urban areas. Evidence shows that globally, rural populations tend to have a disproportionate number of elderly people and children, which increases the demand for basic social services such as health care.[22] In addition, rural populations generally tend to be poorer than their urban counterparts, which makes them more vulnerable to social determinants of health and less likely to have the means to access care.[23,24] Consequently, rural populations carry a greater burden of both communicable[25,26] and non-communicable[27–31] diseases.

a PBB shifts the primary focus of budgeting from inputs to outputs and service delivery performance targets. Input, process, output and outcome data are used to identify the most efficient and effective use of resources in achieving desired outcomes.[17]

Not only is need greater in rural areas, but access to the required care also tends to be more difficult. Based on perusal of the literature,[23,24,30–32] barriers in access to health care in rural contexts are a combination of demographic (age, sex, population numbers and density), geographic (distance and topography) and socio-economic (poverty) components that differ from urban contexts. These have been summarised in Table 1.

Table 1: Similarities and differences between underserved and rural health contexts

Problems shared by underserved and rural areas	Problems specific to rural areas
• High levels of poverty and deprivation make populations more vulnerable to disease and injury and reduce access to nutrition and education (social determinants of health) • Greater burden of disease than in middle- to high-income urban settings • Health systems that are underfunded and poorly managed • Lack of drugs, equipment and human resources within the health system	• Cost and time for patients travelling long distances to access services are more significant for rural people • Cost and time of conducting outreach services, and the resulting need for more health-care workers per capita compared to urban areas • Diseconomies of scale, making the cost of delivering services per capita higher • Ambulances take longer to reach patients • Healthcare workers may be reluctant to live in rural areas as these are often far from desirable amenities (schools, banks, malls, gyms, etc.). Also, fewer opportunities exist for employment of other family members, e.g. spouses

Source: Eagar et al. 2014,[33] Hart et al. 2005.[34]

Primarily because there is no standard definition of 'rural' used in government, or any appropriate definition thereof used within the health system, assessing the difference in need for health care and resources for its provisioning between South Africa's urban and rural areas is challenging.[b]

Where 'rural' has been used as a category in research on health and healthcare resourcing in South Africa, the term has either not been explicitly defined or a proxy measure (such as relative deprivation) has been used.[35] While using proxy measures and in particular relative deprivation[c] has demonstrated some analytical value in measuring rural/urban equity,[13] this approach lacks the complexity necessary to explain how various rural factors act and combine to influence resource needs and differences in access to care.

Therefore, a critical component of our assessment of equity in the allocation of resources that accounts for differences in rural and urban contexts is the development of an approach to the classification of selected units of analysis (province, district, municipal ward or facility) as either rural or urban.

b The Department of Health uses the Integrated Sustainable Rural Development Strategy (ISRDS) rural nodes to identify facilities that would qualify for the rural allowance for healthcare workers. Problems with the designation of these nodes have resulted in issues of equity being inadequately addressed. The approach is under revision as the basis for rural allowance allocations.

c Relative deprivation has been put to good use in the assessment of equity in recent versions of the District Health Barometer presenting analyses of input, process, output and outcome indicators.[13]

Method and data management

Developing the rural index

As a starting point, we reviewed the available literature on approaches to developing functional definitions of 'rural' for the purposes of classification (referred to here as a rural index) in research and analysis. This body of research is evolving, but our review found that factors/variables used in definitions can generally be grouped into four broad categories:[33–38]

1 Measures of health need: these include utilisation, clinical and epidemiological measures or proxies of need such as relative deprivation.[33]

2 Measures of geographic accessibility: longer distances in rural areas not only make it more difficult and expensive to access services for rural patients,[37] but also add to the cost of providing such services.[39]

3 Population measures: rural areas tend to have smaller populations with a greater geographic spread, meaning lower population densities.[40]

4 Policy measures: contextual factors relating to historically neglected groups in rural settings (based on race, ethnicity) who may have high levels of unmet need.[38]

These four categories constituted the basis for selecting variables used in the development of the rural index.

For the purposes of this chapter, we focused on an assessment of equity in the allocation of resources between district hospitals in KwaZulu-Natal. District hospitals are distinct and bounded units of service provision in the sense that each has a clear catchment population; receives easily accessible global budgets; has a clear staffing establishment, and is required to collect and record a range of input, process, and output and outcome data. This allowed us to deal more easily with confounding factors and problems associated with the accuracy of the data.

Selection of factors for the index

All data for our analysis were provided by the National Department of Health (NDoH) from the National Health Information Repository and Data Warehouse (NHIRD).[d] Variables that did not rely on utilisation or facility performance were selected, since these would not account for unmet need.

The following four variables were selected:

1 Deprivation index: due to concerns about the quality of facility-based output data, concerns around different levels of utilisation (unmet need), and the dearth of epidemiological data measured across our units of analysis, we used relative deprivation as our proxy for need. Relative deprivation has been shown to be an effective proxy for need in instances where epidemiological data are insufficient or unreliable.[22,23]

d The NHIRD is an integrated online platfom that links various departmental data systems such as the District Health Information System (DHI), Basic Accounting System (BAS) and the Personnel and Salary Administration System (PERSAL) system into a central point. The system also provides for the geospatial mapping of data for the purposes of analysis and interpretation.

2 Average distance to clinics from district hospitals: district hospitals play an important role in supporting service provision at the clinic level through outreach, supply chain management and the referral of patients to higher levels of care.[41] Longer average distances to clinics potentially increase the cost of providing support and the time needed for outreach.

3 Distance to the regional hospital: distance to the regional hospital was used for two reasons; firstly, district hospitals refer complex cases to regional facilities, such that longer distances have implications for how care is managed and the kind of support that clinicians at rural facilities can expect from specialists. Secondly, this measure provides an indication of distance from urban centres and by implication administrative support, supplies depots and laboratory services.

4 Catchment population: the size of the catchment population was used as our population measure. In some contexts, rural facilities are classified as small hospital facilities due to the comparatively small and sparse populations they serve. The per capita cost of providing services to a small catchment population is higher than that required for a large population because these facilities do not benefit from economies of scale in terms of fixed overhead costs.[39]

Each of the variables was then standardised to have a zero mean and unit standard deviation[e] in order to ensure that variables were within the same range for the development of the rural index.

Selection of outcome variables for analysis

Following the selection of variables for the rural index (considered as an explanatory variable), output variables were selected from the NHIRD that would allow for comparison of facilities against the rural index in terms of resourcing.

The main outcome variables selected were:

- Per capita allocation: this variable provides an indication of the hospital budget allocation per person in the catchment population.[f] As an uncomplicated variable, it is often used in analysis of health system financing and decision-making.
- Cost per Patient Day Equivalent (PDE): PDE is usually used as a measure of efficiency, or how well a facility is doing in terms of spending on service delivery. It is an indicator of the average cost per patient, per day, seen at a district hospital.[g] Usually a high cost per PDE indicates that the hospital is underutilised, expenditure is poorly managed and there is a high degree of wastage. If the cost per PDE is low, the facility may have a bed utilisation rate (BUR) that is too high, or the Outpatient Department (OPD) is being overused.[42]
- Doctors per 10 000 population: this is a measure of the number of doctors working at the hospital per 10 000 population and is included as a non-financial resourcing indicator. This variable was selected because one of the most significant challenges faced by rural facilities is the recruitment and retention of healthcare workers, and doctors in particular.[43,44]

Analysis

Constructing the rural index

The index was calculated by using Principal Component Analysis (PCA). PCA is a statistical method commonly used in testing and selecting variables in the construction of composite indices; the Human Development Index and indices of relative deprivation are good examples of its application.[42] PCA is used to test how variables are associated and change in relation to one another and is a useful approach in assessing the suitability of data and excluding variables that do not contribute meaningfully to the index.[42]

Constructing the rural index using all four variables

Initially, all of the four rural factor variables were used to construct the index. However, results of this analysis revealed that the average distance to the clinic variable did not add value to the index and could be excluded (Box 1). Nonetheless, this does not mean that the variable itself was of no analytical use, but rather that the index could safely be simplified by its exclusion.

Box 1: Results of PCA using all four variables

Using all four standardised variables, the first principal component (PC) is sufficient to account for the variation between hospitals (the first eigenvalue was 2.2 and accounted for 54.5% of the variation, and no other eigenvalue was >1). The first PC had the following coefficients and the following values of the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy.

Variable (standardised)	Coefficient	KMO	KMO Interpretation
Deprivation Index (Depind)	0.594	0.63	Mediocre
Average distance to clinic (Clindist)	-0.106	0.57	Miserable
Distance to regional hospital (Regdist)	0.509	0.81	Meritorious
Catchment population (Catchpopz)	-0.614	0.61	Mediocre

Since the coefficient of clindist is negative in the index using four variables, (as such, the opposite of what was expected, and the KMO measure is "miserable", this variable could be omitted from the index.

Note: A full description of the KMO method and the interpretation of the results can be found in the original paper by Kaiser.[45]

Constructing the rural index using three variables

A 'modified' rural index using the three remaining variables (relative deprivation, distance to the regional hospital and catchment population) was then constructed. The results of the PCA using only three variables is shown in Box 2.

e This was done by subtracting the mean for each from each observation and dividing the result by the appropriate standard deviation.

f This was determined by dividing each hospital's total budget by its catchment population.

g PDE is calculated by adding the number of inpatient days to half the number of day patients and one third of outpatient and emergency visits. The PDE is then divided by the hospital's budget for the year.

Box 2: Results of PCA using only three variables

Using the remaining three standardised variables, the first principal component is sufficient for explaining the variation between districts (1st eigenvalue was 2.2 accounting for 72% of the variation and the other two eigenvalues <1). The coefficients and values of the KMO measure of sampling adequacy are shown in Table 3. The coefficients are all in the expected direction.

Variable (standardised)	Coefficient	KMO measure	Interpretation of KMO
Deprivation index	0.597	0.63	Mediocre
Distance to regional hospital	0.515	0.82	Meritorious
Catchment population	-0.615	0.61	Mediocre

This provided sound reason for confidence that the index could be used to rank facilities based on their scores generated by the PCA.

Table 2: District hospitals ranked on rural index

Facilities are ranked from the most rural to the most urban. Totals for each variable used in the index are included for each facility and are also ranked individually.

Hospital	Hospital Code	Score Rural Index	Rural Rank Score	Catchment Population	Rank Catchment Population	Depri-vation Index	Rank Depri-vation Index	Ave Distance to Clinic (km)	Rank Distance to Clinic	Distance Regional Hospital (km)	Rank Distance Regional Hospital
Manguzi	Mang	2.4962	1	38 324	28	3877.93	4	10.86	36	195.45	1
Mseleni	Msel	2.0424	2	33 944	30	3877.93	4	20.16	13	156.01	3
Mosvold	Mosv	1.8073	3	73 612	22	3724.16	9	20.68	11	160.48	2
Bethesda	Beth	1.3425	4	63 536	23	3724.16	9	20.55	12	118.00	5
Ekhombe	Ekho	1.0893	5	33 116	33	3825.27	6	25.95	5	79.48	9
Itshelejuba	Itsh	1.0680	6	75 668	21	3078.41	27	19.37	15	138.53	4
Nkandla	Nkan	1.0070	7	35 600	29	3825.27	6	12.61	31	73.55	12
Church of Scotland	CHoS	0.9569	8	84 948	19	4102.41	1	18.71	16	71.10	13
Benedictine	Bene	0.8440	9	62 288	24	3513.55	15	15.57	26	88.69	8
uNtunjambili	Untu	0.8437	10	23 576	37	3889.78	2	12.86	30	51.58	22
Reitvlei	Reit	0.8277	11	33 348	32	3661.49	11	12.13	32	36.63	16
Ceza	Ceza	0.7634	12	33 912	31	3192.19	25	16.61	22	90.73	7
Greytown	Grey	0.5653	13	26 948	35	3318.84	22	71.68	19	64.01	17
Charles Johnson Memorial	CHMH	0.5295	14	117 012	12	3616.80	13	16.71	21	76.69	10
KwaMagwaza	KwaM	0.5271	15	31 220	34	3413.89	17	15.74	25	56.70	21
Montebello	Mont	0.5158	16	38 476	27	3793.23	8	14.56	28	35.63	31
St Apollinaris	StAp	0.4433	17	123 076	11	3628.90	12	25.51	6	71.04	14
Mbongolwane	Mbon	0.3610	18	24 240	36	3405.93	19	11.37	33	40.74	27
Christ the King	Chris	0.3140	19	90 068	16	3470.59	16	22.43	10	57.49	20
St Andrew's	StAn	0.2917	20	88 648	18	3412.07	18	14.09	29	58.62	19
Nkonjeni	Nkon	0.2504	21	94 028	14	3192.19	25	15.09	27	70.42	15
Emmaus	Emma	0.0884	22	83 144	20	3264.28	23	24.29	8	48.53	23
Catherine Booth	Cath	0.0327	23	91 552	15	3405.93	19	16.11	23	38.50	28
uMphumulo	Umph	0.0275	24	150 220	10	3889.78	2	16.03	24	30.83	32
Appelsbosch	Appe	-0.0560	25	40 396	26	2978.42	28	10.70	37	37.76	30
Vryheid	Vryh	-0.1364	26	110 892	13	2691.49	29	24.48	7	74.63	11
East Griqualand and Usher Memorial	EGUM	-0.1456	27	46 632	25	1769.20	33	19.46	14	105.41	6
Niemeyer Memorial	Niem	-0.2089	28	88 848	17	3222.62	24	17.94	17	28.40	33
Hlabisa	Hlab	-0.3301	29	256 732	6	3579.89	14	35.54	2	59.42	18
Eshowe	Esho	-0.4661	30	222 148	7	3405.93	19	32.22	3	45.66	25
Estcourt	Estc	-1.2130	31	263 724	5	2589.04	30	26.35	4	18.12	24
GJ Crooke's	GJCr	-1.3749	32	200 392	8	2132.98	31	46.24	1	38.46	29
Dundee	Dund	-1.5971	33	170 028	9	1534.15	34	24.18	9	44.67	26
Murchison	Murc	-2.2021	34	288 664	4	1994.79	32	17.92	18	10.80	35
Wentworth	Went	-3.6174	35	465 428	3	1226.71	36	10.99	35	5.07	37
Northdale	Nort	-3.6587	36	582 700	1	1357.49	35	17.49	20	10.02	36
Osindisweni	Osin	-3.6987	37	501 972	2	1226.71	36	11.07	34	11.93	34

Constructing the index using two variables

Since some of the outcome measures (e.g. per capita expenditure) are related to the catchment population in terms of how they are calculated, an 'alternative' rural index omitting catchment population as a component variable was developed. This was done to ensure that the results of our analysis of these variables against the rural index were not misleading due to the possible confounding effects of including the same variable in both the rural index and the outcome variable.

Continuous versus categorical classification of facilities as rural or urban

We considered classifying hospitals categorically into deep rural, rural, peri-urban and urban facilities for the purposes of analysis. There were no clear cut-off points in the index scores to meaningfully support four categories, and following Royston et al.,[46] we felt that any such separation would be artificial and would make analysis using the index unreliable.

Results of using the rural index to rank facilities

Having ranked facilities on the rural index, we found that for the most part, the ranking mirrored what we had anticipated. Hospitals ranked on the urban end of the index – such as Osindisweni, Northdale and Wentworth – were located in cities.

Middle-ranked facilities such as Greytown, Charles Johnson Memorial and Eshowe tend to be located on well-developed roads (regional roads) and/or in towns with relatively well-developed infrastructure. This relates directly to both lower levels of deprivation and greater accessibility to regional facilities.

Hospitals at the rural end of the index, such as Manguzi, Mseleni and Mosvold, are located in the northern reaches of the province, far from cities or large towns.

There were facilities that did not fall on the spectrum as we had anticipated. Hlabisa was unexpectedly ranked fairly high on the urban end of the spectrum, despite not being located near to a large town or city. In this instance, the facility's catchment population is comparatively large, the catchment population is not exceptionally deprived, (14 of 36) and the facility is substantially closer to the regional hospital than are other facilities to their referral hospitals in the same district (Table 2).

Hlabisa does, however, rank second with regard to average distance to clinics (omitted from the index), which we initially identified as a key variable in classifying facilities as rural (Table 2). While this apparent discrepancy does not bring into question the value of the index, it does draw attention to the importance of not undertaking analyses based on the index as the sole explanatory variable. It is thus crucial to look more broadly at how facilities perform with regard to other key indicators of health system performance.

Analysis of the relationship between the rural index and output variables

The value in any index is found in the extent to which it can be used to explain trends in selected dependant variables. In this instance, therefore, is the rural index useful in explaining differences in per capita budget allocations between district hospitals, cost per PDE and the availability of doctors?

Table 3: Outcome variables by facility

Hospital	Hospital Code	Rural index rank (1 = most rural; 37= most urban)	Doctors per 1 000	Rank doctors per 1 000	Bed Utilisation Rate	Rank Bed Utilisation Rate	Cost per PDE	Rank Cost per PDE	Per Capita Allocation	Rank Per Capita Allocation
Manguzi	Mangu	1	0.52	2	0.59	23	1 437.22	6	3 487.14	2
Mseleni	Msel	2	0.50	3	0.64	16	1 648.89	18	3 296.90	4
Mosvold	Mosv	3	0.19	9	0.60	21	1 661.52	19	1 562.65	17
Bethesda	Beth	4	0.31	4	0.48	31	1 846.85	27	1 662.92	16
Ekhombe	Ekho	5	0.06	34	0.52	29	2 305.65	35	2 036.87	14
Itshelejuba	Itsh	6	0.11	21	0.81	3	1 581.14	15	1 286.51	21
Nkandla	Nkan	7	0.11	20	0.58	24	2 011.90	31	3 132.42	7
Church of Scotland	CHoS	8	0.16	13	0.57	.25	1 818.78	26	1 940.58	15
Benedictine	Bene	9	0.18	10	0.64	17	1 773.45	24	3 339.05	3
uNtunjambili	Untu	10	0.30	5	0.53	28	2 181.32	34	3 155.75	6
Reitvlei	Reit	11	0.27	6	0.65	14	1 666.58	20	3 240.64	5
Ceza	Ceza	12	0.09	25	0.52	30	2 032.89	32	2 532.94	10
Greytown	Grey	13	0.56	1	0.45	35	2 347.19	36	4 741.21	1
Charles Johnson Memorial	CHMH	14	0.09	27	0.61	20	1 424.94	4	1 298.61	20
KwaMagwaza	KwaM	15	0.19	8	0.44	36	2 744.50	37	2 685.68	9
Montebello	Mont	16	0.13	17	0.60	22	1 941.51	29	2 070.62	12
St Apollinaris	StAp	17	0.07	33	0.67	9	1 807.05	25	662.01	29
Mbongolwane	Mbon	18	0.17	12	0.47	33	1 579.18	14	2 995.83	8
Christ the King	Chris	19	0.10	22	0.66	10	1 623.11	17	1 055.96	24
St Andrew's	StAn	20	0.11	19	0.65	13	1 526.69	12	1 217.18	23
Nkonjeni	Nkon	21	0.10	23	0.81	2	1 490.53	11	1 428.59	19

Hospital	Hospital Code	Rural index rank (1 = most rural; 37= most urban)	Doctors per 1 000	Rank doctors per 1 000	Bed Utilisation Rate	Rank Bed Utilisation Rate	Cost per PDE	Rank Cost per PDE	Per Capita Allocation	Rank Per Capita Allocation
Emmaus	Emma	22	0.13	16	0.62	19	1 750.74	23	1 236.75	22
Catherine Booth	Cath	23	0.09	26	0.46	34	1 383.41	3	694.85	27
uMphumulo	Umph	24	0.05	35	0.63	18	1 982.25	30	557.95	34
Appelsbosch	Appe	25	0.17	11	0.55	26	2 073.94	33	2 048.07	13
Vryheid	Vryh	26	0.14	15	0.68	8	1 476.96	8	1 505.55	18
East Griqualand and Usher Memorial	EGUM	27	0.15	14	0.65	12	1 608.67	16	2 241.14	11
Niemeyer Memorial	Nem	28	0.07	32	0.48	32	1 545.01	13	627.33	32
Hlabisa	Hlab	29	0.08	29	0.66	11	1 689.47	21	654.58	30
Eshowe	Esho	30	0.09	24	0.43	37	1 339.01	1	681.31	28
Estcourt	Estc	31	0.08	30	0.64	15	1 694.35	22	638.16	31
GJ Crooke's	GJCr	32	0.11	18	0.72	6	1 487.13	10	900.89	25
Dundee	Dund	33	0.08	28	0.55	27	1 872.66	28	777.13	26
Murchison	Murc	34	0.07	31	0.76	5	1 429.33	5	555.77	35
Wentworth	Went	35	0.04	36	0.89	1	1 480.81	9	412.56	36
Northdale	Nort	36	0.21	7	0.79	4	1 456.08	7	585.78	33
Osindisweni	Osin	37	0.04	37	0.68	7	1 382.58	2	258.83	37

Facilities are ranked according to their rural index scores, with 'most rural' (Manguzi) ranked 1 and 'most urban' (Osindisweni) ranked 37. The value for each outcome variable is also included for each facility and ranked relative to other facilities for that variable.

To test the analytical value of the index in explaining trends, it was necessary to investigate whether there was a statistically significant relationship between the rural index and each variable. The purpose of this was to determine whether 'rural' or 'urban' could influence resourcing in some way.

Regression analysis[h] was used to calculate for a statistically significant relationship between the rural index and the outcome variable.[i] This was followed by a multiple regression analysis[j] to ascertain whether any of the component variables in the rural index had statistically stronger relationships with the outcome variable than with the index itself.

Per capita allocation

Our regression analysis of the rural index and the per capita allocation to district hospitals found that there was overwhelming statistical evidence of a relationship between the two variables (P=0.0004; R^2 = 30.1%). There was no evidence of non-linearity, meaning that per capita allocations change proportionally with changes in a facilities score on the rural index.

This relationship between the rural index and the per capita allocation is represented visually in Figure 4. The regression line shows that it is an inverse relationship between the two variables, meaning that per capita allocations actually increase towards the rural end of the index.[k] Points far from the line correspond to district hospitals for which the per capita allocation is very different from that predicted by the model; in this case, Greytown has a far higher per capita allocation than is suggested by its rural index score.

The vertical axis is expenditure per capita in South African Rand (ZAR). The horizontal axis is the facility score on the rural index. Each data point is labelled with a hospital code, explained in Table 2.

Examining the relationship between each component variable of the index and the per capita allocation variable independently did not give a better result than using the rural index.

At first glance, the relationship would suggest that there is a degree of equity in the allocation of resources between urban and rural district hospitals in KwaZulu-Natal (KZN). However, several factors may influence this trend. For example, rural hospitals tend to have small catchment populations, such that absolute utilisation of those facilities is inevitably lower. All facilities, regardless of location, have fixed overhead costs relating to infrastructure and personnel that must be budgeted for. Small populations and fixed overhead costs result in diseconomies of scale, where the per capita cost of providing a service is inflated in rural areas due to inherently lower levels of utilisation.[38,39]

Cost per patient day equivalent

Our regression analysis of cost per patient day equivalent (PDE) and the rural index (using variables) shows that here too, there was strong evidence of correlation between the two variables (P=0.042). Again there was no evidence of non-linearity. There was also an inverse relationship in this instance, indicating that the more rural the facility, the higher the cost per PDE.

The difference here, however, was that when a multiple regression was run between each component variable from the rural index and the cost per PDE variable separately, there was a better fit than with the rural index alone (P=0.028).[l] In this instance, the cost per PDE showed a strong inverse relationship to the catchment population

h Regression analysis is an approach to assessing the relationship between variables; although this approach can indicate the existence of a relationship, it cannot explain its cause.

i Fractional polynomials[46] were used to determine whether the relationship between the input (e.g. per capita allocation) and the rural index could be non-linear.

j Multiple regression analysis is an extension of regression analysis that is used to determine the relationship of one variable with two or more other variables.

k The estimated regression coefficient is 474.9, so for each unit increase in the rural index, the per capita expenditure increases by R474.90.

l The regression of CPDE on the rural index is not shown as a graphic, because there is better fit for CPDE with each of the component variables independently.

(P=0.024).[m] Thus, as the size of the catchment population increased, the cost per PDE decreased.

There was also no evidence that, adjusting for catchment population and distance to the regional hospital, the cost per PDE was related to the deprivation index (P=0.74).

The overall conclusion is that the size of the catchment area, rather than the rural index, is a good predictor of cost per PDE.

Facilities with small catchment populations within our sample having a high cost per PDE could be due to lower bed utilisation rates (see Table 5).[n] Lower bed BURs result in greater inefficiency because resources are used to maintain beds that are empty rather than being deployed for patient care.

However, not all hospitals with small catchment populations had high cost per PDEs. Manguzi Hospital, for example, which has a fairly small catchment population, also had a relatively low cost per PDE of R1 437. This was actually slightly lower than Northdale Hospital's cost per PDE of R1 456, noting that Northdale has the largest catchment population in the sample. This difference cannot be due to low staff numbers at Manguzi Hospital, which ranked second highest in terms of doctors per 10 000 population, or because of exceptionally high bed utilisation. Possible causes include the cost per PDE being driven by high utilisation of day patient, outpatient and emergency services rather than longer term admissions, and that the hospital could be providing services that should ideally be provided at primary health care level.

Doctors per 10 000 population

There was a very strong relationship between doctors per 10 000 population and, the rural index (P=0.001; R2 = 25.3%). There was no evidence of non-linearity, meaning that the number of doctors per 10 000 population actually increases progressively towards the rural end of the index.

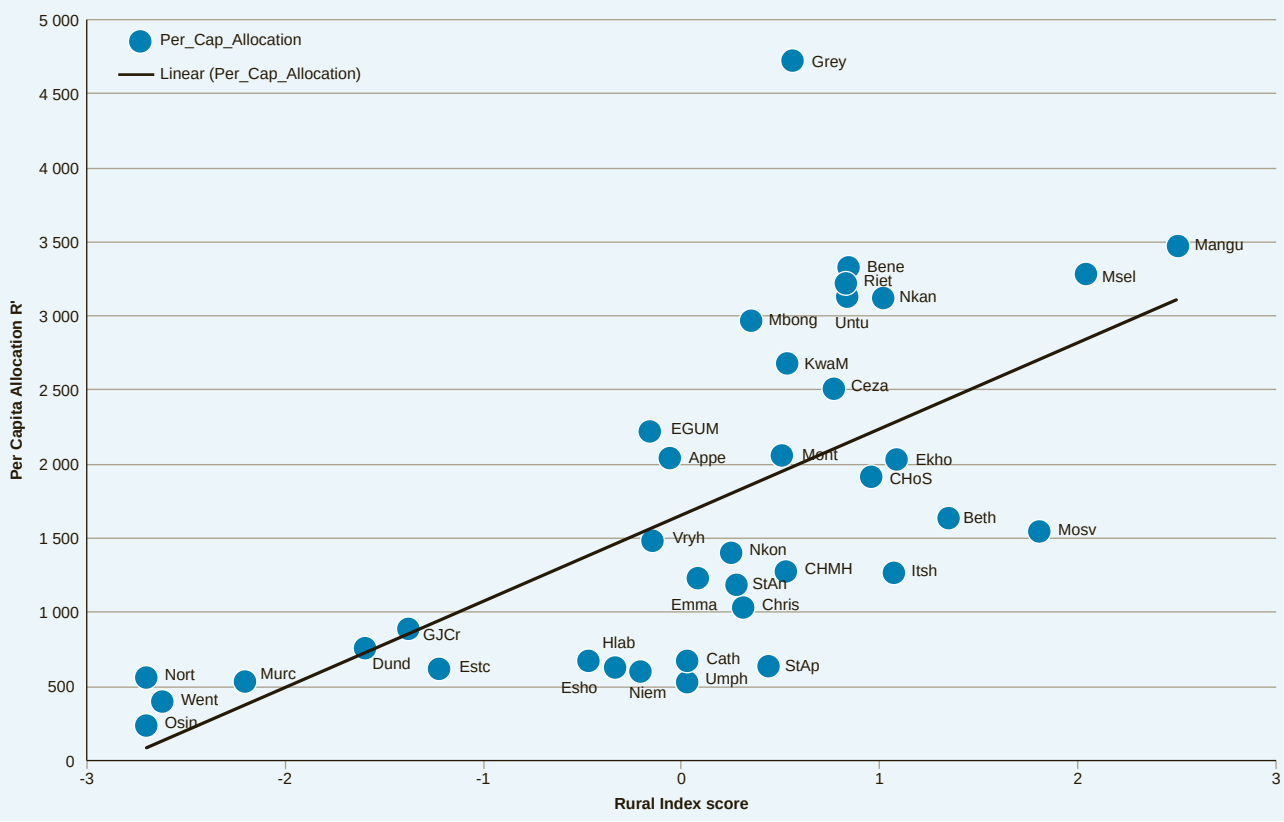
Here there was no evidence that a multiple regression model with separate terms for deprivation index and distance to the regional hospital gave a better fit than the model with the rural index.[o]

The vertical axis represents the number of doctors per 10 000 population, while the horizontal axis is the facility score on the rural index. Each data point is labelled with a hospital code, explained in Table 2.

Of note in Figure 5 is that at the rural end of the spectrum there is a dramatic increase in the number of doctors per 10 000 population, especially for Manguzi Hospital (Mangu) and Mseleni Hospital (MSel).

Worth noting are other outliers (points far from the regression line) that do not fit the pattern. Greytown Hospital has a far higher number of doctors per capita than predicted by its rural index score, while Northdale Hospital, which is very urban, also has a much higher number of doctors per capita.

Figure 4: Regression of per capita allocation on rural index with two variables



m In this model, the cost per PDE decreased by R174.11 for each increase of one standard deviation in the catchment population.

n In our sample, we found that catchment population was the most statistically significant predictor of a facilities Bed Utilisation Rate (BUR) (P=0.026).

o For each unit increase in the alternative rural index, the number of doctors per capita increased by 0.053.

A cursory analysis of these findings suggests that rural district hospitals in KZN are relatively well resourced in terms of the number of doctors working at these facilities, but these findings should be treated with caution. As is the case with per capita budget allocations, the ratio of doctors to the catchment population tends to be inflated due to smaller population sizes in rural areas. Hospitals, regardless of where they are situated, require a minimum number of doctors to provide a basic level of service, so numbers inevitably appear inflated where total catchment populations are small.[39,41]

Analytical value in facilities that do not 'fit' neatly on the rural index

Apparent anomalies or outliers in the construction of the index, and its subsequent use in analysis, highlight the importance of not relying on the index as the only basis for assessing equity in resourcing. It is both necessary and desirable to explore relationships between explanatory and outcome variables independently of the rural index.

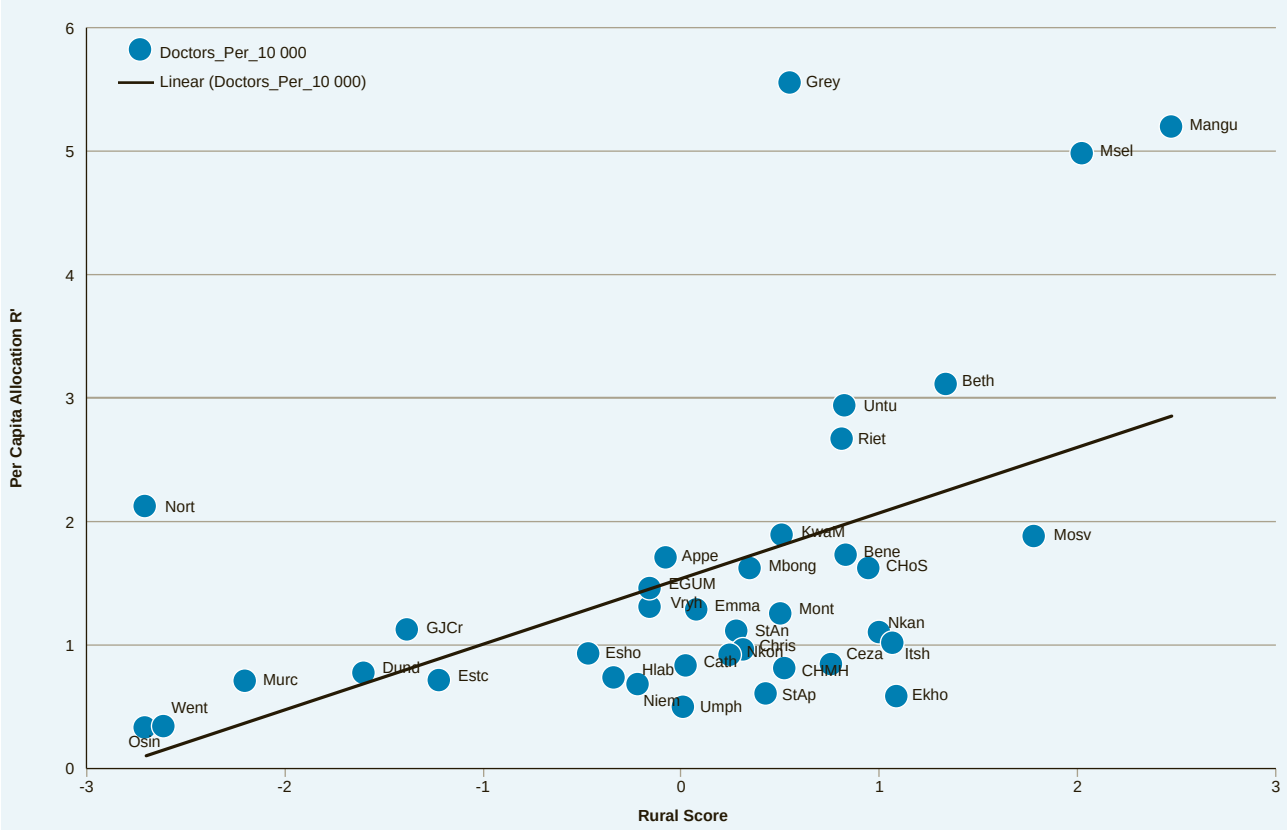
Greytown Hospital is the most obvious example of an outlier in this regard. While falling in the middle of the index with a per capita allocation of R4 741, Greytown was by some margin the best-resourced facility on a per capita basis in KZN.[p] Yet in 2013/14, the hospital had one of the lowest BURs (35th out of 37 hospitals) with a rate of 45%. In South Africa's public health system, a BUR of 75% is generally considered the goal for facilities, with BURs significantly higher indicating overutilisation and under-resourcing, while BURs significantly below 75% suggest that resources are being wasted on empty beds.[q]

Greytown also benefits from the best doctor-to-patient ratio in the province with 5.6 doctors per 10 000 population, compared to the provincial average of 1.6 per 10 000 population. A low BUR and a good ratio of doctors to population contribute to Greytown having one of the highest cost per PDEs in the province. The hospital's cost per PDE is R2 347, which is R614 per PDE more than the provincial average of R1 733.

If understood only in terms of the data, Greytown appears to be highly inefficient in ways that are difficult to justify in the same way as one could for those facilities that fall closer to the rural end of the rural index. However, Greytown offers specialised services (e.g. treatment for multi-drug resistant TB (MDR-TB), which requires long-term hospitalisation. This may be one of the primary reasons for Greytown appearing to be inefficient when this may not be the case in reality.

There are other anomalies that, while less obvious than the Greytown case, merit further attention. Hlabisa, for example, was not placed towards the rural end on the index as had been anticipated. That said, in terms of average distance to the clinic –which is an important rural factor (omitted from the index) – the facility ranks second. Here, resource needs for outreach to clinics are potentially greater than even Manguzi and Mosvold, which perform fairly well on this

Figure 5: Regression of doctors per 10 000 population on rural index with two variables



p Greytown received R1 255 per capita more than second-placed Manguzi and R4 482 more than last-placed Osindisweni.

q According to the data, when compared to the provincial average of 0.3 beds per 10 000 population, Greytown Hospital does appear to have a disproportionately high number of beds with 1 per 10 000 population.

indicator (Table 5). So, any assessment of the allocation of resources would need to be cognisant of such nuances if rural factors are to be fully considered.

Limitations

While the NDoH has made significant progress in improving data management systems over the last few years, the collection and capturing of data at the local level is still typically left to overburdened and under-resourced nurses and administrators.[47] One limitation in our analysis was that we were unable to verify the quality of the data. Also, our analysis only covers a single financial year, partly because some of the data used were not available for multiple years.

All of the variables were given equal value in the analysis and were not weighted. Weighting is often a political decision or one that emerges out of more in-depth analysis, and if such an index were to be used in future decision-making, weighting of variables would certainly be an important exercise.[42]

We also did not include any data beyond the district hospitals, which should be borne in mind when interpreting the findings of the analysis, because it excludes resources that are situated in regional and provincial hospitals and the private sector. Our results therefore do not reflect resources available in particular sub-districts or districts beyond district hospitals.

Furthermore, the model we developed did not account for differences in packages of services offered at facilities. It may well be that rural facilities offer a much larger and more complex package of services than do urban district hospitals because they are often the only hospital services accessible to rural communities.

Finally, the purpose of developing a rural index and then a broader framework for analysis is to inform decision-making; the index does not constitute or serve as the basis for allocation of resources, nor can it or should it replace the role of well-informed and experienced managers.

Discussion

The primary aim of this chapter is to test an approach to the assessment of equity in resource allocation within the public health system in a way that accounts for differences in resource needs between urban and rural service delivery contexts. In developing this approach, we sought to create a classification system that would also provide a foundation for the development of a practical method of decision-making fit for this purpose. Hence, data available on the NHIRD were selected.

Usefulness of the rural index

All too often, composite indices are of little analytical value due to the lack of even a minimum standard of rigour for the purposes of analysis and comparison.[42] Even though using PCA in the construction of the rural index added a layer of complexity to the approach, this was an important step in ensuring that the index was accurate and robust as an explanatory variable.

Analytical value of the rural index

The next question in the process was: 'Does the index have value in an analysis of health-system resourcing?' To determine this, three outcome indicators were selected in order to test an approach using the index: Per Capita budget allocation (budget equity); Cost per PDE at facilities (expenditure against utilisation); and Doctors per 10 000 population (non-financial resource measure).

Per capita allocation and the rural index

In terms of the per capita allocation variable, there was overwhelming evidence of a relationship with the rural index, both with and without catchment population as a variable. What was somewhat unexpected was that per capita allocations actually increased in tandem with increased rurality on the index.

This finding suggests that there is a degree of equity in the allocation of resources to district hospitals in KwaZulu-Natal and that, whether deliberately or not, per capita allocations to some extent account for diseconomies of scale caused by fixed overhead costs and lower levels of utilisation that are inherent in the nature of rural facilities.[39]

This is not to say that resourcing of district hospitals in the province is sufficient or even appropriate, but rather that the trend appears to be moving in the right direction.

Cost per PDE and the rural index

While the rural index was not found to be a good predictor of cost per PDE (even though there was a strong statistical relationship between them), the analysis did show that there was a significant inverse relationship with catchment population, such that the larger the catchment population, the lower the cost per PDE.

In our view, forgoing some degree of ostensible efficiency with cost per PDE is largely justified within contexts with small catchment populations. If these facilities are to provide a standard of care equal to that provided by urban facilities, minimum investments in fixed overhead costs and staff mix should be made.[39]

While it is difficult to say precisely why facilities with small catchment populations within the sample have a high cost per PDE, it appears to be in part due to lower bed utilisation rates (see Table 5).[r]

Doctors per 10 000 and the rural index

The analysis examined the number of doctors per 10 000 population because it has been generally difficult to recruit and retain doctors at rural facilities in South Africa. This has not necessarily been due only to inequities in financing, but results from a combination of factors such as availability of accommodation, employment opportunities for spouses and schooling for children, and a lack of professional support.[41,43,44]

When the number of doctors per 10 000 population was analysed against the rural index, a very strong relationship between the two was found. However, the relationship was in the opposite direction to what one would expect, and the number of doctors per 10 000 population actually increased towards the rural end of the index. Therefore, rural hospitals were not necessarily inequitably staffed with doctors.

r In the sample, catchment population was found to be the most statistically significant predictor of a facility's bed utilisation rate (BUR) with a coefficient of 0.057 (P=0.026). Thus for each increase of one standard deviation in the catchment population, the BUR increases by 0.057.

Of particular interest was that rural hospitals such as Manguzi and Mseleni appear to be significantly better off than other facilities in the province in terms of the number of doctors working at the facilities. The accessible data do not provide a compelling reason for this, and understanding the specific context of these facilities would be important in explaining why they are comparatively well resourced with doctors.

In the absence of research to explain why these rural hospitals are doing well with regard to the availability of doctors, one can only speculate that it is in part due to support provided by non-governmental organisations (NGOs) such as Africa Health Placements (AHP)[s] and rural doctor networks such as the Rural Doctors Association of Southern Africa (RuDASA),[t] which have been actively involved in recruiting doctors to work in these facilities and providing them with long-term professional and social support while based in rural areas.

Analytical value in facilities that do not 'fit' neatly on the rural index

As with the modelling of any index, its validity is achieved by using component indicators that accurately reflect the exact purpose for which the index will be used. In this case, the index includes equity-related indicators alone. The relevance of the index is further narrowed by including only those component variables that meet rigorous statistical testing. The title of 'urban/rural index' does not suggest a narrow definition, nor a narrow application. For this reason, there is a risk of an incorrect perception and an incorrect use of this index in isolation from a deeper understanding of the context in which decisions are being made.

Conclusion

Over the last two decades, much has been done to improve equity in the resourcing of the health system. There is now evidence that the resourcing gap between largely urban provinces such as the Western Cape and Gauteng and largely rural provinces like the Eastern Cape and KwaZulu-Natal is closing.

The picture within provinces is less clear, however. There is tentative evidence suggesting that within rural provinces, funds tend to flow disproportionately to districts and facilities located in urban areas. The difficulty here has been that any assessment of intra-provincial equity is limited by there being no reliable way of distinguishing between urban and rural units of analysis (district, sub-district and facility). Consequently it has been impossible to account for these differences in the allocation of resources.

In this chapter, an approach to the development of a rural index has been tested for use in ranking district hospitals in KZN on a continuous scale between urban and rural context, with a view to establishing whether or not the index was useful for analysing equity and efficiency in resourcing.

The findings were that while the index was useful in distinguishing between urban and rural district hospitals, its value really rests in ensuring that rural factors are accounted for in resource allocation models that prioritise quality improvement in service delivery rather than merely 'efficiency' in its narrowest sense.

With the health system currently undergoing a process of substantive reform under the banner of NHI, there is now an opportunity to take this work forward in a way that begins to deal with structural inequities in access to care between urban and rural service delivery contexts. This not only demands additional resources, but also consideration of the provisioning of a different and more comprehensive package of care at rural facilities.

It is therefore important that a more extensive analysis of the composition and use of a rural index be undertaken with a view to identifying how it could best be used to strengthen resource allocation processes.

s AHP is an organisation that offers human resource solutions for rural facilities in South Africa by actively recruiting and placing foreign and local doctors at rural facilities. See www.ahp.org.za

t RuDASA is an association set up to provide professional and social support to doctors working in rural settings. See www.rudasa.org.za

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