UNIVERSITY OF NATAL DURBAN

MODELLING ACCESS TO A BASIC NEED: THE PROVISION OF PRIMARY HEALTH CARE IN RURAL LESOTHO

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MODELLING ACCESS TO A BASIC NEED:

THE PROVISION OF PRIMARY HEALTH CARE

IN RURAL LESOTHO

by

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MODELLING ACCESS TO A BASIC NEED :
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ABSTRACT. Modelling Access to a Basic Need: The Provision of Primary Health Care in Rural Lesotho. *The provision of basic services to the community is now an important feature of African development planning. Since a major objective of this strategy is to achieve satisfactory levels of accessibility and to generate spatial equality and locational efficiency in the distribution of basic services, location-allocation analysis is likely to re-assume an important position in development geography. This paper presents a method of examining and optimalising the provision of primary health care in rural Lesotho. While describing some useful aspects of this approach, the study identifies severe technical and interpretative problems which undermine its value as a planning instrument. The paper thereby contributes towards the constructive critique of the spatial emphasis in development geography advanced by earlier writers.*

INTRODUCTION

One of the most significant features of recent development literature has been its emphasis upon the basic needs approach (BNA) to development planning (Bequele & Freedman, 1976; Cole-King, 1976; Ghai, 1977; Ghai, Godfrey & Lisk, 1979; Ghai, Khan, Lee & Alfthan, 1977; Lisk, 1977; Sandbrook, 1982; Shannon & Dever, 1974; Sheehan & Hopkins, 1979; Werneke & Broadfield, 1977). It is argued, particularly by theorists of rural development, that integrated development programmes cannot proceed satisfactorily until basic needs are satisfied within the community (Belshaw, 1977; Carlsen, 1980; Chambers, 1978; Lee, 1980; Lele, 1976; Livingstone, 1979; Mohan, 1978; Nsibandze, 1977; Rogge, 1977; Thomas & Boyazoglu, 1978). Hence, the central concern of the basic needs strategy is to provide services (of which water, education, health care and transportation figure highly on the agenda of priorities) within easy reach [1] of every individual in every community. BNA is therefore directed at only the phenomenal aspects of underdevelopment and may be criticised on the grounds that it fails to address its intrinsically political nature (Sandbrook 1982), and, as a result, its contribution may be more superficial than anticipated. Nevertheless, BNA has considerable appeal to the electorate and, partly for this reason, it is being rigorously pursued by many African governments.

The question of access (spatial, economic and social) is fundamental to BNA. Thus, in terms of specifically spatial parameters, the objective of BNA is to provide and position services in such a way as to achieve a satisfactory degree of accessibility and to maximise spatial equality and locational efficiency in their distribution (Richards, 1981; Richards & Leonor, 1982). The solution to this problem requires a form of location-allocation analysis which is familiar to geographers conversant with the methodology of linear programming and its applications to spatial data (Cooper, 1963; 1967; Cox, 1965; Green, Comley and Semple, 1980; Hay, 1977; Massam, 1975; Scott, 1971). Attempts by geographers to identify spatial imbalances in the provision of education (Gould, 1973; 1978; Guruge, 1977; Kinyanjui, 1974; McDowell, 1981; Walker, 1979; Weeks, 1978) and health care (Godlund, 1961; Gould & Leinbach, 1966; Gross,

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1. Measured both in terms of physical access and purchasing power.

1972; Haynes & Bentham, 1979; Schneider, 1967; Shannon & Dever, 1974; Shannon, Spurlock, Gladin & Skinner, 1975) and to optimalise the distribution of these services would therefore appear to be of considerable relevance to the basic needs development strategy currently in fashion.

So, although the preoccupation with, and the explication of, spatial data within development geography has drawn heavy criticism from many quarters (Browett, 1981; Ede, 1982; Massey, 1978; 1979; Slater, 1973; 1974; 1975; 1977; 1978; Soja, 1978; Stuckey, 1975; Wellings, 1983) it is likely that location-allocation analysis will re-emerge as a significant geographic research theme in response to BNA. Thus, the present paper is a contribution towards the theory and praxis of BNA in examining the provision of primary health care in Lesotho. However, our major concern is to document the limitations of the simplistic method we adopt to model accessibility to health services. Severe problems, both technical and interpretative in nature, are encountered in this research and further refinement of the model, it appears, generates only a marginal, and largely fictitious, improvement in efficiency. It is suggested, therefore, that location-allocation analysis, whilst decidedly useful in certain respects, must be treated with caution, particularly when applied to the kind of constricted data base available in Lesotho and should, as other authors imply (Browett, 1981; Massey, 1979; Slater, 1978) accommodate rather than exclude the economic and social aspects of accessibility.

LOCATION - ALLOCATION ANALYSIS

The general problem, which location-allocation analysis attempts to address is "how to serve or supply, in some 'optimal' fashion, a set of 'destinations' that have fixed and known locations. More specifically, what must be determined is the number and location of 'sources' or 'origins' that will, most economically, supply the given set of destinations with some commodity or service (Cooper, 1967, p 1). Given the location of, and the requirements at, each destination, possible limitations to source capacities, and a formula relating distance and cost, the objective is to compute the number of sources, the location of each source, the amounts to be transported from each source to each destination, and to allocate destinations to sources in such a way as to minimise costs to the system.

As stated, the problem is an extremely complex one both theoretically and logistically. However, several intricate mathematical models have been developed which are capable of handling the large number of variables and their organisational permutations (Cooper, 1963; 1967; Leonardi, 1978; Palmer, 1973). Unfortunately, these tend only to produce unrealistic solutions by casually manoeuvering variables which are noted more for their inertia than malleability. For instance, the delineation of service areas around a set of proscribed service points to achieve 'optimality' within the system effectively requires the recipients of that service to review *their* consumption decisions to minimise total travel cost within the network. This sort of exercise therefore works best in situations either where the service is distributed *to* the catchment from a centre rather than being provided at it (cf. Goodchild & Massam, 1969; Massam & Burghardt, 1968; Massam & Goodchild, 1971) or where the outlet is in a position to delineate its catchment by legislation (cf. Mills, 1967; Yeates, 1963).

In the same way, the positioning of service points to minimise travel within a system cannot commence by dismantling the existing infrastructure but must confine itself to amending outlet capacity, catchment size, and/or introducing new outlets to the system (cf. Leonardi, 1978; Maranzana, 1964; Ottensman, 1979; Palmer, 1973; Puu, 1978; Shirland & Ellis, 1979; Teitz, 1968). And, as above, the redistribution of service points is only effective if their catchments reconstitute themselves accordingly. Moreover, this kind of solution is computed by distance travelled from destination to source when it is evident that 'cost' is neither linearly related to, nor exclusively determined by distance (Gesler, 1979; Hodgson, 1978; Morrill, Earickson & Rees, 1970).

It is clear from the literature that the sophistication of location-allocation analysis only introduces further, and increasingly hazardous, assumptions about system fluidity which undermine its usefulness to planning. Hence, there is much to be said for the kind of simplistic model employed by Gould (1973, 1978), Guruge (1977) and Leonor (1982) in their analyses of accessibility to education and by Gould & Leinbach (1966), Haynes & Bentham (1979), Richards (1982) and Shannon et al. (1975) in the context of health service provision.

Broadly put, the procedure here is to set national targets for 'threshold' (the minimum population sufficient for the establishment of a service, with the minimum acceptable capacity in terms of potential consumption) and 'range' (the maximum distance that customers are expected to travel to the service outlet). Research is directed towards the identification of situations where the threshold population is not to be found (either above or below) within the catchment area as defined by the range. Having located such areas, parameters already present within the system may be manipulated (i.e. catchment size or outlet capacity) to achieve optimality. Alternatively, or in addition, new facilities may be introduced to achieve the same effect.

In terms of BNA, the initial constraint, and overriding concern, is the range and, once established, it is allowed only to *decrease* provided that, in doing so, the catchment population does not fall below the minimum threshold for the service. Once the catchments, as delineated by the range, are plotted onto the map, one is able to locate 'inadequately serviced' populations residing beyond them. The objective, then, is to situate supplementary services, reconstruct the catchments, and/or amend the outlet capacities to maximise the improvement (in terms of the total distance travelled by consumers to outlets) in the network's locational efficiency. This type of approach is adopted in the present paper.

BACKGROUND TO THE STUDY

Although the development of clinics as centres for delivering health services in Lesotho can be traced from the colonial era, annual reports by the then Department of Health show that there were very few in operation and that those sponsored by religious institutions were unable to offer preventive care. The first comprehensive study of health provision in Lesotho was conducted aş late as 1962 under the auspices of WHO during its anti-TB campaign. The results were alarming; very few clinics offered any kind of preventive service and large population groups were without or beyond reasonable access to health care.

As a result, a Basic Health Care (BHC) scheme, funded in large measure by UNICEF, was established during 1969 and 1970 under which many clinics were constructed, particularly in peripheral locations, and most dispensaries were upgraded to clinics upon the supply of basic equipment. Under the scheme, BHC, comprising curative services, immunization, TB chemotherapeutic treatment, maternal and child care was made available at each clinic. However, as a result of inadequate planning, the distribution of clinics was such that certain services were duplicated in some areas and absent in others.

It is now recognised that the planning and development of health care must achieve some form of spatial equality. Thus, the Primary Health Care (PHC) scheme approved by the World Health Assembly and by its Regional Committee for Africa in 1976 introduced the concept of community level service and established criteria for catchment thresholds in relation to clinic capacities and for the maximum range of individual service areas (Hicks, 1976; WHO, 1977). The Government of Lesotho formally adopted the PHC model in its third development plan (Kingdom of Lesotho, 1980, p 330) and is now committed to developing clinics in previously underserved or unserved locations and to the general improvement of health care in the country.[1]

Prior to the formulation of a construction programme for rural clinics, the Ministry of Health has appointed a sub-committee to identify spatial imbalances in the health service, to schedule development priorities and to design a procedure to select optimal locations for new clinics. The criteria for adequate accessibility to PHC has been set by the Ministry; every Mosotho, it has decreed, should reside within 5 km of basic health services.

The sub-committee therefore recommended that a pilot study of the current health service be conducted before organising a complete survey of the country primarily to examine, and hopefully overcome, problems of data collection, compilation and analysis, and to test

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1. This programme constitutes a radical departure from the more sophisticated system envisaged in the 1970s wherein BHC would be offered in conjunction with family planning. The 'Comprehensive Health Care' scheme provided for more widely scattered but better equipped clinics. The pilot centre, constructed at Tsa'kholo in Mafeteng District was unsuccessful primarily because villagers living on the periphery of the planned catchment areas were reluctant to make use of the better but more remote facilities. The PHC scheme, while less ambitious, is expected to make more impact by selecting a more realistic catchment size.

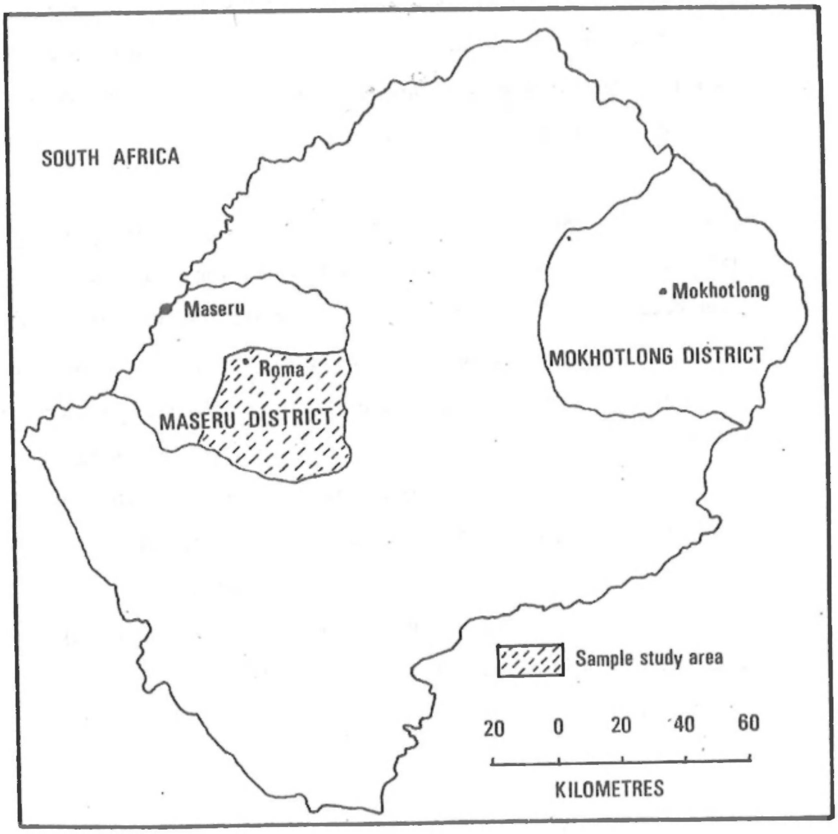

Figure 1. Lesotho : research areas

various locational procedures for efficiency. Two contrasting Districts were chosen for the pilot survey (Figure 1); Maseru, a relatively urbanised and densely populated lowland area (average population density 63.7 km^2, see Table 1), and Mokhotlong, a region of highly dissected upland topography and low population density (average 16.9 km^2, see Table 2).

Field research was completed during July and August 1981 employing two survey teams to examine clinic attendance registers and administer questionnaires to outpatients. The objectives were to: delineate the existing catchments of each clinic, to identify populations residing outside the 5 km catchments, examine imbalances in accessibility to PHC between and within the Districts, and to design a model to select sites where new clinics could be most profitably located. In addition, attention was to be directed in Maseru District to the delineation of Health Service Areas (HSAs) which, according to the Minister of Health, would be administratively controlled by a hospital and contain several satellite clinics and dispensaries within its catchment. [1]

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1. There are 5 hospitals (3 major ones) in Maseru District, but none in Mokhotlong.

RESEARCH METHODOLOGY

Catchment delineation

The survey made use of clinic outpatient attendance data, specifically persons seeking medical care services as against maternal and inpatient services. Care was taken to record attendance over a full calendar year to accommodate seasonal periodicity.. For each clinic, a list of villages from which patients derived was compiled together with attendance frequencies. When plotted onto 1 : 20 000 maps [1] the enclosing perimeter of these villages identifies the *maximum* catchment area for individual clinics.

Two related problems emerge at this juncture in that our catchments are artificially inflated by the inclusion of villages which are represented only to a very minor extent in the attendance data, and by villages which are shared between several clinics. The exclusion of villages contributing less than 1% of the total annual attendance is one, albeit an arbitrary, means of discounting 'insignificant' data. This was used in our study since higher cut-off indices tended to ignore well over 60% of the villages listed.

In addition, it was decided to assign shared villages to the *nearest* clinic. Whilst this method appeared adequate in Maseru District

1. Series L 50 (D.O.S. 421, edit. 4 - D.O.S., 1979).

it proved problematic in Mokhotlong primarily because the 1 : 50 000 maps of the region, being in draft form, conveyed insufficient information to locate most of the villages. An alternative method was therefore devised using Census Enumeration Areas (EAs). An EA comprises several villages grouped together to form a constituency division; hence, it is possible to ascertain the whereabouts of each listed village from the EA tabulations even if their *precise* location remains mysterious. Thus, our method was to identify villages contributing 1% or more of rural clinic attendance within their EAs, and assign EAs containing three or more of these villages to the relevant clinic. EAs enclosing two listed villages were divided into halves and each half assigned to the appropriate clinic and EAs with only one listed village were apportioned by thirds.

Catchment populations for Maseru District, were computed by reference to population distribution data from the 1976 census.[1] With respect to Mokhotlong, catchment populations were derived by adding EA populations and proportional populations (where apportioned between two or more clinics) assuming an even distribution within them.

Identification of inadequately served populations

Employing the governmental criteria that every citizen should reside within five kilometres of PHC, the construction of 5 km catchments identifies the location and size of inadequately served populations.

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1. Bureau of Statistics (1982) 1976 Census Village Lists - 1976 Census Report, Vol. II.

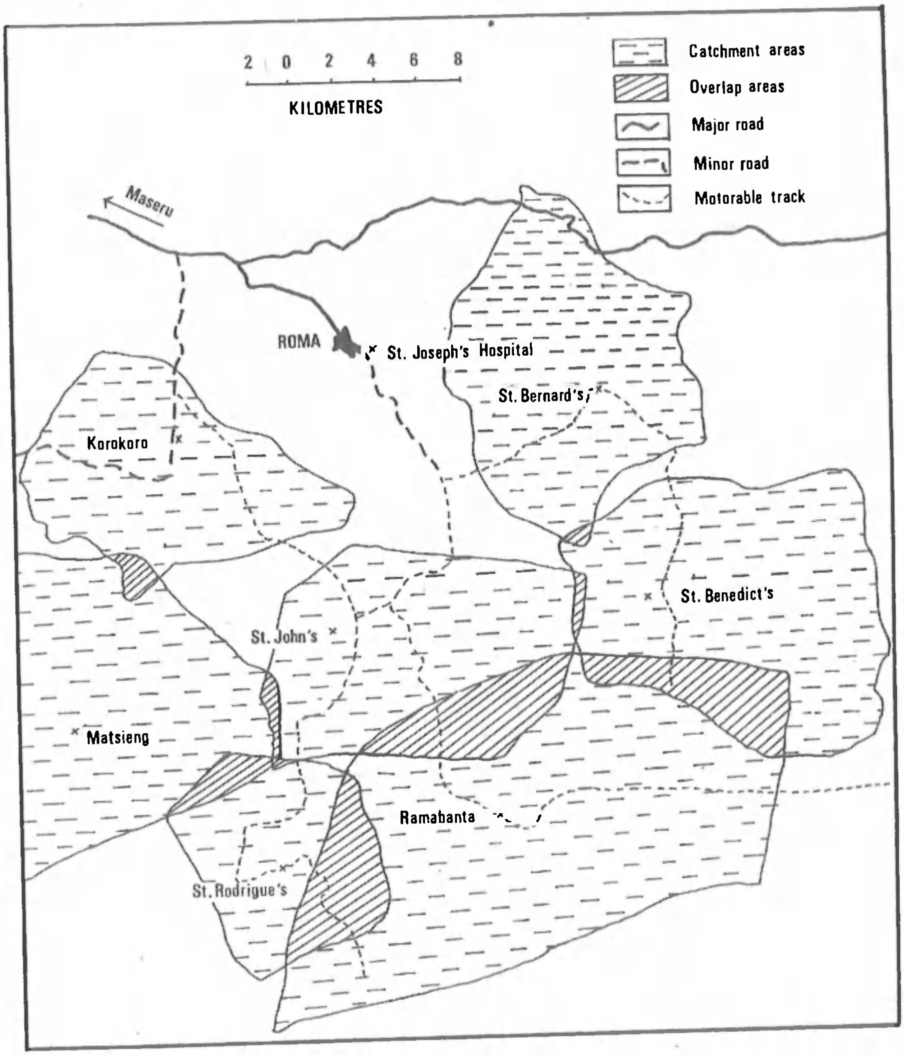


Figure 2: Sample study area: Clinics, catchments and the transport network

Optimalising the location of a new clinic

The objective of our analysis here is to locate a new clinic(s) in such a way that the number of previously disadvantaged people (according to our definition above) accommodated within *its* 5 km catchment is maximised. To begin, we assume the introduction of only one clinic, that the capacities of all clinics are equal, that the population is evenly distributed and that isotropic transportation conditions prevail.

The methodology may be described with reference to our sample study area (see Figures 1 and 2) where PHC is available at eight units; seven clinics and one hospital. In Figure 3, the 5 km theoretical catchments are drawn in place of the actual catchments (Figure 2); a comparison between them demonstrates the existence of underserved areas of considerable size. The next step is to construct a 1.25 x 1.25 locational grid; Figure 3 shows only a sample of these cells primarily for the sake of simplicity and because it would be invalid to consider cells on and towards the boundaries of the study area where our information is necessarily incomplete.

The procedure is to situate the clinic at the centre of each cell and compute the population which it would embrace within its 5 km catchment minus that which is already adequately served by another clinic. Since at this stage, we are assuming an even population distribution, our objective is to measure, in terms of area, the degree of *non-overlap*: that is the proportion of the circle described

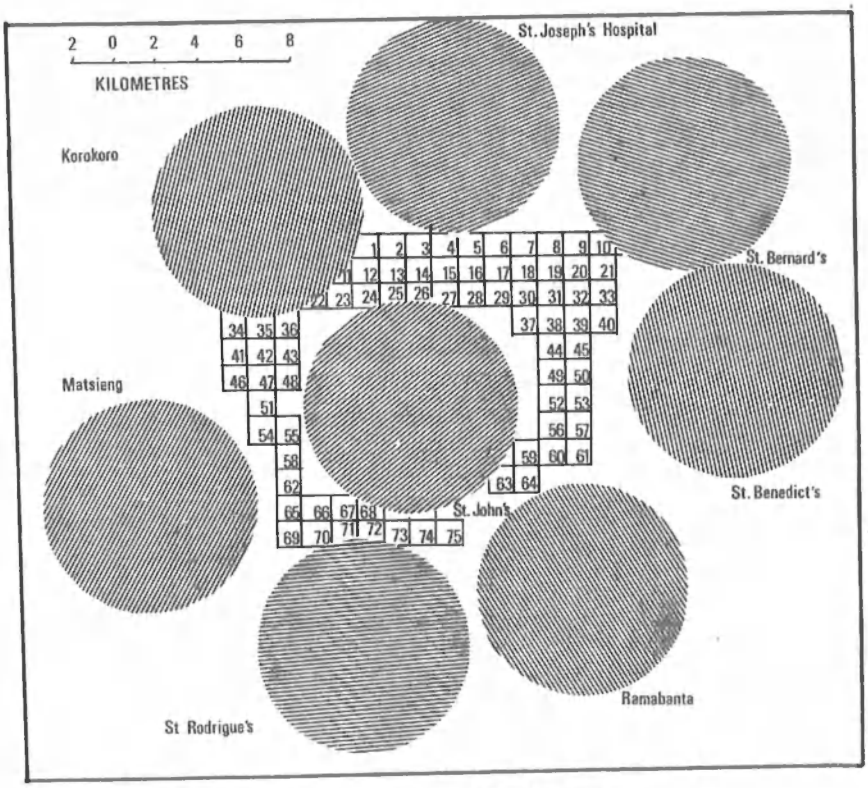


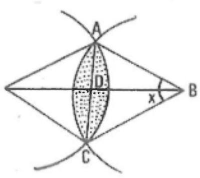
Figure 3: Sample study area: 5km catchment areas and locational grid

around the supplementary clinic which does not fall under the jurisdiction of another 5 km catchment. This index may be measured either planimetrically or by geometric computation. [1]

We may now introduce the constraint that the supplementary clinic locate nearby a motorable track. Figure 2 shows that all the clinics, with the exception of Matsieng, have immediate access to vehicular transport (although this factor is of more imporance in the importation of supplies and the exportation of emergency cases, than out-patient access to the clinics). The optimal location here is defined as the cell with road access generating the highest degree of non-overlap.

As this juncture, we relax the assumption of an even population distribution. Figure 4, abstracted from 1976 Census data, shows population density by cell (in this case covering the entire study area) and indicates a general increase towards the south-west with a local high in the vicinity of Roma. This should have a significant impact upon the optimality of location, and is examined by calculating the *population* of the non-overlapping catchment areas as measured above. This calculation involves the multiplication of the non-overlap area by the population density *factor* (a composite index derived from laying the non-overlapping areas onto Figure 4).

1.



In this case the clinic is situated at B. The shaded area represents overlap with another 5 km catchment. This is given by Area (Segment ABC) - Area (Triangle ABC) x 2

i.e. $2 \frac{x}{360} \pi (5)^2$ - AD x DB.

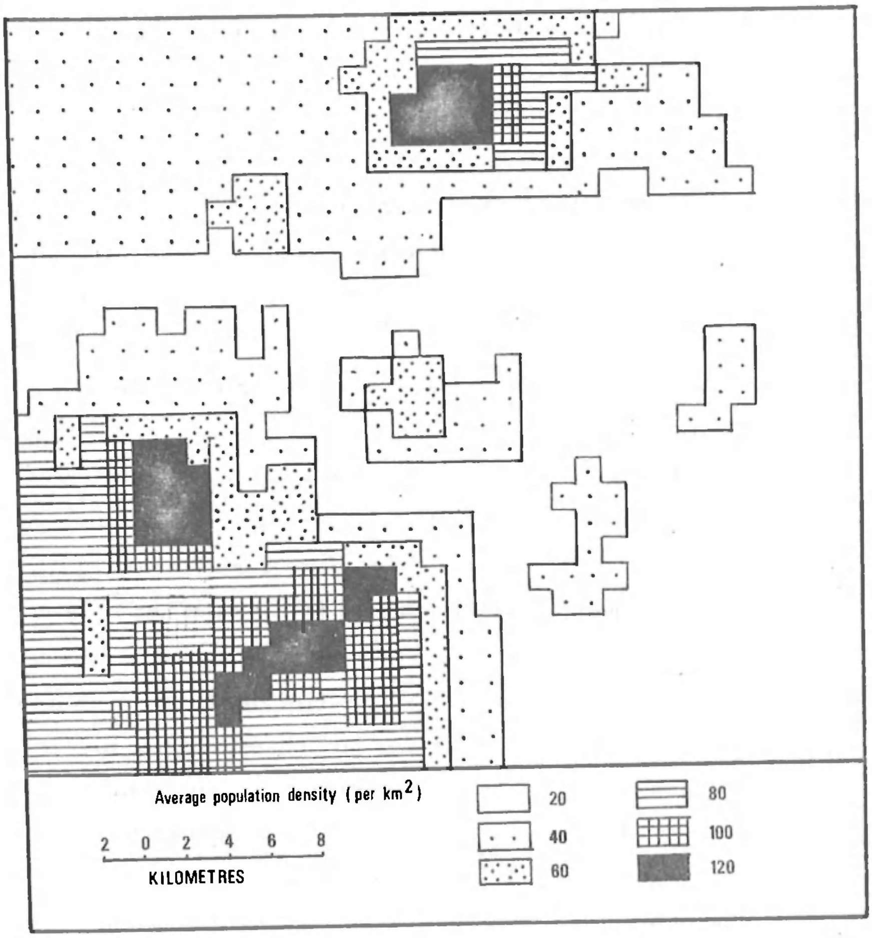


Figure 4· Sample study area: Population distribution

Finally, an attempt is made to include clinic capacity into the locational decision. The survey clearly identified clinics where the facilities were either under-utilised or inadequate. However, the assimilation of this factor into the research design is controlled by the initial constraint on accessibility. Thus it is invalid to 'inflate' catchments beyond the 5 km limit to make use of redundant facilities. The only option is to 'deflate' catchments in cases where the clinic is over-worked and to re-assign the balance to neighbouring clinics where conditions are more favourable. This assumes, of course, that the problem will not be solved either by the construction of additional facilities (at existing or supplementary outlets) or the redistribution of the facilities themselves.

A major problem is encountered at this point in the derivation of a satisfactory index of capacity. Such an index, one may argue, should assimilate several factors; number of beds, quality and quantity of staff and equipment, and the range of facilities at hand. Our definition would not only have to settle upon coefficients describing each of these variables but decide the relative significance of each to the composite index. Moreover, we are interested not so much in clinic capacity *per se* but how that capacity functions with respect to the attendance. We therefore abandoned our attempt to produce 'objective' indices of capacity and concluded that our surrogate (the population served within the 5 km catchment divided by the annual attendance; A/B 'load factor' in Tables 1 and 2) gave a reasonable indication of imbalances in the utilisation of clinic resources, assuming that the attendance is an accurate reflection of clinic capacity.

However, a further problem surfaces - what constitutes an acceptable figure in this respect? Since there is no real answer to this, it would seem illegitimate to employ this index in anything other than a relative context. For example, the average load factor for Maseru District is 2.3 and, in our study area, only Matsieng clinic produces a figure significantly above this (2.9). On these grounds, we might decide to divide a portion of Matsieng's catchment among neighbouring clinics so it can better cope with the population in its vicinity given its present capacity.

In order to reduce Matsieng's figure to an 'acceptable' 2.3, we must deflate its catchment population to 6 378 by reducing the catchment radii. The new radius is determined by laying circles of various radii over Figure 4 and computing catchment populations as above. A radius of 3, 27 km, it was found, enclosed the required population of 6 378. [1]

Matsieng's catchment is then reconstructed (see Figure 5) and the grid is searched once more to locate the cell maximising its non-overlap population. As in Figure 3, only a sample of the grid cells are shown.

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1. Note that had we calculated the new radius by assuming an even population distribution (i.e. $\pi x^2 \propto 6\ 378$, where x is the required radius) then we would have grossly exaggerated its size (i.e. 4.45 km instead of 3.27 km).

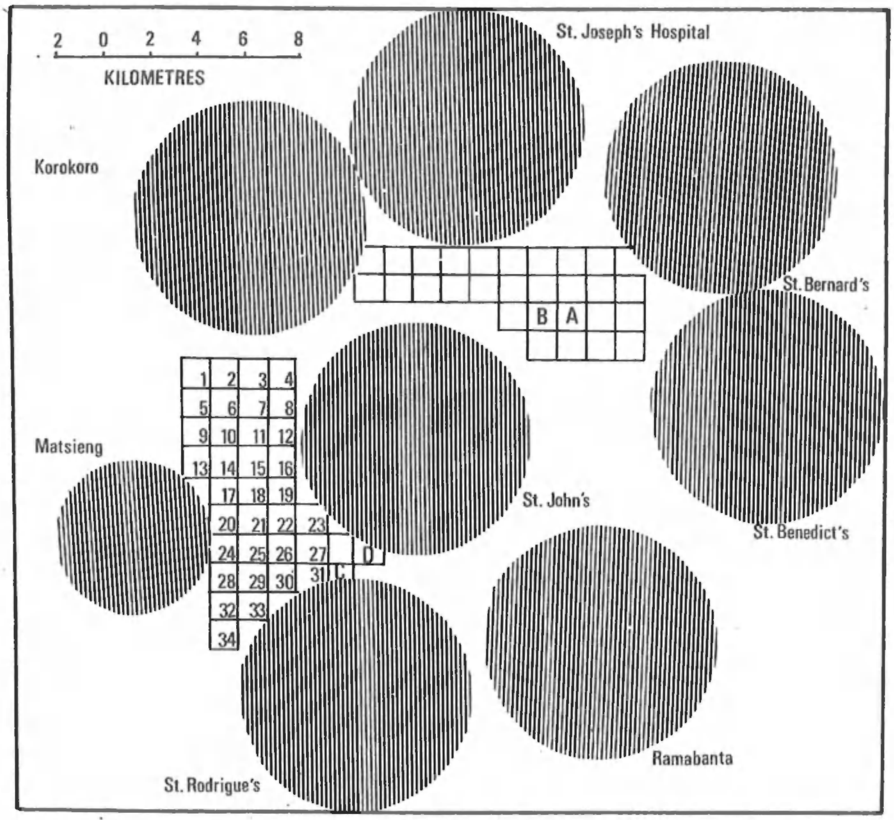

Figure 5: Sample study area: Reduced catchment Matsieng clinic and locational grid

RESULTS

Catchment delineation

The survey demonstrated striking differences between Maseru and Mokhotlong Districts in terms of catchment size and access to PHC (Tables 1 and 2). The 13 Maseru clinics, on average, served a population of 9 024 over 141.7 km²; in contrast, the 8 Mokhotlong clinics were dealing with less people (6 978) on average but spread over a much larger area (412.0 km²). As a result, Maseru clinics accommodated a high percentage of their total catchment populations within 5 km; 64.0% compared to 33.9% for Mokhotlong.[1] However, there is a considerable degree of variation in this index; ranging from 38.2% to 100% in the case of Maseru clinics and from 23.6% to 42.1% in Mokhotlong.

The spatial delineation of the catchments proved problematic for reasons discussed in the following section revealing, for instance, large areas (particularly in Mokhotlong) apparently unserved by any clinic and indicating regions of confusion where several individual catchments overlap.

Figure 2 shows a typical pattern for a sample area around Roma. In

1. In terms of this index, the differences between values recorded for the Maseru clinics and those for Mokhotlong proved significant at 0.001 (Mann-Whitney U = 2; critical U = 11; at $n_1 = 8$, $n_2 = 13$, $\alpha = 0.001$).

TABLE 1

MASERU DISTRICT - CLINICS* AND CATCHMENTS

Name of Clinic	Catchment Population (1976)	Catchment Area (km²)	Population Density (per km²)	% Pop^n inside 5km catchment	Population inside 5km catchment A	Clinic annual attendance B	A/B	No. villages contributing to annual attendance <1%	≥1%
Matsieng	18 470	226.0	81.7	43.6	8 053	2 773	2.9	54	23
Ramabanta	7 710	241.2	32.0	38.2	2 945	2 168	1.4	30	26
St. Bernard's	4 750	138.8	34.2	61.7	2 931	1 245	2.4	15	22
St. Benedict's	4 140	163.7	25.3	53.8	2 227	2 470	0.9	22	10
St. John's	8 320	158.7	52.4	56.1	4 668	3 887	1.2	55	28
Korokoro	5 710	105.8	54.0	81.3	4 642	2 930	1.6	19	20
St. Rodrigue's	10 360	80.1	129.3	98.0	10 153	9 884	1.0	50	27
Nazareth	10 410	173.7	59.9	50.2	5 226	1 299	4.0	20	28
Ntloana Tsoana	3 830	57.1	67.1	100.0	3 830	1 449	2.6	27	25
Thaba Bosiu	10 360	123.5	83.9	68.7	7 117	918	7.8	32	24
St. Barnabas'	7 390	96.0	77.0	92.1	6 806	2 160	3.2	21	19
St. Michael's	16 720	152.9	109.4	60.6	10 132	1 130	9.0	51	23
St. Peter Claver	9 140	125.1	73.1	69.8	6 380	665	9.6	22	14

* Not including 2 other clinics in the District; LPF clinic which serves only members of the Lesotho Paramilitary Force camp outside Maseru, and Lorretto Clinic, the catchment of which is located mostly in Mafateng District. Note also that this does not include the out-patient services of Queen Elizabeth II hospital in Maseru, Mohlomi and Lepereng hospitals outside Maseru, St. Joseph's hospital at Roma and Scott hospital in Morija.

TABLE 2.

MOKHOTLONG DISTRICT - CLINICS AND CATCHMENTS

Name of Clinic	Catchment Population (1976)	Catchment Area (km^2)	Population Density (per km^2)	% Pop^n inside 5km catchment	Population inside 5km catchment. A	Clinic annual attendance B	A/B	No. villages contributing to annual attendance <1%	≥1%
Malefiloane	4 600	559.1	8.2	25.2	1 159	2 890	0.4	35	37
Mapholaneng	6 228	307.5	20.3	34.8	2 167	1 300	1.7	32	24
Libibing	6 022	291.6	20.7	37.2	2 240	1 668	1.3	17	21
Linakaneng	6 123	345.9	17.7	34.4	2 106	1 860	1.1	25	24
Molikaliko	5 559	304.1	18.3	42.1	2 340	3 010	0.8	15	24
Semenanyana	5 574	170.5	32.7	23.6	3 477	2 283	1.5	34	20
St. James	14 733	1053.1	14.0	36.8	2 570	6 897	0.4	13	22
St. Martin	6 985	263.9	26.5	41.2	2 878	7 943	0.4	46	19

this case, the unshaded areas are not necessarily unserved but would fall into the extensive catchment of St. Joseph's hospital. To a large extent, the anomalous catchment shapes can be explained with reference to local topography but it cannot be ignored that the catchments themselves are in fact artificial in discounting villages contributing less than 1% to the total annual attendance of any one clinic. The reconstruction of the catchments without a constraint upon the inclusion of data produces a very different pattern.

Locating the new clinic

Although our analysis covered both Districts in full, the sample area (Figure 2) is analysed here to demonstrate the model. Figure 3 locates 75 cells and in each of these a new clinic is situated and its 5 km catchment delineated. The percentage of overlap encountered in the construction of individual 5 km catchments and the area of the non-overlap region they enclose is shown, for each cell, in Table 3.

Assuming an even population distribution, Table 3 identifies cell 31 as the optimum location. A clinic located here would encounter only 15.6% overlap with other 5 km catchments in the vicinity. However, cell 31 does not have access to a road (Column 6 of Table 3) so we redefine the optimum location as cell 30 which generates 16.1% overlap.

Column 4 of Table introduces population variations to the model; multiplying the composite population density factor (see previous

TABLE 3

LOCATIONAL GRID - CELL OVERLAPS AND NON-OVERLAP POPULATION CATCHMENTS ASSUMING EQUALITY IN OPTIMAL CATCHMENTS OF EACH CLINIC

Cell No.	% overlap of 5km catchment	Non-overlap area enclosed (km^2)	Population density factor (per km^2)	Population enclosed in non-overlap area	Access to road
1.	65.1	27.4	26	712	
2.	61.1	30.5	24	732	
3.	55.2	35.2	24	845	
4.	45.3	42.9	22	944	
5.	38.8	48.0	22	1 056	
6.	34.8	51.2	20	1 024	
7.	30.4	54.6	20	1 092	Yes
8.	31.0	54.2	20	1 084	Yes
9.	34.0	51.8	20	1 036	Yes
10.	44.2	43.8	20	876	Yes
11.	60.8	30.8	28	862	
12.	60.3	31.2	28	874	
13.	59.2	32.0	26	832	
14.	50.9	38.5	24	924	
15.	49.8	39.4	22	867	
16.	37.5	49.1	20	982	
17.	29.0	55.7	20	1 114	
18.	22.9	60.5	20	1 210	Yes
19.	22.0	61.2	20	1 224	
20.	26.3	57.9	20	1 158	
21.	36.3	50.0	20	1 000	
22.	57.9	33.0	30	990	
23.	59.5	31.8	28	890	Yes
24.	59.3	31.9	28	893	
25.	57.6	33.3	26	866	
26.	49.8	39.4	26	1 024	
27.	44.7	43.4	24	1 042	
28.	36.9	49.5	22	1 089	
29.	28.0	56.5	20	1 130	
30.	16.1	65.9	20	1 318	Yes
31.	15.6	66.3	20	1 326	
32.	20.0	62.0	20	1 256	
33.	33.1	52.5	20	1 050	
34.	37.2	49.3	30	1 479	
35.	44.4	43.6	30	1 308	
36.	49.8	39.4	28	1 103	
37.	21.2	61.9	20	1 238	Yes
38.	17.3	64.9	20	1 298	
39.	23.4	60.0	20	1 200	
40.	34.4	51.5	20	1 030	
41.	34.2	51.7	30	1 551	
42.	40.1	47.0	28	1 316	
43.	46.9	41.7	28	1 168	
44.	23.4	60.1	20	1 202	
45.	23.4	60.1	20	1 202	
46.	36.0	50.2	30	1 506	
47.	39.1	47.8	30	1 434	
48.	42.0	45.5	28	1 274	
49.	27.2	57.1	20	1 142	
50.	27.2	57.1	20	1 142	
51.	41.2	46.2	32	1 478	
52.	33.1	52.5	20	1 050	
53.	32.0	53.4	20	1 068	
54.	45.0	43.2	34	1 469	
55.	47.3	41.3	34	1 404	
56.	40.7	46.6	20	932	
57.	39.3	47.6	20	952	
58.	53.1	36.8	42	1 546	Yes
59.	49.6	39.6	20	792	
60.	44.9	43.3	20	866	
61.	41.2	46.2	20	924	
62.	54.9	35.4	48	1 700	
63.	57.0	33.8	22	744	Yes
64.	54.7	35.6	20	712	
65.	61.6	30.1	56	1 686	
66.	59.3	31.9	58	1 850	
67.	60.8	30.8	60	1 848	
68.	62.1	29.8	60	1 788	Yes
69.	61.3	30.4	66	2 006	
70.	61.1	30.5	64	1 952	
71.	58.1	32.9	64	2 106	
72.	62.5	29.4	60	1 764	Yes
73.	62.2	29.7	56	1 663	
74.	69.2	29.7	54	1 604	
75.	72.2	21.8	50	1 090	

section) by the area of the non-overlapping region (Column 3) gives the population enclosed within the area of non-overlap. The optimum location is now cell 71 which, despite generating 58.1% overlap, encloses 2 106 people within the borders of the non-overlapping area. However, if we insist that the clinic should have immediate access to a road, cell 68 becomes the optimum location. It is clear that the increase in population density to the south-west of the study area (Figure 4) has a considerable impact upon the locational decision.

The final stage in the analysis is to consider clinic capacities. As discussed in the previous section, Matsieng's catchment has been "deflated" so that surplus population can be re-assigned to neighbouring clinics. The argument is that Matsieng's capacity is inadequate to accommodate the population presently enclosed within its 5 km catchment. Figure 5 therefore shows Matsieng with a smaller catchment (3.27 km) whilst the others remain the same.

In Figure 5; A, B, C, D refer to cells 31, 30, 71 and 68 (Table 3). A new grid is drawn; for the sake of simplicity, it locates only 34 cells in the south-west corner of the region. Table 4 gives the results; cell 28 is now the optimum location (enclosing 2 781 people). Clearly, the redistribution of part of Matsieng's catchment to its surroundings has moved the optimum location towards it (from cell C to cell 28). However, if the transport constraint is maintained, cell D remains the optimum location. [1]

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1. Cell D encloses a population of 1 788 compared to cell 19's (the apparent optimal location in Table 4) 1 404.

TABLE 4

LOCATIONAL GRID - CELL OVERLAPS AND NON-OVERLAP POPULATION CATCHMENTS WITH REDUCED CATCHMENT FOR MATSIENG CLINIC

Cell No.	% overlap of 5km catchment	Non-overlap area enclosed (km²)	Population density factor (per km²)	Population enclosed in non-overlap area	Access to road
1.	31.0	54.2	30	1 626	
2.	34.2	51.7	28	1 448	
3.	42.5	45.2	28	1 266	
4.	46.0	42.4	26	1 102	
5.	30.1	54.9	30	1 647	
6.	34.2	51.7	30	1 551	
7.	40.1	47.0	28	1 316	
8.	46.9	41.7	28	1 168	
9.	40.4	46.8	30	1 404	
10.	36.0	50.2	30	1 506	
11.	39.1	47.8	30	1 434	
12.	42.0	45.5	28	1 274	
13.	48.7	40.3	34	1 370	
14.	46.0	42.4	32	1 357	
15.	41.2	46.2	32	1 478	
16.	49.8	39.4	30	1 182	
17.	54.3	35.9	34	1 221	
18.	45.0	43.2	34	1 469	
19.	47.3	41.3	34	1 404	Yes
20.	56.5	34.2	44	1 505	
21.	56.3	34.3	44	1 509	
22.	53.1	36.8	42	1 546	
23.	57.4	33.5	40	1 340	
24.	57.1	33.7	52	1 752	
25.	57.6	33.3	50	1 665	
26.	54.9	35.4	48	1 700	
27.	59.0	32.2	48	1 546	
28.	47.9	40.9	68	2 781	
29.	62.1	29.8	66	1 967	
30.	61.3	30.4	66	2 006	
31.	61.1	30.5	64	1 952	
32.	62.5	29.4	82	2 411	
33.	62.1	29.8	86	2 563	
34.	62.1	29.8	90	2 682	

Further analysis

Several extensions to the model are possible. However, these are not described in detail since the improvement in efficiency generated by further model sophistication appears more artificial than genuine (see following section).

A simple but tedious addition to the model is the introduction of 2.....n clinics to isolate the optimal locations of two or more clinics examined in combination. In our example, for a set of 2 clinics, one would locate clinic A at cell 1 (Figure 3) and calculate the non-overlap population for the pair of clinics as clinic B is shifted progressively from cell 2 to cell 75. The procedure is repeated situating clinic A in cell 2, 3 ..... 75. Thus the overlap population for the set of 2 clinics is computed for 74 permutations.

Another modification would be to deflate the catchments of more than one clinic, perhaps by establishing a standard A/B index to which all units must conform. However, in this operation, we not only have to justify our selection of the stated index but assume that the index is a satisfactory measure in the first place. We could also insert a less rigorous transport constraint into the model by ranking each cell with respect to its distance from a road (rather than using the dichotomy YES/NO) as well as by the population enclosed within its non-overlapping catchment. The inclusion of this variable, however, requires specification of the impact of proximity to roads upon catchment populations (for example, if cell x encloses 20% less people than cell y within its non-overlapping catchment, but is 20% nearer, in Euclidean terms, to a road, do we consider these cells equivalent as locational options?) Moreover, at this point we are calibrating access in temporal rather than spatial dimensions. Our data pertaining to temporal catchment patterns are too inadequate to include in the model.

MERITS AND LIMITATIONS OF THE MODEL

The research survey has been broadly successful in locating populations whose access to PHC is unsatisfactory in respect of defined criteria. This information is clearly of considerable use to government in scheduling priorities in the development of rural clinics. For instance, the relative poverty in accessibility to PHC in Mokhotlong District, particularly in the vicinity of Malefiloane and Semenanyana, is strongly indicated in our results. Similarly, in Maseru District, the Matsieng and Ramabanta catchments are identified as the most seriously disadvantaged.

However, the micro-level delineation of individual catchments and location of supplementary clinics in accordance with optimalising principles is subject to gross inaccuracy, partly as a result of the inadequacies of, and gaps within, the data base, and partly in response to the artificiality of operational decisions required by the research methodology. These problems seriously undermine the pragmatic value of the model employed in this paper. Furthermore, it appears that refinement of the model, while possible, cannot satisfactorily accommodate the difficulties encountered in its application to the Lesotho data.

The demarcation of the catchments relies heavily upon the accuracy and continuity of attendance records in the clinic registers. In several instances, this proved problematic; the most serious difficulty being the listing of villages by alternate names, which only the closest familiarity with the territory could solve. This is partly responsible for the difficulty in tracing villages on the maps; the other reason is that not all villages are marked on maps by name (again, only a field check can verify the interpretation of these data). In the same way, the detection of villages well inside catchments as drawn for which no records appear indicates either gaps in documentation or errors in their interpretation (a common feature of the Mokhotlong results).

Another particularly acute dilemma was the selection of criteria to delineate the catchment boundaries. The exclusion of villages contributing less than 1% of the annual attendance, which may appear to discount 'insignificant' data, is nonetheless a purely arbitrary decision. Furthermore, it gives a completely false impression of the degree of catchment overlap. Figure 2, for example intimates that overlap is relatively insignificant but it is also evident that there are considerable areas in this construction apparently *outside* any catchment suggesting a measure of inaccuracy in the original delineation. Replotting the catchments to enclose all the listed villages (increasing the overlap coefficient to nearly 80% for Maseru and 70% for Mokhotlong) dismisses the notion of an efficiently interlocking lattice system of health care provision. The supposition that the peripheral regions of catchments are also 'insignificant', and can therefore be legitimately ignored in the planning exercise, is not justified by the data. For Maseru District, an average of 59% of the villages listed in the clinic registers (see Table 1) and 53% in Mokhotlong District (see Table 2) are located outside the 1% boundaries.

An alternative procedure, which, in Lesotho's highly dissected terrain, might improve upon the original method, is to construct catchment boundaries along important ridge lines where present in the topography. Unfortunately this is not the case; in some instances, this system inflates a catchment artificially by enclosing unpopulated areas, in others, it excludes villages which are, contrary to our definitions of logic in the matter, patronising a clinic on the far side of a ridge.

Some other permutations which rearrange the catchments with respect to different criteria marginally improve upon the efficiency of the network but one must still conclude that the lattice model, as cherished by government planners, is entirely artificial. Our research indicates that central government should direct more consideration to the factors underpinning the confused interlocking catchment patterns we discovered rather than attempting to beat them into fictitious shapes for the purposes of planning. The responses from questionnaires administered to clinic outpatients reveal that distance is only one of the prime considerations in selecting any one clinic. Personal preferences, perceived differences in the quality of service and staff, familial (for accommodation) and business connections in the clinic locale all figure significantly in the decision (cf. Earickson, 1971; Gesler, 1979; Morrill & Earickson, 1969).

More importantly, the shape of individual catchments is strongly influenced by the activities of traditional healers practising in or near them. The data suggest that villagers make use of one type of medicine as often as the other and it is by no means the case that the jurisdiction of traditional healers is a strictly local one or that the treatment is confined to only the most minor complaints. It appears that many healers, particularly those with some reputation, operate through a complex information network and admit outpatients from considerably distant locations. It is vital, therefore, that catchment delineation proceed in awareness of the distortion introduced by traditional healing.

The problems encountered in locating catchment boundaries compound the difficulty of delineating HSAs. The agglomeration of neighbouring clinic catchments into a hospital HSA will only succeed in accumulating their inaccuracies. Moreover, hospital records suggest that this method is, in any case, fundamentally misconceived. St. Joseph's hospital in Roma (Figure 2) treats patients from most of

Lesotho and encroaches into Maseru itself despite the presence of the country's largest hospital in the capital. The southern boundary for St. Joseph's HSA which one might construct from Figure 2 would be quite meaningless.

A final problem with catchment delineation is the calculation of their populations. Besides the uncertainty involved in their construction, their irregular shapes necessitate approximation in deriving their population from density maps. The precision of a village level census is lost in the process. In addition, the method of delineating catchments and computing their populations from EAs in Mokhotlong District is clearly subjective and unsatisfactory.

As regards the location-allocation analysis, there are several intrinsic problems, few of which can be solved through further refinement of the model. First, the technique hinges upon the initial official constraint - that every Mosotho should be within 5 km of PHC - which, upon closer scrutiny, is unsuitable and inadequate. Although we have introduced a transport constraint we are still, in the construction of 5 km circular catchments, assuming isotropic access conditions despite the existence of vehicular traffic and highly dissected topography. The identification of underserved populations and the location of new clinics should more logically proceed from the introduction of a temporal rather than spatial constraint, most likely producing star-shaped rather than circular catchments extending along transport routes and valleys. However, whilst it is possible to acquire data on travel times, our questionnaire responses proved neither accurate nor comprehensive enough to construct temporal isolines. Moreover, the *perimeter* of a temporal catchment would have to be recalculated for each cell in the locational grid as well as its non-overlapping area. Without primary data or surrogatory variables describing the effect of roads and slope on temporal flow patterns, this would be practically impossible.

Second, the evaluation of optimality in any location - by the population enclosed within the non-overlapping section of the 5 km catchment - is unrealistic in a situation where overlap is, and will continue to be, an important feature. There is no reason to suppose that the introduction of a new clinic will impose any more rationality on the system than before. The 'optimality' of the selected location, therefore, is likely to be largely spurious.

Third, our measure of clinic capacity in relation to catchment population remains inadequate in the absence of a more exact and comprehensive coefficient of capacity assimilating quantity and quality factors of staff, clinic and equipment. Our index A/B is sensible only if the recorded attendance represents or approaches the maximum. This was not always the case in our study. For instance, the average load factor for Mokhotlong clinics was 0.7 (see Table 2) and 2.3 for Maseru (see Table 1)[1] but this comparison is invalid primarily because so many of the villagers in Mokhotlong live such a long way from the

1. In terms of this index, the differences between values recorded for the Maseru clinics and those for Mokhotlong proved significant at 0.01 (Mann-Whitney $U = 14.5$, critical $U = 11$, at $n_1 = 13$, $\alpha = 0.01$).

clinics that the tendency is to ignore modern medicine altogether. Furthermore, our method of incorporating the load factor into the analysis assumes that populations can be 're-assigned' to different clinics. In effect, then, the impact of the planning exercise hinges upon the community's response to it, which, given our analysis of the situation, is quite unreasonably expected to be perfectly rational.

Finally, the problems of including boundary data we encountered in the selection of our sample area for presentation in this paper cannot be erased by inflating the study area even to the national level since the government intention to administer PHC by District will itself impose artificial boundaries on the analysis. For the purposes of administration, it will be unacceptable to operate a clinic from one District when most of its patients come from another. In practice, this may mean that no new clinics will be constructed in the vicinity of District borders regardless of the loss in efficiency to the entire system.

CONCLUSION

The study presented here highlights the difficulties of applying location-allocation analysis to examine the provision of a basic need within a developing country. Two basic problems emerge: the limitations of the data base, and the unjustified assumptions required by the model. Our method can succeed in giving only the roughest indication of catchment boundaries and the location and size of underserved populations. Moreover, the locational grid procedure generates optimality of a doubtful character and its further sophistication only reduces the credibility of the results. And, even if a more efficient model could be developed, its merit hinges upon the rational response of the villagers concerned, something which can neither be expected nor incorporated into the design.

It is also evident that our concern with spatial accessibility tends to direct attention away from other factors equally, if not more, important. Firstly, in the Lesotho context, a temporal definition of range would be far more appropriate if it could be operationalised. Secondly, other factors, economic, cultural and social have considerable impact upon accessibility to services [1]. All of these deserve consideration in identifying inadequately served populations and locating supplementary outlets.

One practical suggestion we offer as an outcome of this research is that the Government of Lesotho should think more carefully about the rural clinic construction programme. Besides the fact that our method of identifying disadvantaged populations is imperfect and that the optimality of the locations selected by the model will be fictitious in large measure, our findings suggest that the provision of PHC through the construction of more clinics might be less

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1. Aspatial features of accessibility to health care are discussed, for example, by Earickson (1971); Gesler (1969); Morrill & Earickson (1969); Morrill, Earickson & Rees (1970).

efficient than other methods. Since we cannot expect villagers to behave in the 'rational' manner expected by government planners, it would seem more practical to take PHC to the villages rather than provide it at a central outlet.

All this would require is the identification of poorly served populations and the recruitment of para-medics who are then assigned to them. This has the advantage, as Anon (1979) and Hicks (1976) allege, of reducing both the cultural and economic constraints on the provision of PHC, both of which are severe problems in Lesotho. Para-medics can gain the acceptance of the community far more quickly than clinic staff and, by stressing basic health education, emphasise preventive rather than curative care.[1] In Lesotho, where traditional healing is still powerful, para-medics could have a particularly strong impact by helping to eradicate some of its malpractices which needlessly overburden clinics and hospitals.

However, whilst our comments on the type of location-allocation analysis employed in this study have been largely negative, we do not

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1. As Streeten (1981, p xix) argues: "While health is a major objective according to a basic needs approach, the evidence here suggests that health services, as conventionally defined, may not be an important input, just as formal schooling may not be necessary for education. Curative health services of a western type are rendered more or less useless in the absence of other conditions for improving health. For example, in a village in Gambia, the British Medical Research Council provided specific curative treatment to each child in need. There was only a small difference in child mortality between this village and a 'control' untreated village".

imply that different kinds of models may be of greater value in different situations. Rather, our contention is that location-allocation models will be of little use to development planners if their use of them is incautious. Since this kind of exercise is likely to be a growth area for geographic research in the realm of development studies, it seems vital that more attention is given to its logistical limitations and pragmatic applications rather than to the construction of theoretically sophisticated but practically redundant methodologies. It is therefore pertinent to conclude with McCarthy's (1981, p 116) comment: "Notwithstanding the current vogue to the contrary, spatial analysis remains an important tool in the professional geographer's kitbag. It is a tool we allow to become blunt at our peril".

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DEVELOPMENT STUDIES UNIT

The Development Studies Unit is a multi-disciplinary unit within the Centre for Applied Social Sciences at the University of Natal in Durban. The Development Studies Unit was established at the beginning of 1982 with the purpose of providing a focus for research into the problems of developing areas, with a view to assisting the University to play a meaningful role in the upgrading of the quality of life in the poorer areas surrounding it.

As well as undertaking research in many areas of South Africa, the Unit offers a post-graduate Masters programme in development studies. The Unit has published the following:

Working Papers :

1. Jill Nattrass	The Dynamics of Black Rural Poverty in South Africa
2. Jill Nattrass	The Dynamics of Urbanisation in South Africa
3. Paul Wellings	Modelling Access to a Basic Need: The Provision of Primary Health Care in Rural Lesotho