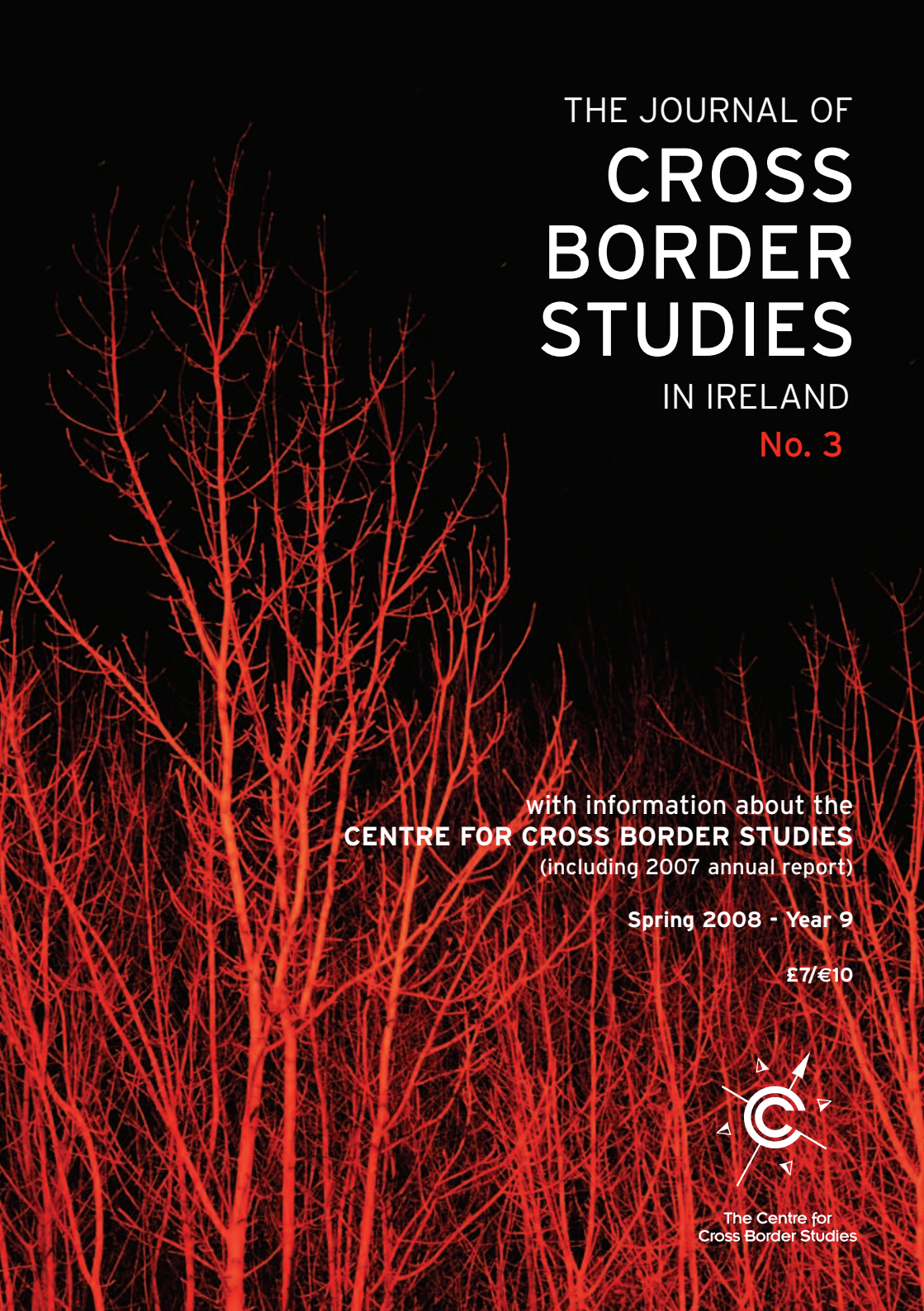

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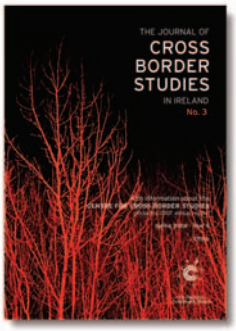

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EU Programme for Peace and Reconciliation in Northern Ireland and the Border Region of Ireland

SURVEYING THE SICKBEDS: INITIAL STEPS TOWARDS MODELLING ALL-ISLAND HOSPITAL ACCESSIBILITY

Ronan Foley, Martin Charlton and Patricia Clarke

Ronan Foley

Martin Charlton

Patricia Clarke

There has been increasing interest in recent years by both civil servants and academics in both Irish jurisdictions in modelling economic and social structures across the whole island, with health services one of the key areas explored[1]. There has been some limited cross-border movement in the utilisation of health care, and a recently published preliminary study by Jamison and Butler (2007)[2] examined the existing configuration of acute hospital services, identifying considerable potential for cross-border collaboration in these services, particularly in the border region.

Hospital rationalisation remains somewhat further advanced in Northern Ireland than in the South, which may present some issues around reciprocal service provision.[3] However, strategic reorganisation plans in the health sector have been drawn up since 2000 in both jurisdictions, as represented by the Hayes Report in the North[4], and the Hanly Report[5], the Developing Better Services Report[6] and the Teamwork Report[7] in the Republic. However all these reports contain practically nothing with a cross-border dimension. Recent developments in cancer services – with patients from Donegal going to Belfast for radiotherapy – show that it is possible to begin to envisage the future pattern of acute hospital services on a cross-border basis. This initiative is the first indication that the Irish Government is prepared systematically to access

services in the North which benefit citizens of the Republic[8].

This article, based on work the National Centre for GeoComputation at NUI Maynooth is doing for the Centre for Cross Border Studies, is a development of Jamison and Butler's work in that it takes a geographical or spatial approach to measuring accessibility to acute hospitals and examines how the current configurations in both jurisdictions can be expressed in terms of an 'accessibility score'. It also investigates quantitatively another of these authors' themes, namely the relative accessibility of hospitals both North and South as expressed by beds per patient.

The role of spatial planning

Jamison and Butler note the role of history in explaining the current distribution of hospitals North and South. For a health geographer this is a crucial aspect in modelling health care provision.[9] The distribution of the current hospital network in Ireland reflects the previous organisation of hospital services, developed from the 18th century onwards and reflected in the pre-partition model, which covered the whole island. In this model the general hospital provision was broadly based on two elements: voluntary hospitals, mostly located in the cities, and the general county hospitals, typically associated with local authorities.[10] The pattern of provision after partition initially maintained these structures. In the latter half of the 20th century, the introduction in Northern Ireland of the National Health Service model created one structure, while a notional national public hospital system, but one characterised by a more complex public-private mix with a stronger role for private health insurance, emerged in the South.

Similarly, the organisation of hospitals in both jurisdictions differed. In the North, they were organised under a Trust model with multiple sites within each Trust area. For the purposes of this article we have based our assumptions on a Trust model with nine acute hospitals and a simple bed count with no differentiation by specialism. In the South, the 40 hospitals providing acute care are a mix of voluntary hospitals and Health Board/Health Service Executive funded units. Within both jurisdictions there is a range of hospital sizes, expressed in both the number of specialisms and the total bed count, although the latter was the sole measure which was used in the model for this study.

There has been a concerted effort in both jurisdictions in recent years to look seriously at the organisation of hospital services. In addition to the reports listed above, the 2005 Appleby Review[11] is crucial because it looked at the performance and efficiency of the wider health and social services in Northern Ireland and identified particular weaknesses and inefficiencies. All these reports are informed by the twin aims of providing both a more equitable and a more efficient health service. In this paper it is the spatial element whose

exploration could help in improving that service which concerns us. Clearly geographical tensions always exist in any decision on where to locate health services. These will reflect tensions between urban and rural areas, between densely and lightly populated areas, and between local, regional and national imperatives. Few decisions made around either additions to, or cuts in, service provision escape the contentious question of exactly where these adjustments should take place. Both Jamison and Butler and Murphy and Killen[12] stress the importance of spatially-informed decision-making when choosing the location of new hospitals (both regional and service-specific).

One area where policy is arguably lacking is evidence bases with spatial dimensions. It is possible to access information on an annual basis on the nature and level of hospital service provision in terms of bed counts, occupancy rates, specialisms and day patient activity. These statistics are associated with individual hospitals but can also be aggregated up to regional or national level. It is also possible to get information on utilisation of services though spatially-tagged data, although this is better in the North due to the existence of UK postcodes and the very limited spatial coding contained in the South's Hospital Inpatient Enquiry System. Both these data sets have been studied and analysed but rarely have their locational and spatial aspects been put together in a holistic way. Additionally, geographical aspects such as density of population and the impact of distance have rarely been factored into strategic planning.[12]

Yet the fact is that all policy requires better evidence bases. The existence of data sets which can be spatially referenced and fed into analytical tools such as Geographical Information Systems (GIS) means that there is now considerable potential for a spatially informed modelling approach which can provide valuable evidence bases for making decisions about locating hospital services. This article begins in a small way to identify how those spatial data sets can be put together to help inform such planning. Perhaps the primary value of a GIS based approach is its ability to collate large volumes of information and to produce not one answer but several answers to inform a number of different planning scenarios.

The aim of the work the National Centre for GeoComputation is currently doing for CCBS is to start using a spatial approach to examine specific aspects of accessibility associated with existing and potential future hospital provision on an island basis. It is by definition a pilot study and the aim is relatively broad for this reason. The specific objectives of the study are: to use GIS to model spatial accessibility to acute hospitals in both Northern Ireland and the Republic of Ireland; to model for two different time periods to see how changes in bed provision and local populations have an impact on accessibility; to provide a spatial measure of supply equity in the form of beds per patient; and to explore

how changes, even over a very short time period, impact spatially on improvements or reductions in bed supply.

The arrival of GIS and digital spatial data

Modelling accessibility is a subject that has engaged the minds of medical and health geographers from an early stage. One of the original core texts in the subject was by Joseph and Phillips[13], which explicitly studied the twin terms accessibility and utilisation. While the two themes can be and often are discussed separately, it is important to acknowledge the utilisation dimension up front, although this study will focus primarily on accessibility. Clearly any study of access to and utilisation of health care needs to be aware also of core concepts such as need, equity, supply and demand – it is important to recognise that all these elements play a role in a full exploration of accessibility.

We have incorporated some of these elements into our spatial modelling, though others would require additional data and research. For example supply is expressed through the number of hospitals but also the relative size of those hospitals and the level of services provided. Demand is often measured through utilisation, but there are issues here in terms of how fully demand identifies need in a setting of waiting lists and staffing shortages, and where the structure of the system itself informs utilisation rates. This is a particular issue in a study like this one, which looks at two quite different health care systems, North and South. Need is also a complex term with a number of different definitions relating to expressed need in the form of patients and unexpressed need within the wider population[13]. Finally, equity can be expressed in a number of ways, depending on whether one uses a vertical or horizontal definition,[14] or even whether one takes a measure based on population or catchment area[15].

The work of Khan and Bhardwaj[16] is particularly useful in developing a fuller understanding of what they refer to as spatial and aspatial aspects of accessibility. The aspatial aspects they refer to include a wide and complex set of variables including income, education, social class, insurance and other social and economic factors which affect how people access and utilise health care. They identify these as being separate but linked elements to the more purely spatial aspects of location, distance, time and supply which provide the other part of the equation. Together these provide a completely integrated model, but it is the spatial side of the equation that this article will focus on, while understanding that a fuller development incorporating the aspatial would be needed to develop the work in the future.

The traditional approach used by medical and health geographers has been to focus on a number of core datasets and use these in the modelling of accessibility. Some of these approaches were used before the

widespread use of GIS and digital spatial data.[17] The arrival of the latter has, however, allowed for more efficient and effective modelling using a number of new spatial analytical techniques. The location and distribution of health care facilities form the first layer of information. While much of this work has focussed on secondary and tertiary care, other services associated with primary care, community care and even voluntary services have also been modelled in this way.[1,19]

The second core element is a layer that incorporates demographic data and the distribution of different populations. These function as proxies for demand and need and can be broken down into sub-populations depending on the services being modelled[8]. The final layer of information needed is on the transportation network used to model the spatial linkages between patients or potential patients and services. This was traditionally modelled as Euclidian or straight-line distance, which often enabled planners to quickly see buffers or catchments zones around hospitals and to visualise quickly those areas or groups which fell outside those zones.[2]

With the advent of GIS, the ability to overlay and merge these three different layers within a single automated information system provided an important new evidence base for health care planning[21]. Brabyn and Skelly[22] took these core elements and combined them in a vector (linear) GIS to model access to public hospitals by travel time across New Zealand. They identified an effective accessibility score by area, weighted by population, and which also incorporated a locally relevant remoteness factor. Other studies have used the power of the GIS to produce more robust forms of spatial modelling by including consideration of distance along road networks and travel time.[23, 24] Other researchers[25, 26] have used additional spatial modelling techniques to measure the effect of clustering of services and its impact on access.

Within the Republic of Ireland, the first work that looked at the geography of hospitals and the ways in which geography could be used to model proposed changes was carried out in 1979[17]. This looked at the impacts of the 1968 Fitzgerald Report and modelled a proposed re-organisation of hospitals into a set of regional networks, a proposal surprisingly similar to proposals in 2007. More directly relevant were a number of recent studies which were informed by policy decisions and aimed at modelling the implications of those decisions. Teljeur et al[27] carried out the first GIS-informed study of the potential impact of the Hanly report by producing tabulated outputs by health board area for the effect of Hanly on travel times for two specific acute interventions, heart attacks and road traffic accidents. Essentially they modelled a pre and post Hanly model for these interventions and concluded that access to services for them had deteriorated. Kalogirou and Foley[28] also modelled the impact of Hanly more widely in terms of general hospital provision. They identified three

different models: one current, one based on a partial roll-out of Hanly and one based on a full roll-out. Two further recent studies have focused on the optimal location of a new national children's hospital[29, 12]. What has been useful in all these studies is the development of GIS-based models to provide the beginnings of an evidence base which informs policy by identifying the importance of geography in the decision-making process. The current work begins to extend the above analysis by applying it on an all-island basis. While there are clearly structural and system-based complications in modelling two hospital networks simultaneously, we hope that the spatial outcomes from the modelling will interest policy makers in the role of geography on both sides of the border.

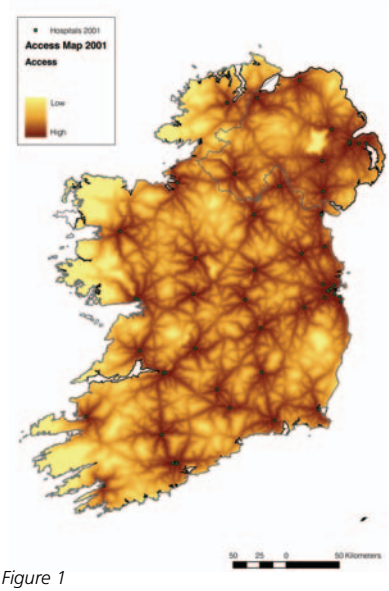

Figure 1

Data and method

With governments in both Irish jurisdictions engaged in the restructuring of health services, the Centre for Cross Border Studies approached the National Centre for GeoComputation to critically explore the potential for developing a GIS-based spatial model of access to hospitals on an all-island basis. The initial pilot study has a single research aim: to develop a robust model of spatial accessibility which would be realistic enough to satisfy health care planners while also being technically sound enough to satisfy GIS modellers. It was driven by the three core geographical considerations mentioned previously: the distribution of potential patients (potential need and demand), the configuration of hospitals North and South (potential supply) and the transport network (accessibility based on travel time).

Based on the literature on spatial accessibility, three core datasets were identified as being essential. These were:
a) demographic data at electoral division (ED) and output area (OA) levels (drawn from the Northern Ireland Statistical Research Agency and the Central Statistics Office in the South);
b) point datasets for individual hospitals with associated data on size, status and levels of provision (data was gathered directly from the Department of Health,

Social Services and Public Safety in Northern Ireland and the Irish Department of Health and Children); c) data related to the road networks in both countries (commercially purchased NAVTEQ data).

A number of issues arose in relation to spatial scale, compatibilities of classifications and the timing of data collection, but a robust initial model was still produced[30, 31]. This will be more fully detailed in a final report later in 2008.

Given that the aims were to produce a working accessibility 'score' as well as to define nominal catchments, the model started by assuming nominal non-overlapping catchments for each hospital. Once these catchments were defined and mapped, it was possible to use the background demographic data to compute the number of residents in each catchment. Given that we also knew how many beds were available in all the hospitals, we could compute the ratio of beds per head of population in Northern Ireland and Republic of Ireland. We were then able to compute the expected number of beds if local supply followed the national rate, and calculate the ratio of the actual number of beds relative to the expected number of beds – this gave us the local bed rate as a 'location quotient'. This approach will be more fully described in the final project report.

The second piece of modelling was more complex: it was carried out within the GIS to combine the road network, travel speeds and the specific locations of the hospitals with small area population counts to produce an effective 'cost-distance' surface which provided us with an accessibility score. The final technical stage was to remodel the accessibility scores with the border both included and excluded in order to examine its spatial effect on hospital activity in both jurisdictions.

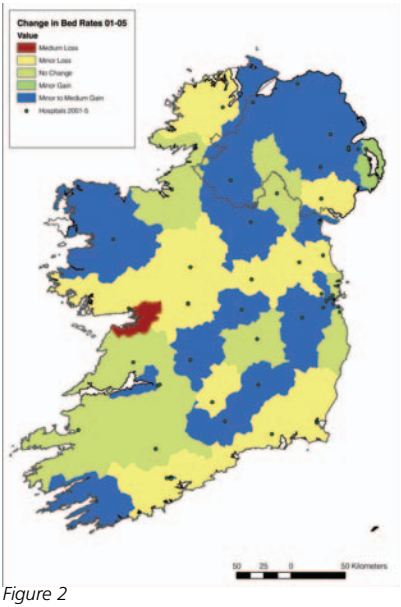

Figure 2

Some initial results

The initial modelling focused on the years 2001-2002 as this was the best fit in terms of demographic data North and South. There was an estimated combined island population of 5.59 million in this period. The total number of beds modelled into the system at this

time was 14,129, and taking the two jurisdictional datasets together an all-island rate of 0.00257 beds per person was calculated. Multiplying each modelled catchment's population by this rate would yield the expected number of beds in a particular area, which could be compared with the actual number. Not unexpectedly, the initial map ***(Figure 1)*** identified a strong clustering of high accessibility around urban centres. Obviously this was affected by the location of most hospitals in high density population areas. Equally it was not surprising that there were low levels of accessibility in much of the western seaboard and in upland areas of Northern Ireland. These 'common sense' conclusions indicated that the modelling was working satisfactorily.

The second phase of the modelling looked at the period 2005-2006 using updated hospital, road and demographic data. There were strong caveats on the demographic data due to the lack of up-to-date small area data for Northern Ireland, and as a result this data was modelled from district level estimates. The accessibility modelling identified for 2005-2006 provided results very similar to the earlier 2001-2002 period. It was difficult to get a strong sense of change from the spatial accessibility maps as the two periods were only five years apart and the increases in bed provision were matched by increases in population across both jurisdictions. However it was interesting – and encouraging for policy makers – that the provision of beds in this period (15,008 in 2005-06 as opposed to 14,129 in 2001-02) kept up almost exactly with a 6.2% increase in the island's population.

It was also interesting to look at change in a more disaggregated way by examining 'modelled' bed rate provision at regional and local levels. As noted in the methodology section, for each hospital catchment a form of location quotient was calculated which compared actual local provision to the expected provision if all-island averages were applied. When the two time periods were compared ***(Figure 2)***, it was possible to tease out more fully changes at a local level. A number of areas showed a reduction in their location quotients, most definitively in Galway but also in the Midlands, along the south coast, in Donegal and in south Down. Much of Northern Ireland saw slight increases in the their location quotients as did parts of central and mid-Leinster, and – perhaps surprisingly – even some more remote parts of Mayo and west Cork. Policy makers could find this data, even with the caveats mentioned, useful in a number of ways. Spatial approaches such as this identify more exactly where change is taking place. However it should be noted that a reduction in the location quotient for an area like Galway, while it might suggest a diminution of service provision, could also indicate an over-supply in the first period which was brought back in line with the national average in the second period.

The most interesting part of the modelling was when the impact of the

border was modelled as two scenarios, one with and one without the border. This allowed the impact of a 'non-border' scenario to be modelled and compared with provision in the present separate systems. This identified the location of areas close to the border which were disadvantaged in terms of accessibility, as well as the extent, expressed in excess travel time zones, of that disadvantage ***(Figure 3)***. This was done by using the GIS to calculate a time disadvantage grid. This grid was then classified into time bands, and vectorised and intersected with the population data to obtain the proportions of accessibility and inaccessibility in each band.

The most significant finding was that while 52% of the population in border areas were disadvantaged by the presence of the border by less than five minutes, a full 26% of the residents were disadvantaged by fifteen minutes or more. Put bluntly, for someone suffering a heart attack or a serious road traffic accident, this 'border factor' could make the difference between life and death[32]. As Figure 3 demonstrates, the GIS was able not only to calculate these inequities but also to identify exactly where these zones were. Thus, for example, people living in north Donegal in the Inishowen peninsula and in south Donegal near Lough Derg could travel to hospitals in Northern Ireland faster in an emergency. Likewise people living in west Tyrone would get faster access to emergency care in the

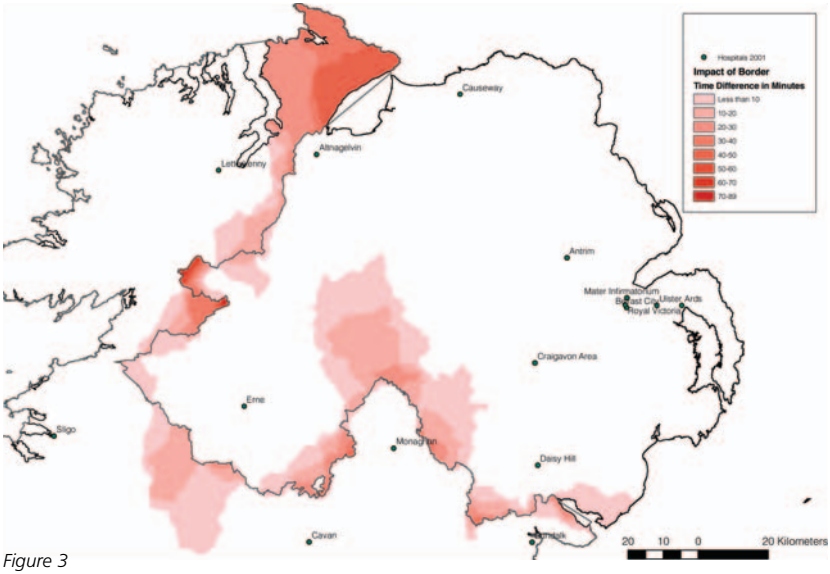

Figure 3

Republic of Ireland. Other areas where travel to hospital distances would be decreased by allowing cross-border access include north-west Cavan along the N87, in the Cooley Peninsula and along the Northern Ireland border with Monaghan in areas such as Aughnacloy, Roslea, Keady and Crossmaglen. This exercise thus identified another very useful policy function for a spatial modelling approach in a cross-border context.

Conclusions

A developed version of this model would incorporate analysis of population data at small area level along with health service data by specialism (utilisation rates, staffing numbers, hospital throughput etc), but this was beyond the scope of this initial research. In addition, a number of caveats exist in relation to accurate bed counts (most are averaged across the year) and the extent to which certain hospitals might be slotted in or out of the model. However the primary aim of the research was to identify the potential of GIS for 'scenario modelling' involving both a spatial and a numerical analysis of the impact of the border. Tracking the spatial impact of future policy developments using this method should be very feasible. It should have particular applications in the south-west of Northern Ireland, where a new hospital is being planned for Enniskillen, and in the north-east of the Republic where a new regional hospital has been proposed, both serving border region populations.

Additionally a predictive version of the model for 2011 or even 2015, which included planned hospital capacity changes, would also be relatively easy to do once the respective datasets in the two jurisdictions are in place. Such modelling could also feature a set of scenarios based on minimal, partial and full achievement of those plans. A third, quantitative approach would be to model individual services according to accessibility, perhaps also weighted by utilisation data. Finally, detailed qualitative research would be required to put flesh on the bones of such spatial modelling by using new data on utilisation, patterns of referral, links with primary care, and local evidence on both public feeling and patterns of *ad hoc* use. The role of private insurance and private hospital care would also have to be factored into such a study.

Communities on both sides of the border are reluctant to embrace government policy of centralising hospital services, believing that the majority of time critical emergencies can be treated locally. An illuminating study by Nicoll et. al. (2007)[33], a leading UK researcher, concluded that for every extra 10 kilometres you travel when you are seriously ill, your risk of dying rises by one per cent. There is good evidence for some groups of emergency patients, for example major trauma patients with multiple injuries, that travelling longer distances to specialist care centres improves outcomes. Anecdotally these groups of people are already bypassing local care and being taken directly to the nearest appropriate care irrespective

on which side of the border it is delivered. However Nicoll suggests that for patients in anaphylactic shock, choking, drowning, or having acute asthma attacks who need urgent care, having to travel increased distances for care that could be delivered locally is detrimental. Applying this principle to the border region, optimal patient care could be delivered within an integrated border zone, similar to the Thierache region on the French-Belgian border, where people are allowed to access their nearest hospital service irrespective on which side of the border they live.

Understanding the connections and impacts of health services across the Irish border is crucial for meeting the complex and diverse needs of the border population. The experience of Co-operation and Working Together in developing the Cross-Border GP Out-Of-Hours service[34],which integrates legislation and professional issues, financial systems, information exchange, and pharmaceutical issues across the border, should be applied to improve access to hospital care. This spatial modelling tool offers a real opportunity to investigate the benefits of such an all-island configuration of health systems.

Ronan Foley is a Lecturer in Geography at National University of Ireland Maynooth and a research associate of the National Centre for GeoComputation

Martin Charlton is the Deputy Director of the National Centre for GeoComputation at NUI Maynooth

Patricia Clarke is the Research Manager of the Centre for Cross Border Studies, Armagh

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