



## DEFINING LOCALITIES FOR HEALTH PLANNING: A GIS APPROACH

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**Abstract**—The National Health Service in Britain is undergoing far-reaching changes. While District and Regional Health Authorities are currently merging, professionals agree that primary health care is most efficiently managed at the local level. This paper uses geographical information systems (GIS) capabilities to identify a nested hierarchy of localities for the management of primary health care in West Sussex, England. GIS coverages were developed which contained key criteria for defining local areas, including nodes or focal points of service provision, edges which act as physical or psychological barriers to movement, districts such as official administrative areas and interaction criteria such as journey to work, school and family doctor (GP) surgeries. Central to the derivation of the localities was a large matrix of patient to GP flows based on postcoded data. Once managed, these data revealed clear geographical patterns of patient to GP allegiance. A large-scale field survey obtained supporting information on the perception of areas from local residents.

*Key words*—health planning, locality, geographical information systems

### INTRODUCTION

The purpose of this paper is to show how Geographical Information Systems (GIS) can be used to identify local areas for primary health care planning. We discuss both geographical concepts and specific tools, in this case, the ARC/INFO Geographical Information System (GIS). The paper divides into four main sections, beginning with a brief outline of the current changes within the U.K. National Health Service, particularly in relation to the effective delivery of primary health care and the 'localities' debate. We then provide an overview of how English health authorities have approached the task of defining their own localities for health planning and offer a brief review of the literature on regionalization problems in service delivery and the potential application of GIS. Third, we outline criteria for defining localities in the county of West Sussex, in the south of England. We discuss the strategy adopted and the use of GIS; interactive querying of the GIS database and, in particular, overlays of different data sets, provided the key approach to assessing appropriate localities. An alternative approach to regionalization using entropy-maximizing information statistics to identify which areas needed to be grouped together in order to minimize the cross-border flow of patients to doctor's surgeries is also reported. Finally, we offer some conclusions on the usefulness of a GIS-based approach to locality definition.

### LOCALITY PLANNING

Significant variation in health over fairly small areas is well-known to geographers and epidemiologists and

is currently being reflected in national and international trends towards primary care development and planning at the local scale. The World Health Organisation (WHO) recognize the importance of intersectoral collaboration between service providers and of community participation in their 'Global Health for All Strategy' [1]. Such ideas have been instrumental in the development of locally-based health-care initiatives in many countries. At root, these perspectives make the claim that community involvement in health care facilitates better health and that such involvement necessitates collaborative planning focused on relatively small and coherent communities.

In the U.K., these issues are reflected in policy documents such as the 'Cumberlege' report on community nursing [2] and the 1987 White Paper on Primary Health Care [3], both of which argued strongly for localism and community as organizational bases for care delivery. The current interest in local responsiveness amongst U.K. health authorities also coincides with an emphasis on consumerism in the national health policy agenda through which public involvement in health care planning and delivery is encouraged; locality planning is a means towards this goal [4, 5]. It is contended that, by basing health care planning on small geographical areas, recognizable and known to the public, there will be greater public involvement in, commitment to and understanding of the disposition of health care resources.

In the U.K., much of this policy imperative stems from the relatively large size of District Health

Authorities (DHAs). Originally envisaged, at their creation, as corresponding to the catchment of district general hospitals, actual population sizes varied substantially, ranging from about 90,000 to 860,000 [6]. Recent changes within the NHS have altered the role of the DHAs. Notably, the shift to the 'internal market' system in April 1991 separated the role of service providers from purchasers. The DHAs are no longer responsible for providing health care directly, but for purchasing services on behalf of their resident population and many are currently merging to form larger 'commissioning agencies'. Purchasers require a detailed assessment of priorities, specific needs, likely levels of demand and quality criteria. Within this context, and in a situation of relatively little information on both unit costs of supply and likely patterns of demand, 'locality purchasing' is being adopted to enable health care to be better targeted towards local needs.

#### THE PRACTICE OF LOCALITY PLANNING

While many health authorities are moving towards locality planning or locality purchasing, the literature suggests some diversity in the aims identified by different authorities. Issues such as management, budgeting, service delivery, planning, information gathering and community/consumer involvement have been identified as relevant, with priorities varying between district health authorities [7]. There have also been differing approaches to the delineation of localities, ranging from a bottom-up approach involving consumers and community groups, for example, in Riverside and West Lambeth, London, to a top-down approach driven at district level by senior managers, as in Wandsworth and Islington, in London [6].

In technical terms, locality planning has been variously seen as a normative modelling problem and a mapping exercise. The latter perspective has dominated in Britain and will be discussed below. The former approach has undoubted strengths and examples of its fruitful application to social and public service delivery zonation problems have been widely discussed, particularly in the North American literature, but also in Britain [8–11]. Normative modelling has tended, however, to be concerned mainly with the generation of service areas around a provider facility rather than the identification of communities who may exercise choice or have choice exercised for them with regard to the providers which they use. It has also relied on a more sophisticated technical background than the mapping approach and depends on assumptions and conceptualizations which, though academically tenable, lack the immediate heuristic impact of the mapping approaches. There are indications that a sound basis is now emerging for the integration of normative modelling with GIS-based approaches to provide a combined strategy [12], but for much

practical day-to-day health planning, the mapping approach retains a slight edge with regard to acceptability.

Various GIS packages are increasingly being used by health authorities for mapping approaches to locality planning. This strategy adds considerable value to traditional map plus survey methods for community identification [13] as it links with health authority needs with regard to the profiling of local areas in terms of population characteristics and health status. It enhances information for health planning. Yet, at the same time, it too suffers problems. Not only are there obvious difficulties reflecting the availability of geocoded, accurate and timely information which also affect normative models, there are also problems associated with the basic spatial units which are used to form localities. Localities are often uncritically equated with readily available sets of boundaries, in particular, aggregations of census wards. The key aim should be to identify an appropriate set of basic spatial units, which allow linkage to important data sources such as the census, but which are then capable of aggregation to local areas or localities which are meaningful, both to local residents and in terms of health planning.

#### *Identifying localities: previous approaches*

GIS is now widely used in the U.K. in work purporting to be concerned with locality planning [14–18]. This section discusses examples of U.K. health locality planning where the prior considerations for defining the boundaries of local areas have been explicitly reported.

Initial approaches to the delineation of localities often compared maps of existing service and administrative boundaries. For example, one of the earliest attempts to introduce locality planning was undertaken by the Exeter Health Authority in the early 1980's [19]. The aims were to improve liaison between the District Health Authority, Social Services and other statutory bodies and to achieve continuity in terms of the sub-areas used by different service providers. The Exeter district was divided into 12 localities, with populations ranging from 10,000 to 40,000. Coterminous boundaries between social services areas, health service and general practitioner (GP) areas were identified as a starting point and then modified to reflect local community features such as school catchments and shopping centres.

A broadly similar approach was taken to identify 'neighbourhoods' in North Staffordshire, for the purposes of data collection, service delivery and possible implementation of health forums [20]. In this case, two approaches were considered, but rejected as unfeasible: a large scale survey of residents to assess levels of neighbourhood allegiance, and a computer based location/allocation modelling exercise. Instead, 'neighbourhoods' were based on overlays of maps, manually transformed to a uniform scale, to identify

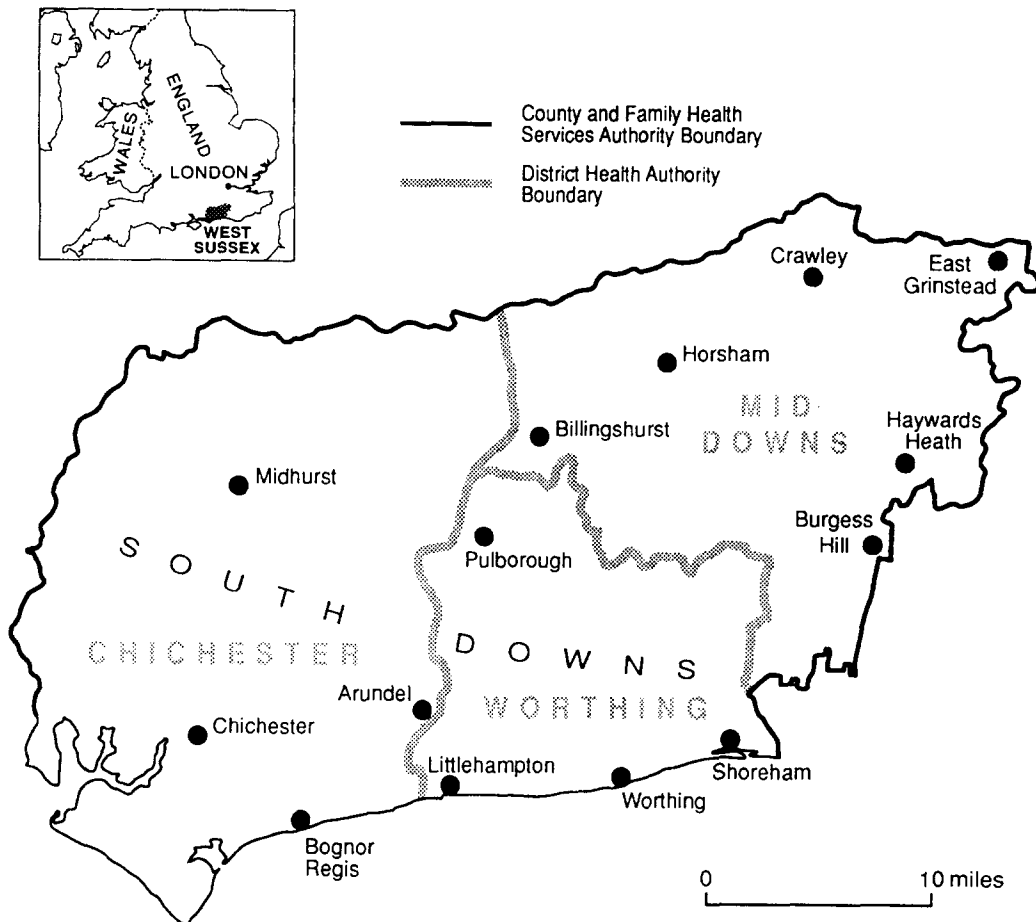


Fig. 1. West Sussex.

coincident boundaries between existing spatial units used by health and social service providers, planners, local government (wards and parishes), police, local education authorities and the Post Office.

Pre-existing sources of boundary data undoubtedly represent some aspect of the underlying 'community areas', furthermore they are often readily available. However, few directly relate to the likely spatial patterns of health service utilization. For example, GP catchment areas often overlap and also cross District or Regional Health Authority boundaries. A regionalization specific to health-care provision needs to be based on relevant information. Moreover, although often intuitively reasonable, the final decisions regarding the integration of different

boundaries depend on local knowledge and are seldom explicitly formalized. Finally, reliance on the integration of official boundaries to form localities might be argued to constitute a management-centred rather than consumer-oriented solution; the extent of consultation with local residents is often limited. Tacket and Curtis have rightly concluded that a "rational approach (to the identification of localities) should address questions about the most suitable criteria for defining communities and operational areas of local services" [6]. Unfortunately, their attempt to relate functional space (where people live, work and socialise) to administrative units (census and post-codes) was compromised by the need to collaborate with the local authority. Health authority localities

Table 1. Elements of the urban environment [27]

Paths	The channels along which the observer usually, occasionally, or potentially moves, e.g. streets, pedestrian paths, bus routes
Edges	Linear elements which differ from paths in that they act as boundaries or barriers to movement, closing off one area from another, or seams along which two areas are related, e.g. city walls, edges of redevelopment
Districts	Medium to large sections of the city, which the observer mentally enters 'inside-of' and which are recognized as having some common, identifying character, e.g. perceived neighbourhood areas
Nodes	Strategic points in a city which are the intensive foci to and from which an observer travels, e.g. road junctions, rail or bus stations, important street corners or meeting places. They are either the convergence of paths or the polarizing centre of a district
Landmark	Also a point reference but, unlike nodes, are usually a physical object which can be seen from a distance and which act as a radial reference, or local feature, to provide cues for navigation within the urban environment, e.g. features used when giving directions to someone

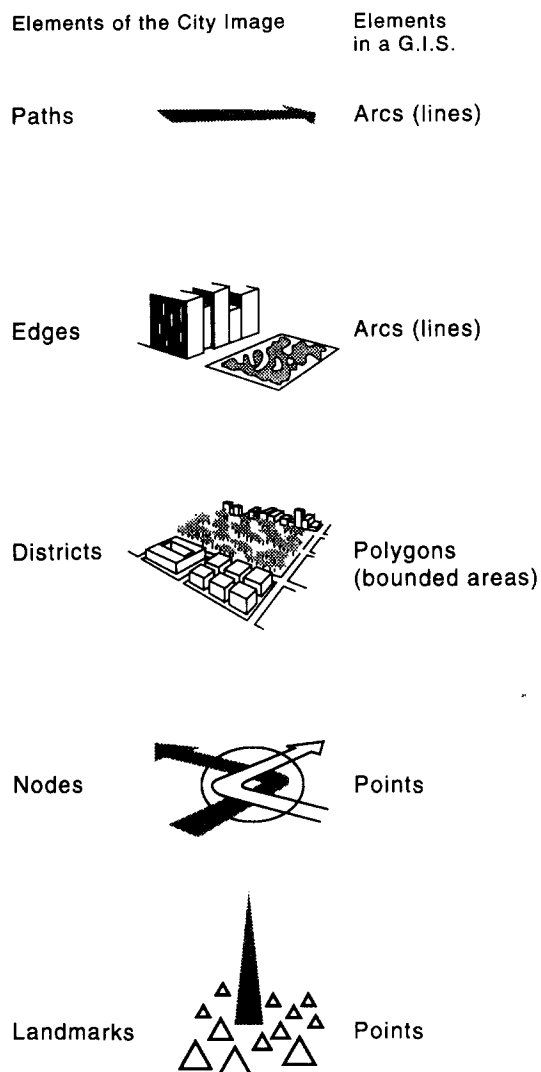


Fig. 2. Elements in a GIS.

from individual preference and allegiance data upwards to more familiar basic spatial units such as wards, can be re-aggregated to reflect functional local areas.

#### IDENTIFYING LOCALITIES IN WEST SUSSEX

The need to identify local areas in West Sussex stemmed primarily from a concern with the equitable allocation of health care resources; an initial imperative therefore focused on the need to identify meaningful areas onto which existing health service and related data could be mapped. This suggested an emphasis on basic spatial units for which routine data are available. A second concern was the issue of more effective care delivery to readily understood areas. West Sussex is a large, mainly rural area and access to health care is especially a problem for the elderly. The number of people aged over 65 accounts for around one-fifth of the population, with the 'over-85s' projected to increase by 11% over the next 4 years [22]; the relative immobility of this population strengthened an argument for a relatively large number of small localities representing coherent communities which could be easily recognized by local residents. A third key aspect of 'locality planning' was that the localities should facilitate collaboration between the DHAs within the County of West Sussex (Chichester, Mid Downs and Worthing) and West Sussex Social Services department (Fig. 1). This implied that the current DHAs should be identifiable within any system of localities. Consideration of these initial criteria suggested that a nested hierarchy of localities, with the DHAs forming a clear upper level, was a logical goal for the research. Further discussion led to the establishment of approximate guidelines on the number/scale of localities: about 12 local areas should be delineated, nested within each District Health Authority (36 localities in all) and of approximately equivalent population size. However, these criteria were not binding and in fact, some were relaxed in order to allow alternative proposals to be put forward.

The most problematic issue was clearly the interpretation of 'coherent community'. The value-laden and contested meanings of the terms 'locality', 'neighbourhood' and 'community' were recognized [23]. 'Locality' was felt to be most appropriately defined by reference to functional areas identified for the planning of primary health care. A 'neighbourhood' has been defined as "a spatially delimited community, the existence of which is more often readily perceived by outsiders than by residents" [24]. The notion of the 'coherent community' was thought to incorporate both perceptual and functional aspects; coherent and easily recognizable local areas were required in order to monitor and respond to specific primary health needs and to achieve more effective health care delivery by establishing communications with local groups within established functional areas.

were constrained to incorporate local authority 'neighbourhoods', based on old London Borough boundaries. These 'neighbourhoods' were then aggregated by asking GPs to identify the areas in which the majority of their patients lived. Obvious problems included the many doctors with patients from across the whole DHA and overlapping GP catchments.

In summary, previous approaches to locality definition appear to have been only vaguely formalized and have tended to rely on an intuitive approach to data integration. There has also been a tendency to take a 'management and information led' approach in which localities are defined in terms of administrative boundaries, particularly wards, simply because of the availability of statistical information for these units [21]. The full potential of GIS in addressing these shortcomings appears to have been neglected. Using GIS, sets of information at any scale

### *The strategy*

In order to reflect perceptual, functional and formal divisions of geographical space within West Sussex, a GIS-based strategy was adopted to integrate different layers of geographical data using the ARC/INFO GIS [25, 26]. In selecting the data for West Sussex, we drew on the work of Lynch, which provides an insight into how people perceive the urban environment and construct their patterns of daily activity around 'mental images' of the city [27]. The links between perceptions and use of space and identity with particular communities allowed us to use the elements of the urban environment identified by Lynch (Table 1) as a conceptual framework for the identification of key spatial datasets. Figure 2 illustrates these elements and shows how they can be recast within the framework and terminology of a geographical information system (in this case, ESRI's ARC/INFO) as arcs (lines), polygons (bounded areas) or points. Additional information was linked to the map features to allow analytical queries of the data and other GIS operations, as discussed by Twigg [21]. Each set of data was stored as a separate layer or 'coverage' within the GIS, listed in Table 2.

### *GIS coverages*

This section discusses the data coverages created for West Sussex in terms of thematic levels and shows how each level was used in the identification of the localities.

*Level one: official boundaries.* The inclusion of official boundaries in the GIS database was important for two reasons. First, the initial criteria had suggested that existing DHA boundaries should be identifiable within the final set of localities. Secondly, the importance of data linkage, particularly with census information, meant that the localities should be based on appropriate spatial units.

Various sets of official boundaries were examined which, in contrast to the studies discussed earlier, showed a high degree of coterminosity. The county

boundary is coterminous with the West Sussex Family Health Services Authority (FHSA) (Fig. 1). West Sussex FHSA covers the three District Health Authorities of Chichester, Mid Downs and Worthing. Within the county, joint planning between the District Health Authorities and West Sussex Social Services was facilitated by coterminous boundaries between the DHAs and Social Services divisions, except for three parishes. All county council services, including Social Services, were delivered to local areas delineated on a common spatial basis: the civil parish. Thus, Social Services divisions and sub-divisions, Education Areas and Library Service divisions all follow Parish boundaries. County Council Community Areas, used by County Councillors in their constituency work (public meetings, targeting service information and monitoring local needs) were defined as groups of parishes. Furthermore, the role of parishes in local politics suggests that they play an important part in community identity, particularly in a rural county such as West Sussex.

The case for choosing the civil parish as the basic spatial unit for building localities was clearly considerable. It is not, however, unproblematic. First, official routine health data are not produced by civil parish in the U.K. The utility of a parish-based solution therefore departs from the optimal for the health service. Nevertheless, health data are increasingly available in a geocoded disaggregated form capable of combination, using GIS, to any chosen zonation—an approach which, though requiring investment, adds flexibility and value to data analysis. Second, the main towns of West Sussex: Chichester, Worthing and Crawley, were each single parishes and in need of a finer spatial subdivision. In these towns, the urban wards were used as an imperfect but available basis for identifying intra-urban communities. Using ARC/INFO, the 1991 enumeration districts were aggregated to parishes and an integrated coverage of parishes and urban wards generated to provide the basic spatial units capable of aggregation to form localities. The remaining levels within the GIS

Table 2. Data coverages for West Sussex

Thematic level	City element	GIS feature	GIS coverage
Official boundaries	District	Polygon	Census ED Census wards Parishes Social services divisions DHA boundaries
Perceived neighbourhoods	District	Polygon	Survey of residents Extent of urban area
Key services	Node	Points	Schools Libraries Post offices Ambulance stations GP surgeries
Roads & railways	Path	Arcs	Roads Railways
Natural boundaries	Edges	Arcs	South Downs Rivers
Catchments	District	Thiessen polygons	School catchment areas
Flows		Arcs	Journey to work Patient to GP

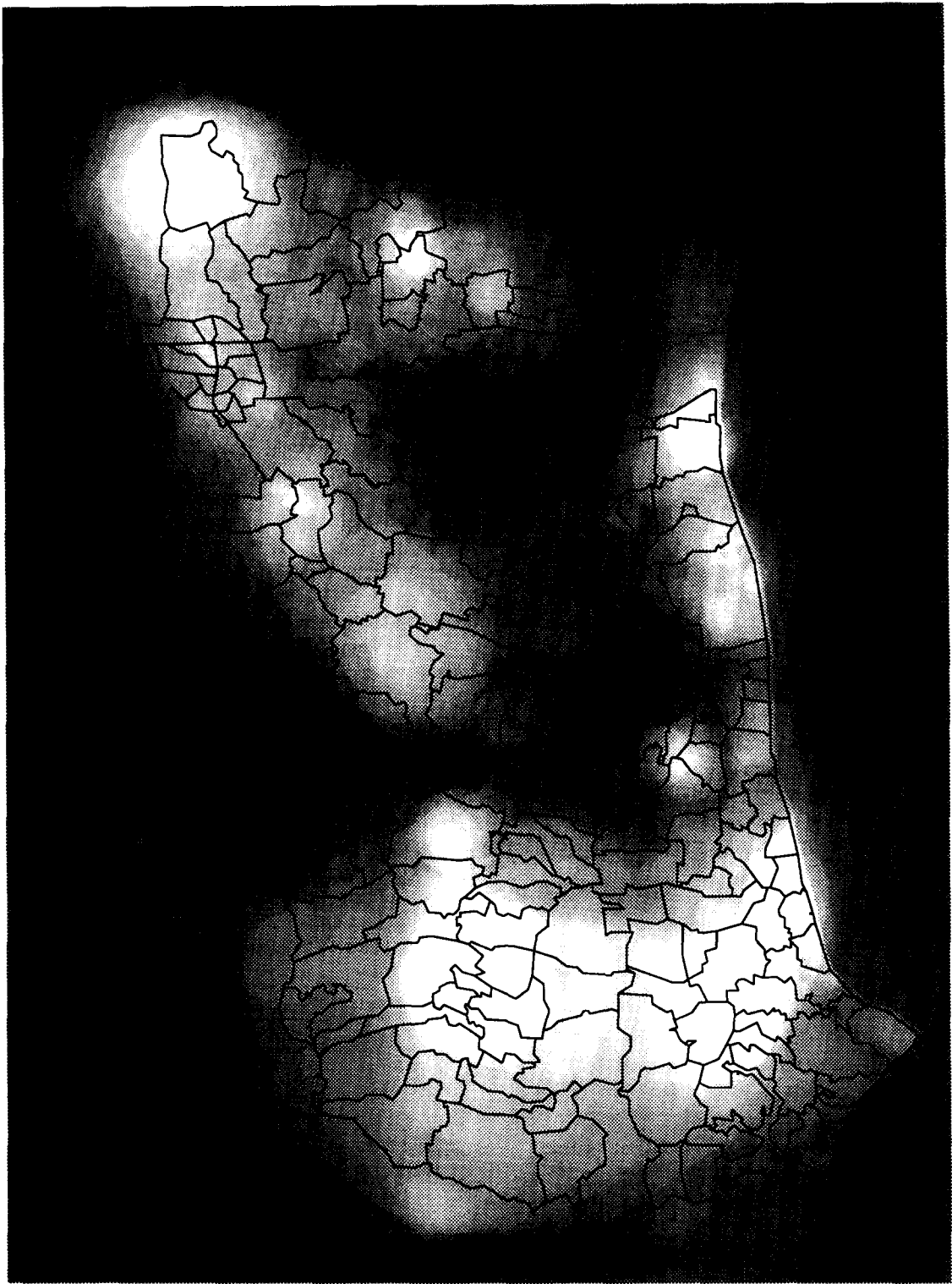


Fig. 3. Perceived communities.

provided the criteria which governed or constrained the aggregation of these basic spatial units.

*Level two: perceived neighbourhoods.* Unlike the other layers, information on local perceptions of 'neighbourhood' and 'community' is rarely available from published sources. A questionnaire and mapping exercise was therefore devised, drawing on previous studies of community and neighbourhood [13, 28]. This was piloted with members of the Community Health Councils, local organizations set up within each District Health Authority to represent the consumer's view, and then repeated using street interviews in the shopping centres of the 15 largest towns in West Sussex. This approach was chosen in order to provide easy access to the largest number of people in a fairly short period of time; over 1000 responses were obtained. Respondents were asked to outline their local neighbourhood on a base map and to provide supporting information on the strength of local community feeling. Perceived neighbourhoods varied from closely circumscribed areas corresponding to the built up area of villages, small towns or sub-areas within large towns, to extensive areas. This variation reflected different social networks, access to means of transport and commuting patterns.

A random sample of 500 individuals' neighbourhoods were digitized and entered into the GIS. The

separate coverages were then converted to raster format (100 m grid squares). Each grid square was coded 1 (inside a neighbourhood) or 0 (outside) and the separate coverages were merged using the GRID module of ARC/INFO, so that each cell of the grid contained a frequency count of the number of respondents who had included that cell within a local neighbourhood. Figure 3 indicates the results of this process with the white shading highlighting areas identified by at least 50 respondents. While clearly constrained by the sampling strategy and of relatively limited utility in the overall GIS strategy, Fig. 3 offers a useful subjective assessment of relative strength of locality allegiances. It offers support for the decision to use wards as the basic spatial unit in urban areas, and it also assisted in the validation of functional areas derived from service utilization patterns.

*Level three: key service centres.* These coverages contained data on the location of post offices and sub-post offices, County libraries, schools, ambulance stations and doctor's surgeries. The coverages were created by converting postcoded address lists to Ordnance Survey grid references via the Central Postcode Directory. Maintained by OPCS and marketed by the Post Office, this is a computerized file which matches the first address in each unit postcode

Table 3. Solution 1. Three-tiered hierarchy of spatial units, maintaining existing DHA boundaries as the highest level

DHA	Local Community Division (LCD)	LCD population	No. of LCAs	Local Community Area (LCA)	LCA population	No. of BSUs*	LCA Code
Chichester	Manhood Peninsula	18,287	2	Selsey	8754	1	1
				East/West Wittering	9533	6	2
Chichester	Chichester	50,501	4	Chichester (North)	9973	9	3
				Chichester (West)	10,920	5	4
				Chichester (East)	18,597	7	5
				Southbourne	11,011	6	6
Chichester	South East Chichester	75,387	3	Arundel	13,416	10	7
				Bognor Regis	43,529	4	8
				Felpham	18,442	5	9
Chichester	The North	33,640	4	Midhurst	13,516	15	10
				Fernhurst	6364	5	11
				Loxwood	5408	4	12
				Petworth	8352	12	13
Worthing	North Worthing	35,290	3	Pulborough	9098	5	14
				Storrington	10,668	5	15
				Henfield/ Steyning	15,524	7	16
Worthing	West Worthing	52,238	2	Littlehampton	24,197	5	17
				Angmering	28,041	7	18
Worthing	South Worthing	97,912	3	Goring by Sea	48,905	6	19
				Broadwater	31,588	4	20
				Findon/Salvington	17,419	3	21
Worthing	East Worthing	57,544	2	Sompting/ancing	25,821	3	22
				Shoreham by Sea	31,723	2	23
Mid Downs	Burgess Hill	39,493	2	Burgess Hill	25,510	1	24
				Hurstpierpoint	13,983	8	25
Mid Downs	Haywards Heath	43,815	2	Haywards Heath	33,891	5	26
				Cuckfield	9924	6	27
Mid Downs	Horsham	73,176	3	Horsham	58,140	10	28
				Billingshurst	9180	3	29
				Cowfold	5856	4	30
Mid Downs	Crawley	125,356	5	Ifield/Langley Green	19,752	4	31
				Broadfield/Gossops Green	32,607	4	32
				Three Bridges	21,436	4	33
				Worth/Pound Hill	25,022	5	34
				East Grinstead	26,539	2	35
Totals		702,639	35		702,639	192	—

\*BSU is the abbreviation for 'basic spatial unit', which in this case were the rural parishes of West Sussex, with the addition of the urban wards in Chichester and Worthing.

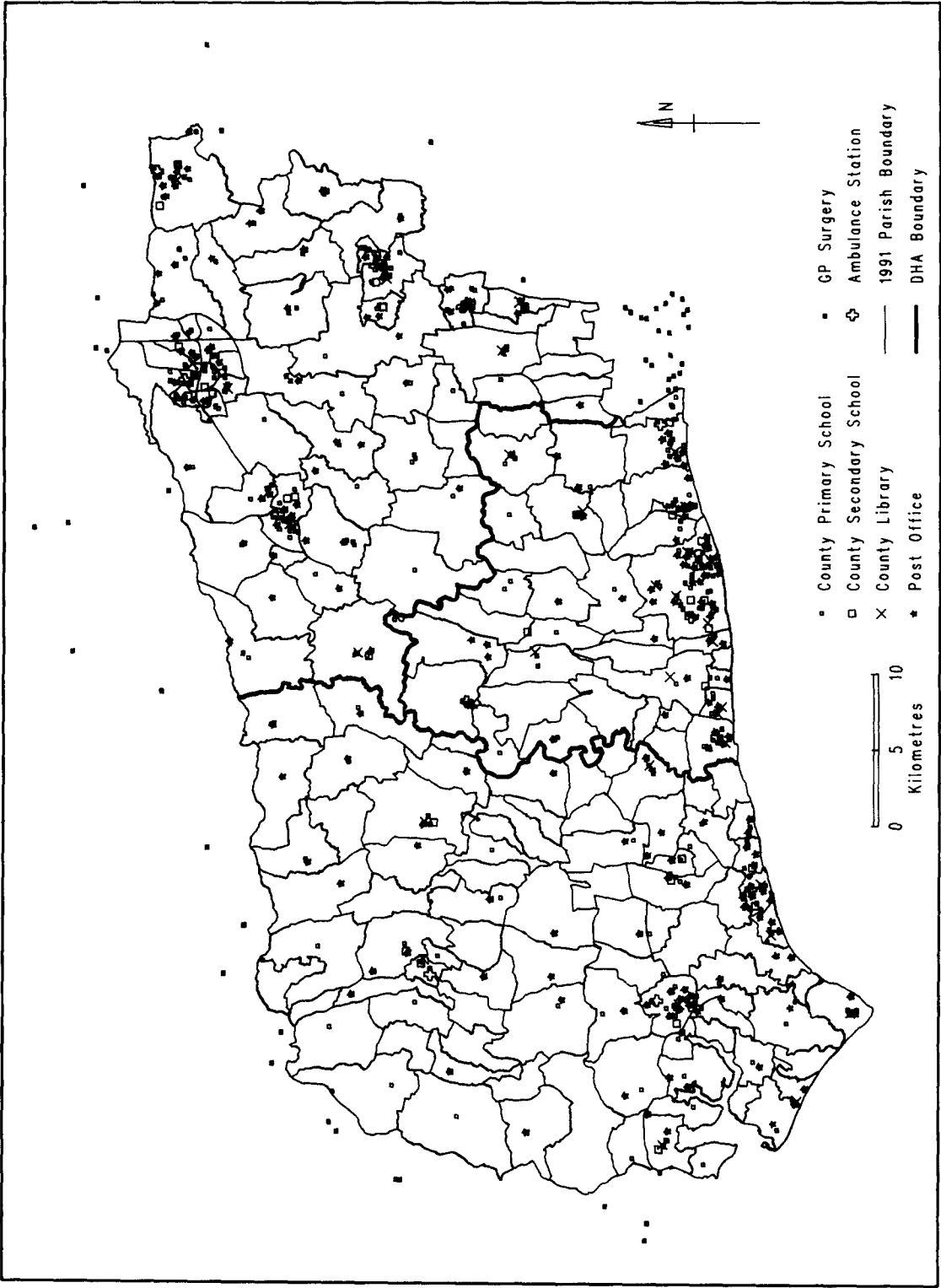


Fig. 4. Service centres.



to an Ordnance Survey grid reference, accurate to the nearest 100 m for England and Wales. An overlay of the service locations illustrated the concentration of activity at nodal points in the main towns (Fig. 4). It also demonstrated that Midhurst, Petworth and Pulborough are important centres in the rural area to the north of the County, while Crawley, a new town, is characterized by polycentric nodes located in the separate neighbourhoods around which it was planned.

*Level four: roads and railways, natural boundaries.* Features such as railway lines and roads, as well as rivers and hills, act to restrict movement, social interaction and hence community development in certain directions. In West Sussex, the South Downs act as a major dividing line (Fig. 5).

*Level five: flows and catchments.* Analysis of population movements to key services can be used to define functional catchment areas. Where such data are unavailable, theoretical catchments can be defined as Thiessen polygons around service centres, within ARC/INFO. Coverages were generated of school catchment areas, journey-to-work flows and, most importantly in the context of the emerging emphasis on primary health care in health service planning, GP catchments. The latter analysis was based on actual patterns of patient to doctor allegiance, as revealed by the patient register and GP/surgery address databases held by the FHSA. Data selected from the patient register included the code of the patient's registered GP and the patient's home postcode. The GP/surgery

database was used to link every GP to the postcode of their main practice address. We were unable to identify whether the patient attended a local branch surgery or the main practice. However, the FHSA argued that many branch surgeries only offered a partial service, often held on an *ad hoc* basis. Patients may also see any of the doctors in a practice. For these reasons, patient flows were linked only to main surgeries.

725,000 records for the West Sussex population registered with West Sussex GPs were extracted from the patient register after removing those records with postcodes which were missing (18,000) or impossible to link to an enumeration district (6000). Each patient address (origin) and main practice (destination) was then allocated to its enumeration district using the OPCS Postcode-ED directory and cell counts were generated for a matrix of origin/destination pairs using SPSS [29]. The 12,000 potential flows were imported to ARC/INFO and plotted to reveal a complex pattern, although core areas and major axes could be identified. A second stage selected the dominant flow out of each ED using SPSS; the plot of this procedure showed a much clearer pattern of patient to doctor allegiance (Fig. 5). The area served by a surgery varied from fairly wide rural areas, for example around Midhurst, to tight clusters of flows around local surgeries in Bognor Regis and Crawley. This coverage provided cross-validation of the information on service nodes and the indications of the maps of perceived communities.

Table 4. Solution 2. Localities unconstrained by existing DHA boundaries

DHA	Locality	Population	No. of BSUs <sup>a</sup>	Locality code
Chichester	Selsey	8754	1	1
Chichester	East/West Wittering	9533	6	2
Chichester	Bognor Regis	43,529	4	3
Chichester	Felpham	18,442	5	4
Worthing	Littlehampton/Angmering	51,342	8	5
Worthing	Worthing	97,912	13	6
Worthing	Sompting/Lancing	25,821	3	7
Worthing	Shoreham by Sea	31,723	2	8
Worthing	Henfield	10,268	5	9
Worthing/Mid Downs	Cowfold	10,447	6	10
Mid Downs	Hurstpierpoint	13,712	7	11
Mid Downs	Burgess Hill	25,510	1	12
Mid Downs	Cuckfield	10,860	7	13
Mid Downs	Haywards Heath	33,891	5	14
Mid Downs	East Grinstead	24,351	1	15
Mid Downs	Worth/Turners Hill	27,210	6	16
Mid Downs	Three Bridges	21,436	4	17
Mid Downs	Broadfield/Gossops Green	32,607	4	18
Mid Downs	Ifield/Langley Green	19,752	4	19
Mid Downs	Horsham	58,140	10	20
Mid Downs	Billingshurst	9180	3	21
Worthing	Storrington	10,668	5	22
Worthing-Chichester	Pulborough	11,299	9	23
Chichester	Loxwood	5408	4	24
Chichester	Petworth	6151	8	25
Worthing-Chichester	Arundel	14,312	14	26
Chichester	Chichester (East)	18,597	7	27
Chichester	Chichester (West)	10,920	5	28
Chichester	Chichester (North)	9973	9	29
Chichester	Southbourne	11,011	6	30
Chichester	Midhurst	14,497	16	31
Chichester	Fernhurst	5383	4	32
Totals		702,639	192	—

<sup>a</sup>BSU is the abbreviation for 'basic spatial unit', which in this case were the rural parishes of West Sussex, with the addition of the urban wards in Chichester and Worthing.

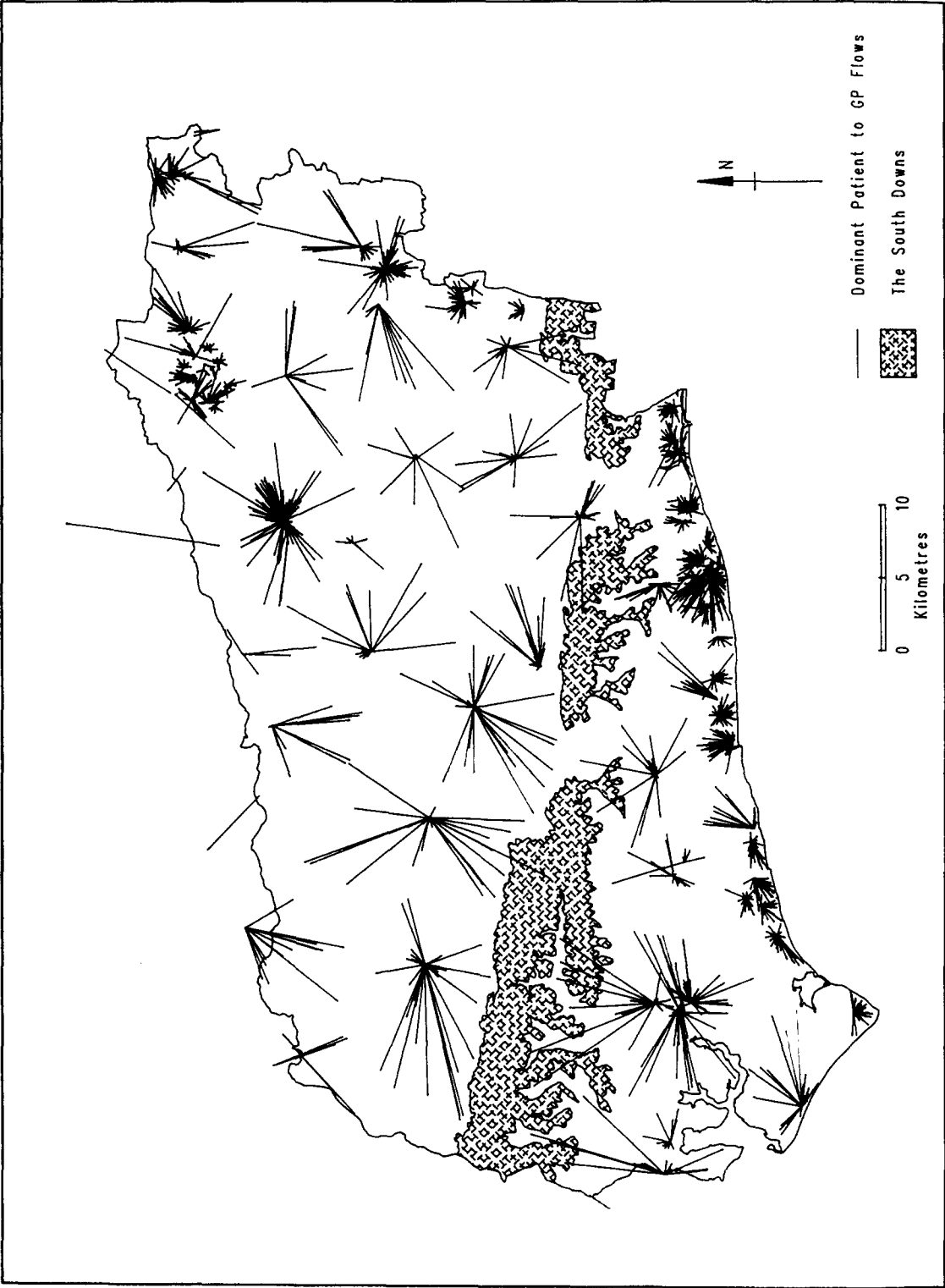


Fig. 5. Patient-GP flows and the South Downs.

Table 5. Solution 3. Two-tiered hierarchy of spatial units, classification based on GP/Patient profile

DHA	Higher Level Area (HLA)	HLA population	No. of LAs	Local Area (LA)	LA population	No. of BSUs*	LA code
Mid Downs	Crawley	100,961	3	Langley Green/Tilgate	34,734	6	1
Mid Downs				Pound Hill/Turners Hill	30,132	6	2
Mid Downs	Central Belt	210,934	16	Ifield/Rusper	36,095	7	4
Mid Downs				East Grinstead	26,539	2	3
Mid Downs				Horsham	52,834	6	5
Mid Downs/Chichester				Loxwood	7732	5	6
Mid Downs				Haywards Heath	33,891	5	7
Mid Downs				Cuckfield	9629	5	8
Mid Downs				Billingshurst	10,018	4	9
Chichester				Petworth	7283	10	10
Chichester				Fernhurst	5383	4	11
Chichester				Cowfold	6151	5	12
Worthing				Pulborough	9098	5	15
Worthing				Storrington	9640	4	16
Chichester				Bury	2201	4	17
Mid Downs				Hurstpierpoint	13,712	7	18
Worthing				Henfield	5527	3	20
Worthing				Steyning	10,498	5	21
Worthing	Midhurst	13,365	2	Bramber	798	1	30
Chichester				Rogate	3934	3	13
Chichester	Burgess Hill	25,510	5	Midhurst	9431	11	14
Mid Downs				Burgess Hill	25,510	1	19
Chichester				East & West Dean	2849	6	22
Chichester				Bosham	5013	3	28
Chichester				Chichester	15,705	7	29
Chichester				Oving/Donnington	16,909	6	33
Chichester				East & West Wittering	9533	6	37
Chichester				Southbourne	10,030	5	23
Chichester/Worthing				Arundel	4191	8	24
Chichester				Slindon	14,653	8	25
Worthing	Worthing	67,920	2	Patching/ Findon	2357	3	26
Worthing				Worthing	65,563	8	32
Chichester/Worthing	Angmering/Littlehampton	47,110	1	Angmering/Littlehampton	47,110	6	27
Worthing	Adur	57,544	1	Adur	57,544	5	31
Worthing	Ferring/Central Worthing	34,721	1	Ferring/Central Worthing	34,721	5	34
Chichester	Bognor Regis	43,529	1	Bognor Regis	43,529	4	35
Chichester	Middleton-on-Sea	13,413	1	Middleton-on- Sea	13,413	2	36
Chichester	Selsey	8754	1	Selsey	8754	1	38
Totals		702,639	38		702,639	192	—

\*BSU is the abbreviation for 'basic spatial unit', which in this case were the rural parishes of West Sussex, with the addition of the urban wards in Chichester and Worthing.

### Regionalization: generating localities

The GIS-based approach allowed the generation of several alternative regionalizations, using different approaches (visualization and statistical) and designed to meet slightly different criteria. The regionalizations presented here are only three of the many possibilities, but represent both interpretive and statistical approaches to locality definition.

*Visualization.* One of the main advantages of a GIS is its visual impact. The initial approach to locality definition was therefore to use this visual impact, the "eye of experience" [30], to interpret overlays of the various data layers. Focus groups held with health service managers and representatives of other public service agencies explored different combinations of indicators. The resulting deliberations were discussed with consumer organizations and refined by researchers with local knowledge. This interactive approach highlighted similarities in the patterning of several of the data layers and indicated that primary care utilization, a key element in the internal market, strongly reflected the constraints of natural, perceptual and service centre factors. For this reason, and on the recommendation of the focus groups, GP flows

and their relationship to the chosen basic spatial units assumed a central importance in the regionalization process.

*Solution 1.* The first regionalization (Fig. 6 and Table 3) began by defining a highest level constrained to match the existing DHA boundaries. The second level (12 units) was broadly similar to Social Service 'divisions'. Nested within these were 35 'local areas' based on groupings of the basic spatial units of wards and civil parishes reflecting patient-GP flows.

*Solution 2.* Following the emerging tendency for DHAs in the U.K. to merge, it was proposed that the three DHAs in West Sussex should merge from 1 April 1995 following public consultation during the summer of 1994. Further intentions include the possible formation of a West Sussex Commissioning Agency in 1995/6 combining the merged DHAs and the FHSA, and joint commissioning between health and the county social services department to purchase 'community care' for people whose needs include both health and social components. A second visualized regionalization was developed to reflect this developing political situation. By relaxing the constraint of existing DHA boundaries, the second regionalization was also able to reflect the existence of cross-border

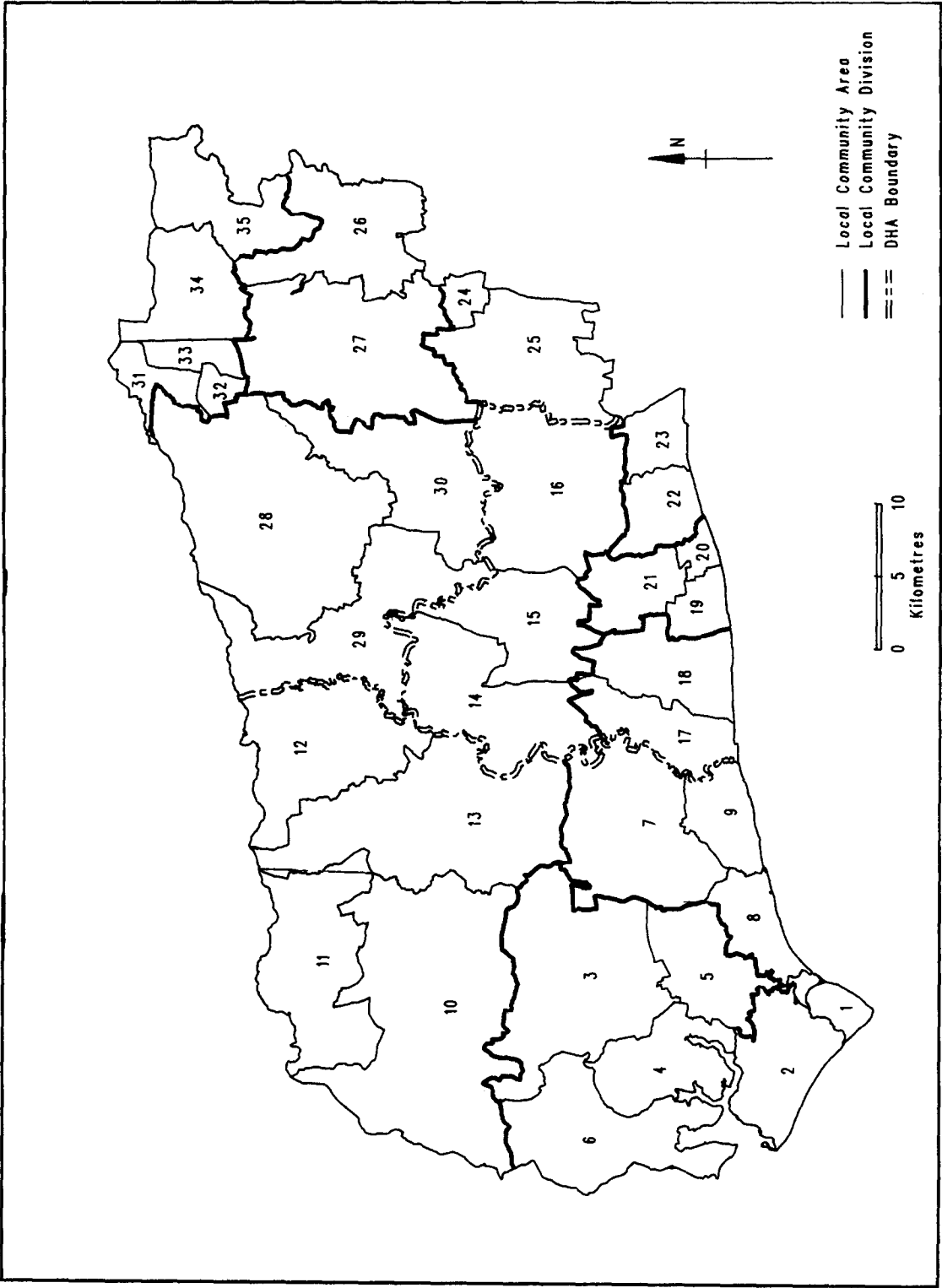


Fig. 6. Localities for health planning: solution one (constrained approach).

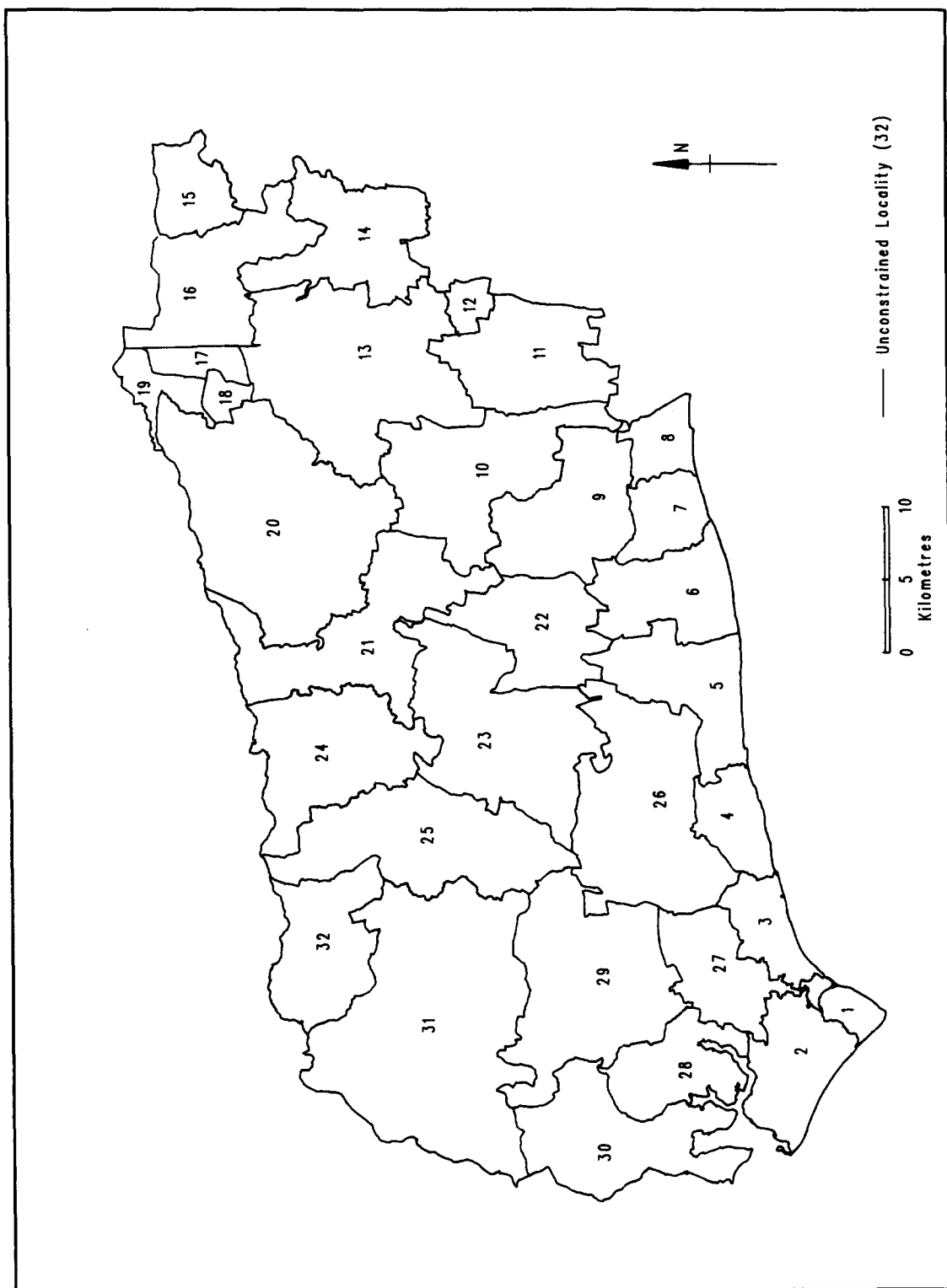


Fig. 7. Localities for health planning: solution two (unconstrained approach).

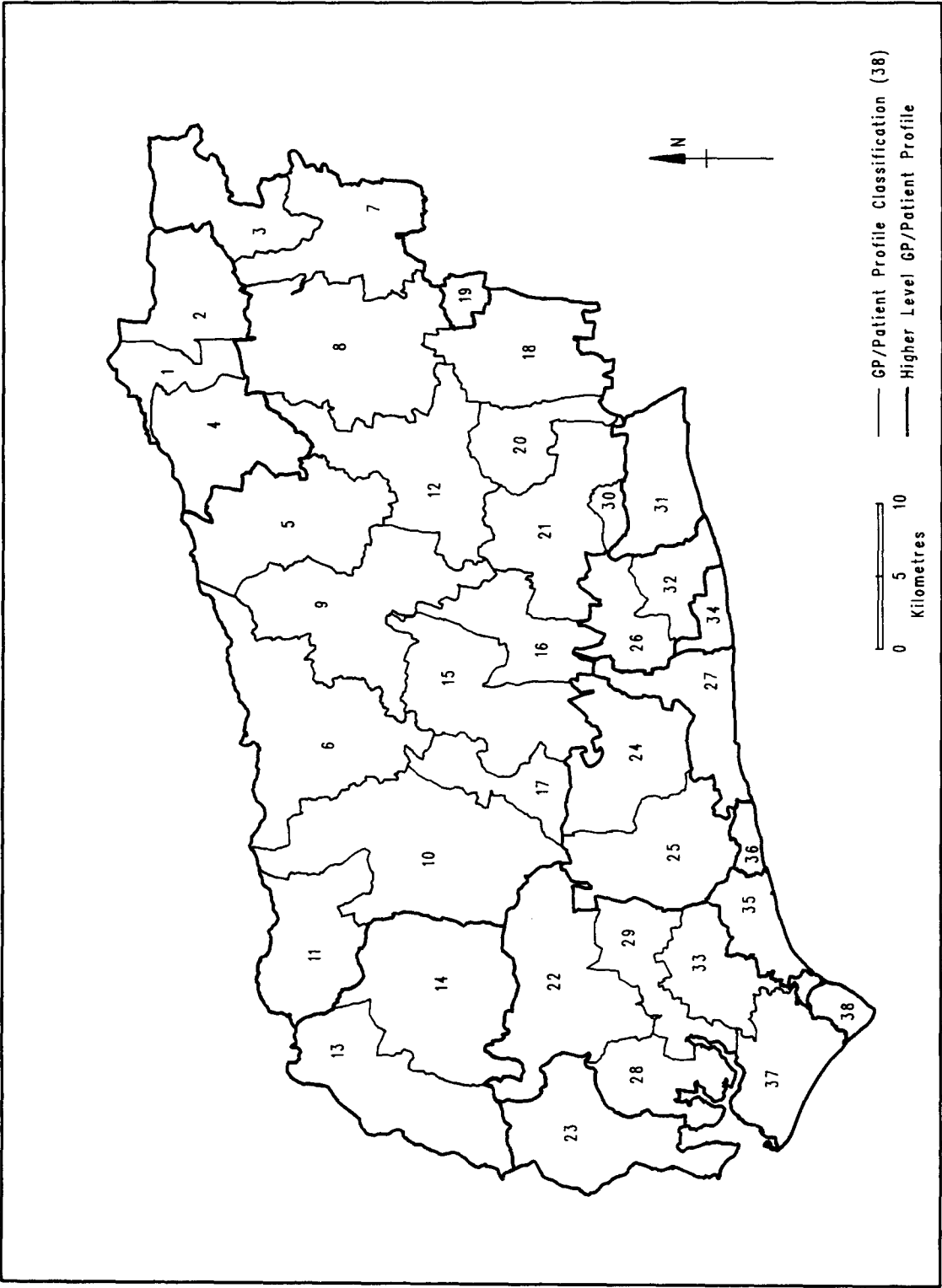


Fig. 8. Localities for health planning: solution three (information statistics approach).

patient to GP flows. Using the same interactive approach a new set of 32 areas were identified (Fig. 7). Table 4 identifies these localities and provides details on their size, both in terms of population and the number of constituent basic spatial units. The table also links the localities to the DHA(s) in which they fall. The main changes from the first solution were due to cross-boundary flows between Chichester and Worthing DHAs, especially around Arundel and Pulborough, and between Worthing and Mid Downs DHAs in the area north of Worthing and Shoreham.

*Solution 3: classification using information statistics.* The final approach to regionalization grouped the basic spatial units according to a single criterion. A classification algorithm based on information statistics was used to identify which parishes/wards to combine in order to internalize the major flows to GP practices [31]. For this analysis, patients and surgeries were re-allocated to the basic spatial unit of urban wards/rural parishes to produce a new origin/destination matrix. Data preparation involved transforming a list of origin/destination cell counts to a full rectangular file in which each row represented a GP (destination unit) and each column represented the patient's home (origin unit). Cell counts were converted to row percentages to produce a profile for each GP in terms of the origin of their registered clients.

For any population, there is a finite number of ways in which  $N$  individuals, in this case GPs, can be classified into  $K$  groups ( $K$  ranges from 1 to  $N$ ). The classification algorithm finds that grouping (where  $K$  is specified in advance) which maximizes between-group and minimizes within-group differences, based on analysis of variance criterion. The iterative procedure calculates the between-group inequality for each possible combination of individuals within the specified number of groups ( $K$ ). Alternative groupings can be evaluated using the  $R_i$  test statistic, a measure of the between-group inequality as a proportion of total inequality. This can be interpreted as a percentage: the higher the value, the greater percentage of variation is between groups. As the number of pre-specified groups is increased, so will the value of the 'best'  $R_i$  test statistic, as the groupings become more fine-tuned and within-group variation is low. Finally, a cut-off point is reached at which increasing the number of groups does not result in significantly better  $R_i$  values.

Starting from the initial aim of identifying around 36 areas, the 'best' solution suggested aggregation of the basic spatial units into 38 localities. These were then classified into 14 higher-level units in the same way (the  $R_i$  values for different numbers of groupings were compared; 14 was an appropriate 'cut-off' point). The two-tiered set of 'local areas' and 'higher level areas' is shown in Fig. 8. Table 5 identifies the local areas and provides information on the number of constituent basic spatial units and the population size for each local area and higher level area. The table also

shows how the local areas are grouped into the higher level areas and indicates how these areas relate to the existing DHA boundaries, although the DHA boundaries were not taken into account during the classification procedure.

*Discussion.* The three proposals for localities (Figs 6, 7 and 8) can be seen as a continuum, from a set of spatial units which are constrained by existing service boundaries (the DHAs) in solution 1, to units which are defined purely in terms of current patterns of primary care utilization (solution 3). The third solution is based entirely on a single criterion, while the interactive approaches take account of a range of geographical, perceptual and functional criteria, including the coverages of patient to GP flows and the perceived neighbourhoods suggested by local residents. Since each solution is composed of the same set of building blocks (parishes and urban wards), it is fairly easy to switch from one set to another. In particular, the weight given to current DHA boundaries may shift when the DHAs merge. The third classification, based entirely on patient flows, could be seen as over-simplistic but did match fairly closely and thus lends support to the sets of units derived from the unconstrained interactive approach (solution 2).

The three solutions are clearly not without problems. First, they are technocratically-derived, particularly in the case of solution three. Despite the input of perceptual mapping, the role of the general public in generating the regionalizations was non-existent. They also had limited input in validating the areas. This shortcoming would be likely to have an impact on public understanding and commitment to the recommended areas. Second, the eventual stress on GP flows led to a situation where localities for future planning were being based on current patterns of service utilization. Third, the tables indicate that the original criterion of roughly equal populations was not satisfied; some 'communities' were larger and others smaller in what was ultimately felt to be a realistic and important finding for health planning. Finally, in focusing on health service use, the regionalization took no account of variations in health status between the different areas.

## CONCLUSION

GIS provides the most appropriate framework for designing an information system to combine geographically referenced social services and Health Authority patient and service data [14].

Geographical Information Systems are increasingly being used by health authorities, particularly for health planning and profiling of local areas [15, 32]. This paper demonstrates that they can also be effectively used in the preliminary stages of identifying coherent local areas for assessing health needs, particularly when they make use of data on patterns of service usage. This constitutes an advance on manual approaches to the delineation of localities and,

through the integrative capabilities of GIS, allows a number of problems to be addressed. Specifically, the paper has indicated how the utility of pre-existing boundaries can be evaluated against more perceptually-grounded data; it has also enabled comparisons to be made between the 'stated preferences' of residents, based on a field survey of perceived local neighbourhoods, and the 'revealed preferences' indicated by actual patterns of spatial behaviour, such as visiting the family doctor. Whilst GIS systems may allow for more sophisticated and rigorous regionalizations than those presented here, it is also true that the use of GIS as described in this paper offered significant advantages in terms of data integration, the interactive querying of the database and the preparation of map output.

The key element in defining localities for health planning is the choice of an appropriate basic spatial unit. In West Sussex, the localities were groupings of rural parishes and urban wards. These units are the basis for current service boundaries, an important consideration in implementing new proposals to improve service delivery. They also enable data linkage with sources such as the census since both wards and parishes are aggregations of census enumeration districts. Data can therefore be aggregated to the level of localities to produce population profiles, which can inform the assessment of health needs. The goal of empowering local communities depends on consumers having access to information and a forum to voice their views. In West Sussex, the parishes are the smallest scale of grass-roots political allegiance. Localities defined from this basic spatial unit should therefore reflect 'coherent community areas' and increase the flow of information between service agencies and consumers.

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