

Transportation accessibility issues and the location of a national facility: the case of a new paediatric hospital to serve the Republic of Ireland

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ABSTRACT

This study considers the accessibility of three locations that were identified for consideration by the Health Services Executive for locating a new national children's hospital: The Mater, St. James's and Tallaght. Accessibility to each of these sites is considered first within the context of the Dublin region and then with respect to the area outside that region. For the Dublin region, a Dublin Transportation Office data set that gives travel times in the peak and off-peak periods is used along with small area population statistics derived from the 2002 census to identify: 1) the proportion of the total population, 2) the population aged 0 to 15 years and 3) of the female population aged 15 to 35 years that are nearest each of the three hospital sites. A similar analysis is conducted for the rest of the country using, where appropriate, published public transport schedules. The results suggest that in choosing a location for a single facility that is to serve the Dublin region only and where accessibility interpreted as minimisation of travel time is of over-riding importance, a city centre location is best. However, where the facility is to serve the national population and where the bulk of journeys to it will be by car, the results suggest that a strategic location to the west of the city will maximise accessibility.

Key index words: hospital location, accessibility, service planning.

Introduction

Identifying a geographic location that is accessible to the largest number of people is a difficult task. It is a problem that has concerned geographers and planners for a number of years. This paper examines and evaluates transportation accessibility issues for locations being considered for the development of a new national facility. Three possible sites for locating a new national children's hospital are examined and conclusions are drawn in relation to the site which is most accessible for various population cohorts throughout the country.

Locational accessibility

Geographical access can be conceived as an attribute of either locations (i.e. place accessibility) or individuals (i.e. personal accessibility) (Kwan *et al*, 2003). Perhaps the primary determinant of place accessibility is the position a location occupies within the broader transport network. It is well-established for example, that the ease with which individuals can access locations in terms of the travel cost incurred has a major influence on surrounding land use patterns as well as land values. Therefore, the nexus between land use

development, land intensity and transport is inextricably linked with locational accessibility (see Hansen, 1959). On the other hand, personal accessibility is generally concerned with an individual's ability to access a range of activities in the surrounding environment.

The accessibility of a location is not constant; rather it varies depending on its proximity to a range of activities at different periods of the day. From the point of view of users, the manner in which diverse social groups differentiated by multiple axes of dissimilarity (e.g. gender, race, ethnicity, social class, income) are represented in an analytical framework is an important element when determining accessibility (Kwan *et al.*, 2003). The ability of an individual to reach a specific location depends on level of personal mobility. This is dictated by issues such as modal choice availability which, in turn, is related to issues such as income and social class. These considerations underline the importance of considering the social dimension and equity of locational accessibility. They imply that an accurate assessment of locational accessibility should take into account different periods of the day and different modes of transport. It highlights also the importance of identifying specific target groups when analysing locational accessibility.

Accessibility can be analysed by using a specific spatial framework (usually based on census tracts or an equivalent system of zonal configuration) or through a point-based framework using individual level data such as data from travel diaries. The methods that have been used for measuring accessibility vary. They range from spatial interaction models to location-allocation models to notions concerning the space-time prism and the restriction of individuals' activities (see Burns, 1979; Taaffe *et al.*, 1996; Dijst and Vidakovic, 2000).

Numerous applications demonstrate that research concerning locational accessibility has a significant relevance to policy and planning. Accessibility studies have been applied in attempts to link disadvantaged households to jobs (Shen, 1998; Scott 2000) and have been applied also to the provision of social services (Talen, 1997, 2001). Other applications include the evaluation of public transit accessibility (Murray, 2001, 2003), accessibility to voter stations and resultant voter participation (Gimpel and Schuknect, 2003) and the analysis of network vulnerability in terms of infrastructure vulnerability (O'Kelly, 1998). Clearly, accessibility studies have considerable importance for planning and policy making.

This study assesses the accessibility of three potential sites for a national children's hospital. A number of earlier studies have considered the location of hospital facilities within an Irish context. Horner and Taylor (1979) used the location-allocation problem to determine the optimal locations for twelve hospitals and compared the solution to that proposed in the Fitzgerald Report (1968). More recent work has investigated the potential impact on travel times of the redistribution of accident and emergency services in Ireland (Teljeur *et al.*, 2006) and the impact on accessibility of possible hospital rationalisation strategies (Kalogirou and Foley, 2006). Our work differs from the foregoing studies in that it deals with the locating of one national facility. In addition, we employ data relating to actual travel times in the peak and off-peak periods rather than rely on estimates based on travel speeds for various road types. We focus on specific social groups of relevance.

Study context and objectives

In February 2006, a Report commissioned by the Health Service Executive (HSE) concluded that Ireland could support one world class tertiary children's hospital and

recommended that this be located in the Dublin region (McKinsey and Company, 2006). The Report proposed criteria for choosing the best location for the new facility. One of these criteria was ease of access; another was that the new hospital should be co-located with an existing hospital.

This study assesses the regional and national accessibility of three potential sites for a new national children's hospital: Tallaght, the Mater and St. James's. These sites were chosen because they were the main sites short-listed for consideration by a HSE/ Department of Health and Children Task Group which was established to advise on the best location for the new facility (Health Service Executive, 2006). The Mater and St. James's sites are located adjacent to the city centre; the Tallaght site is located c. 10 kilometres south-west of the city centre. While our study relates to the three named sites, the methodology that is employed could handle any number of pre-specified sites.

The objectives of this study were two-fold: first, to construct maps outlining the accessibility of locations in the Dublin region and nationally to each of the three sites and second, to determine the proportion of the overall population, of females in the 15-35 age cohort (i.e. those considered to be of child bearing age), and of children in the 0-15 age cohort who are closest in terms of journey time to each of the three sites. Indeed, it is possible to conduct a similar analysis for any pre-specified population cohort. All of the maps were constructed using geographical information system (GIS) mapping software and the population calculations were also undertaken in a GIS by integrating information relating to each population cohort into the attribute table of the district electoral division (DED) shape files.

In common with other similar studies, the authors considered journey time to be the most important determinant of accessibility particularly within the context of locating a medical facility where speed of access is considered to be all-important¹. We were anxious, insofar as was possible, to use actual journey time data and to take account of time of day and mode of transport. In this sense, variation in traffic congestion levels was considered as well as the equity dimension of transport accessibility.

Zonal system and data

The journey time data used in this study was derived from the Dublin Transportation Office (DTO) Dublin Transport Model which maintains an accurate representation of the geography of travel in the Dublin Region. This region is taken as comprising all of Dublin City, Dun Laoghaire-Rathdown, Fingal and South Dublin together with parts of counties Kildare, Meath and Wicklow. The dataset used consists of origin-destination journey time information for a 463 zonal system of the Dublin Region for 2001. The zonal system is based on District Electoral Divisions (DEDs). The data is reported by mode of transport (car and public transport) and by travel period (peak and off-peak³).

When deriving travel times for use in this study, the system of 463 zones employed by the DTO were amalgamated to form a revised division of the Dublin region² into 58 zones. Zones were amalgamated in a GIS using Jenk's optimisation method which classifies features based on natural breaks in data values. The method is used to minimise the squared deviations of class means. Each DTO zone is associated with a zonal number that is locational specific and the 463 zones were amalgamated into larger zones on the basis of their locational similarity.

For each of the 58 zones, a weighted average travel time was computed (using the disaggregated 463 zones) to each of the three hospital sites. It is important to note that all of the data depicted on the maps refers to the weighted average travel time values for the more broadly based 58 zonal system.

Methodology and results

In this study, accessibility is considered for two areas: the Dublin region as previously defined and the rest of the Republic of Ireland. Handy (1993) has demonstrated the importance of considering accessibility at a number of spatial scales. Given the importance of mode availability within the context of accessibility, access by car and by public transport is considered separately and, where possible, separately for the peak and off-peak periods.

The Dublin region: access by car

For each of the 58 zones, the travel time to each of the three hospital sites by car was determined. From this information, each zone could be assigned to the hospital site nearest to it in terms of travel time. Figures 1 and 2 show those parts of the Dublin Region that are nearest in terms of travel time by car to each of the three hospital sites in the peak and off-peak periods respectively⁴. In the case of the peak period (Figure 1), the outer southern suburban area is assigned to Tallaght while the northern suburban area and the north inner city area is assigned to the Mater. The south inner city and south-eastern suburbs are assigned to St. James's.

During the off-peak period, traffic conditions in the inner city and on the main routes radiating out from the central area improve thereby yielding lower journey times. Thus it might be expected that certain zones that are closer in terms of travel time to Tallaght in the peak hour would be assigned in the off-peak to one of the city centre sites. As can be seen (Figure 2), this occurs, but to a limited extent only. Certain areas that were assigned to Tallaght in the peak hour are now assigned to St. James's; the area that is assigned to the Mater site remains virtually unchanged.

Table 1: Percentage of total population, of children aged 0-15 years and of females aged 15-35 years in the Dublin region located closest in terms of travel time by car to the three hospital sites.

	Population	0-15 Years	Females 15-35 Years
Peak Period			
Tallaght	31.0%	35.4%	29.5%
Mater	42.3%	43.0%	42.3%
St. James's	26.7%	21.6%	28.2%
Off-Peak Period			
Tallaght	25.1%	29.7%	23.9%
Mater	41.9%	42.5%	41.2%
St. James's	33.0%	27.8%	34.9%

Figure 1. Peak car journey time advantage to Tallaght, the Mater and St. James's hospital by place of origin

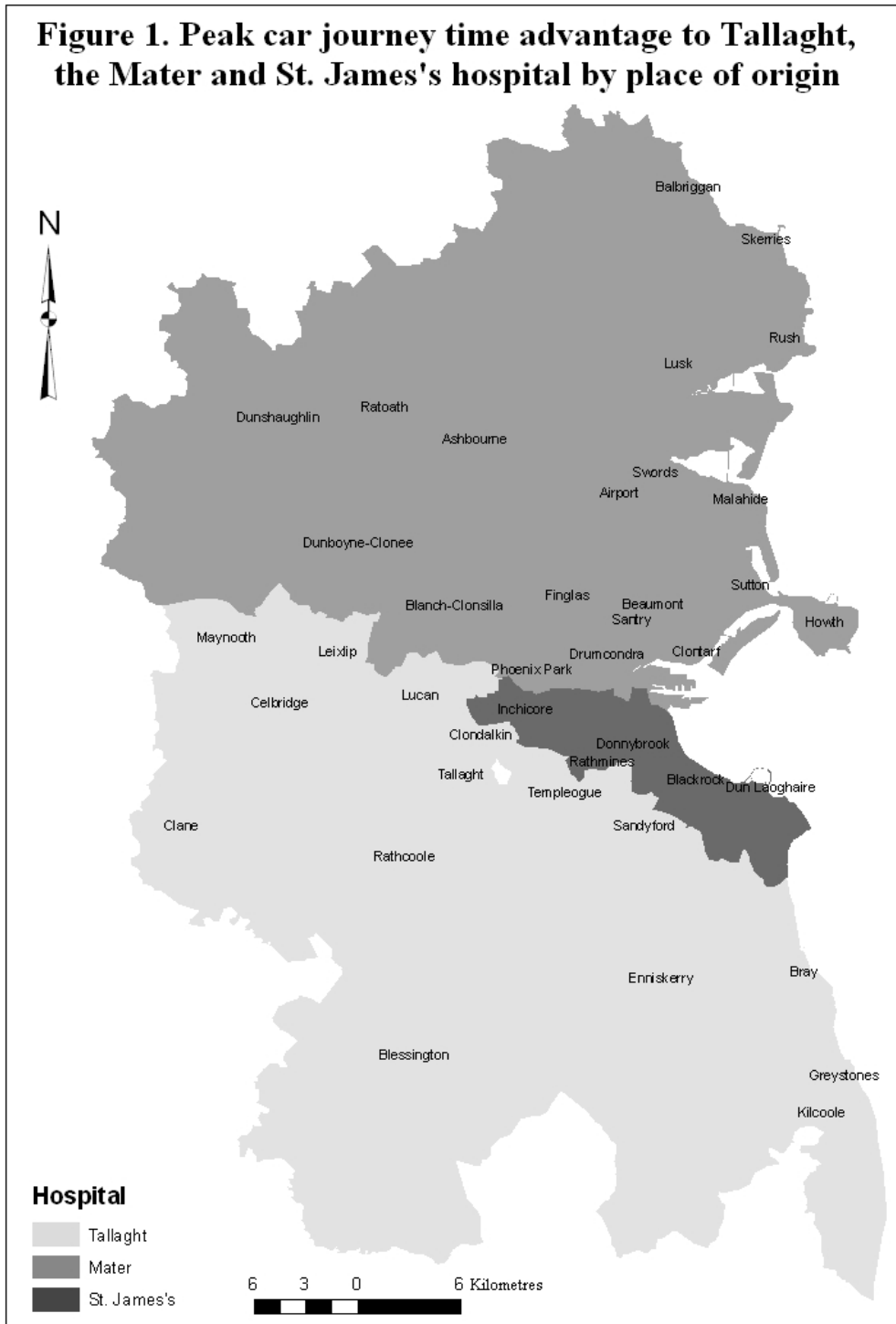
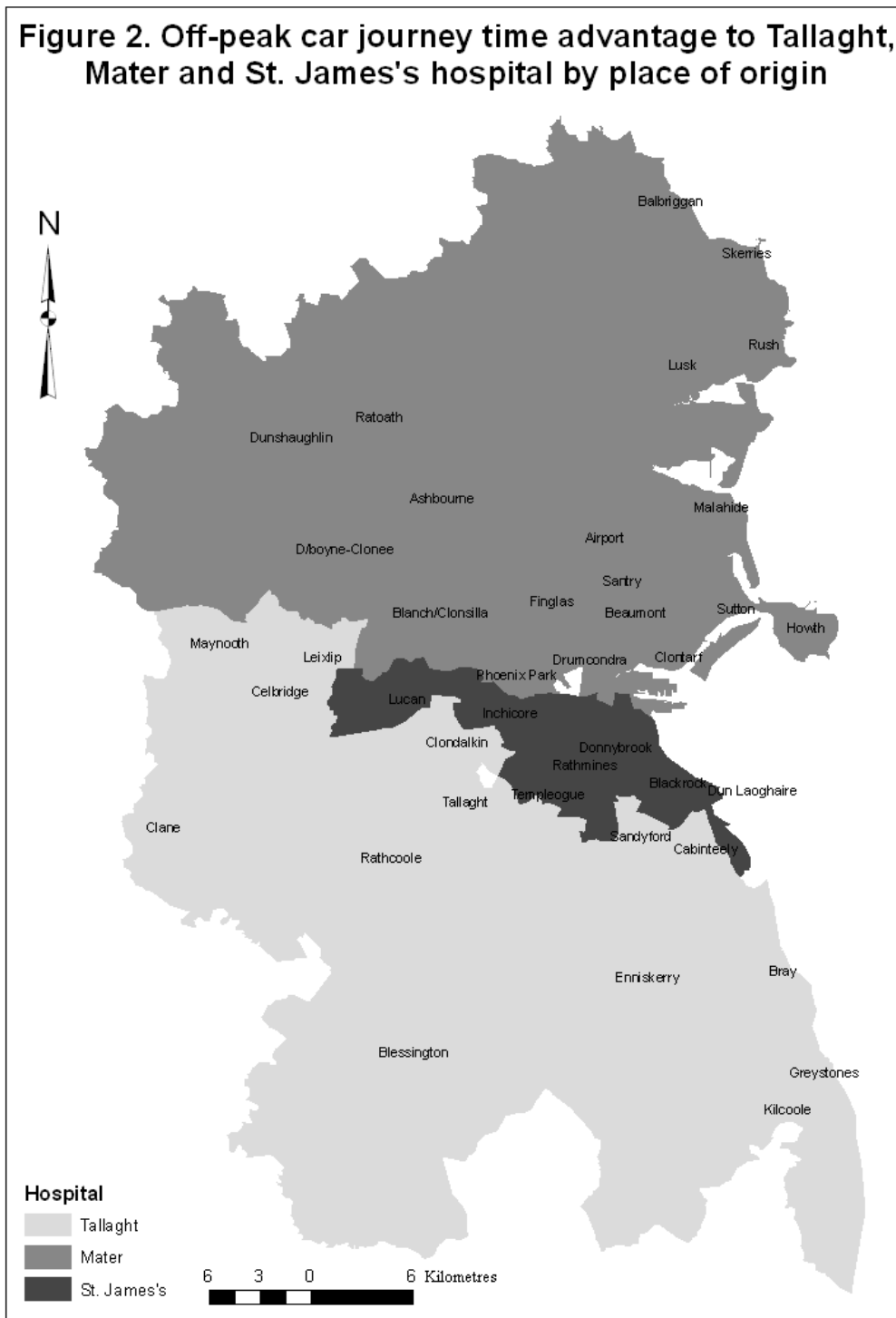


Figure 2. Off-peak car journey time advantage to Tallaght, Mater and St. James's hospital by place of origin



Bearing in mind that it is the location of a hospital for children that is of interest, maps relating to three population statistics that could be derived from the small area population statistics (SAPS) derived from the 2002 *Census of Population* were prepared namely: total population, children aged 0-15 years and women aged 15-35 years. The percentage of each of these groups nearest to each of the three hospitals could then be determined by time of day and by mode of transport (Table 1).

During the peak hour, the Mater site is the most accessible to the largest percentage of each of the three populations considered followed by the Tallaght site and the St. James's site. The results are remarkably consistent for each of the three populations. In the off-peak period, and as suggested by comparing Figures 1 and 2, the percentages of each of the populations nearest to Tallaght decrease while those for St. James's increase; the percentage figures for the Mater site remain more or less the same. This implies that the Tallaght site becomes less accessible relative to St. James's site and the Mater sites in the off-peak period. It reflects the greater ease of access to the city centre area in the off-peak.

For each of the population groups considered in Table 1, the Mater site serves the largest percentage despite the fact that it is near the city centre rather than in the suburbs where, in particular, more children and women of child-bearing age are located. The reason for this is clear from Figures 1 and 2; whether the peak or the off-peak is considered, the Mater site serves not only the north inner city but also the northern suburbs including areas of Fingal that have seen considerable development in recent decades. While the Tallaght site also serves areas that have been growing rapidly in recent decades, part of what might be considered to be its hinterland, most notably the area along the south-east coast, is assigned to St. James's. The foregoing analysis leads to the conclusion that for the Dublin region, the Mater site is the most accessible in terms of journey time by car followed by the Tallaght site.

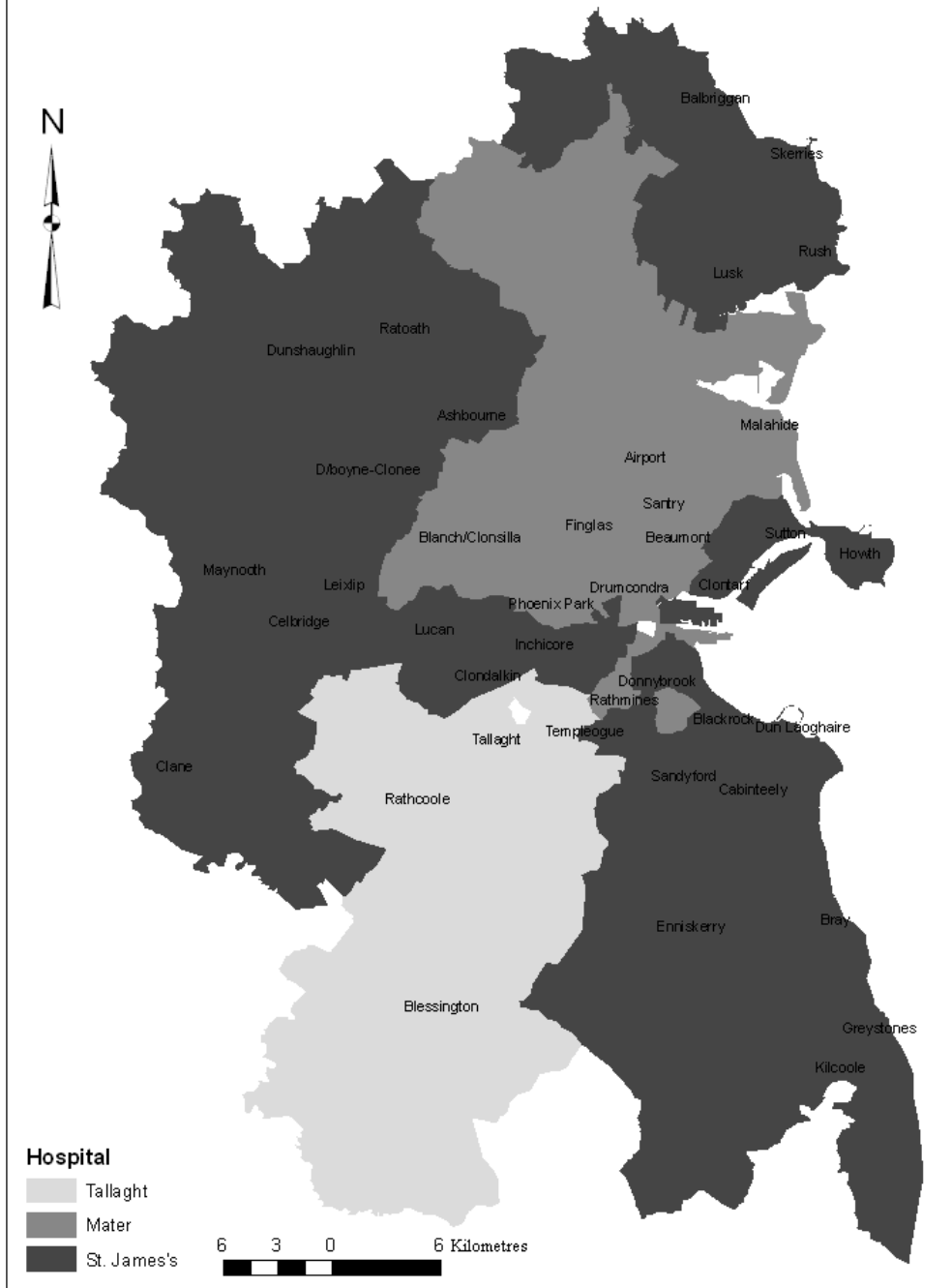
The Dublin region: access by public transport

The methods used in this part of the analysis were as for private transport. It is important to note that in the DTO dataset, the calculation of travel times by public transport incorporates waiting time and a time penalty where a change of vehicle is required.

Figures 3 and 4 show those parts of the Dublin region that are nearest in terms of travel time by public transport to each of the three hospital sites in the peak and off-peak periods respectively. A comparison shows that the areas assigned to each of the three hospital sites vary considerably by mode of transport. In particular, the area assigned to Tallaght is much smaller reflecting the fact that the public transport network in Dublin is mainly radial in nature and focused predominantly on the city centre which benefits the city centre hospital sites. Second, the geography of the public transport network is such that the area assigned to the St. James's site is much greater than was the case with private transport: in particular, parts of the western and north-western suburbs and of the northern coastal suburbs are now assigned to St. James's.

Comparison of Figures 3 and 4 shows that the areas assigned to each hospital remain fairly similar as between the peak and off-peak periods. The area assigned to Tallaght is even smaller in the off-peak which highlights the relative paucity of public transport to this suburban location during off-peak hours. It is notable also that some of the western suburbs that were assigned to the St. James's site in the peak are now assigned to the Mater site and similarly with Tallaght. This reflects the fact that the off-peak public transport service declines in these areas in the off-peak period.

Figure 3. Peak PT journey time advantage to Tallaght, Mater and St. James's hospital by place of origin



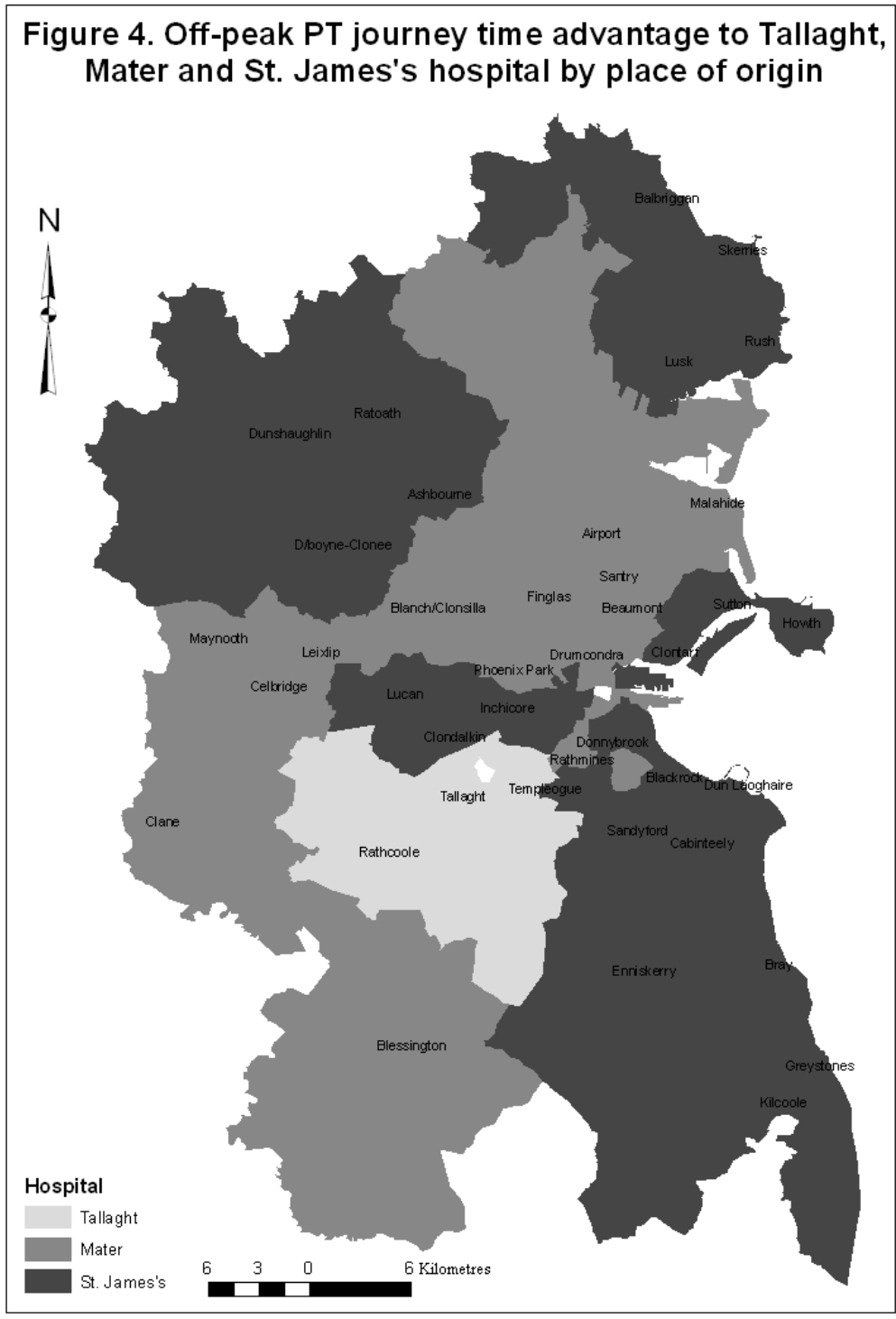


Table 2 gives the percentage of each of the three populations located closest in terms of travel time by public transport to each of the three hospital sites. For the peak period, the St. James's site is the most accessible followed by the Mater site and the Tallaght site. As in the case of the car results, the percentage figures are remarkably consistent over the three populations.

As was the case with the figures for car travel (Table 1), the off-peak percentage figures are similar to those for the peak period. The percentages assigned to the St. James site decline slightly while those for the Mater site increase. The figures for the Tallaght site show little change.

Table 2: Percentage of total population, of children aged 0-15 years and of females aged 15-35 years in the Dublin region located closest in terms of travel time by public transport to the three hospital sites.

	Population	0-15 Years	Females 15-35 Years
Peak Period			
Tallaght	10.5%	11.8%	10.3%
Mater	33.3%	32.2%	35.4%
St. James's	56.2%	56.0%	54.3%
Off-Peak Period			
Tallaght	10.4%	11.8%	10.1%
Mater	37.1%	36.8%	39.4%
St. James's	52.5%	51.4%	50.5%

The rest of Ireland: access by car

As stated at the outset, the key issue from the point of view of the individual is which hospital site is nearest in terms of travel time. For an individual travelling from outside the Dublin region, the bulk of the journey will be along one of the national primary routes. From the point of view of accessibility, the crucial issue is the journey time to each of the three hospital sites from where these routes begin to diverge. For each of the national primary routes entering the Dublin region, the DTO data set was consulted to determine the mean travel time in the peak and off-peak periods from the initial point of divergence to each of the three hospital sites (Table 3).

Table 3: Mean travel time by car in the peak and off-peak periods from each of the national primary routes entering the Dublin Region to each of the three hospital sites.

	National Primary Route Number and Location of Divergence					
	N1 Santry	N2 Finglas	N3 Blanch.	N4 Lucan	N7 Newlands Cross	N11 Shankill
Peak Period						
Tallaght	67 Mins.	58 Mins.	56 Mins.	54 Mins.	24 Mins.	86 Mins.
Mater	41 Mins.	27 Mins.	33 Mins.	72 Mins.	56 Mins.	88 Mins.
St. James's	60 Mins.	45 Mins.	48 Mins.	61 Mins.	43 Mins.	86 Mins.
Off-Peak Period						
Tallaght	72 Mins.	59 Mins.	51 Mins.	37 Mins.	17 Mins.	60 Mins.
Mater	34 Mins.	17 Mins.	21 Mins.	44 Mins.	55 Mins.	68 Mins.
St. James's	48 Mins.	29 Mins.	28 Mins.	35 Mins.	39 Mins.	64 Mins.

Transportation accessibility issues

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In the peak hour, car trips entering the Dublin region *via* the N1, N2 or N3 and proceeding to the Mater site have the lowest associated travel time while those entering *via* the N4 and N7 reach the Tallaght site in the shortest time. Cars entering the Dublin region *via* the N11 travel onwards equally rapidly to the Tallaght and the St. James sites. As mentioned previously, the DTO data set relates to 2001 i.e. to before the completion of the southern section of the M50 motorway. The completion of this section of the M50 means that for traffic inbound *via* the N11, the Tallaght site is now the closest in terms of mean travel time.

The results for the off-peak are similar in relative terms to those for the peak. Cars entering the Dublin region *via* the N1, N2 or N3 reach the Mater site in the shortest time while those entering *via* the N7 and N11 reach the Tallaght site in the shortest time. Cars entering *via* the N4 at Lucan now reach the St. James's site two minutes more rapidly than is the case with Tallaght. However, given the deteriorating traffic conditions in the inner city area since 2001 and bearing in mind the various road improvements that have taken place between Tallaght and Lucan, it is more realistic to assign off-peak traffic entering the Dublin region along the N4 to the Tallaght site.

To summarise, the travel time data suggests that for traffic entering the Dublin region, whether in the peak or off-peak hours, cars entering *via* the N1, N2 and N3 routes should be assigned to the Mater site whereas cars entering *via* all other routes should be assigned to the Tallaght site.

In order to determine the proportions of the various populations located outside the Dublin region that are nearest in terms of travel time by car to the Tallaght and Mater sites, it was necessary to determine a boundary between the N3 and N4 to demarcate the areas that would utilise each of these routes to enter the Dublin region. This was done by drawing a boundary running half-way between the routes and overlaying it on a map of DEDs. Each DED lying between the two routes was thus assigned to the nearer of the two National Primary routes. Where the boundary line ran through a DED, the DED was assigned to the National Primary route that served in excess of 50 per cent of its area.

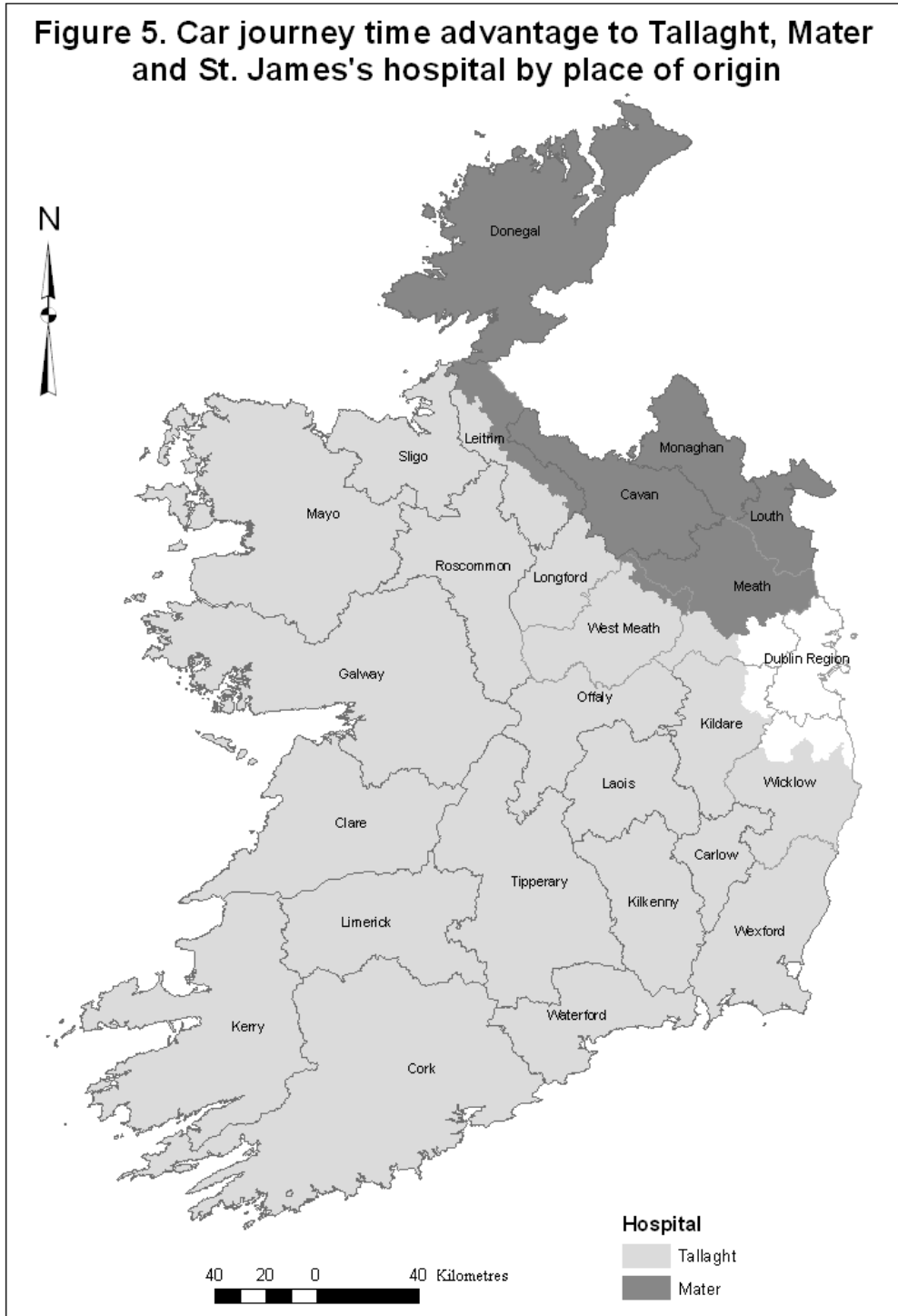
Figure 5 shows the areas that are most accessible by car to the Tallaght and Mater sites. As can be seen, the area closest to the Tallaght site is far more extensive than that closest to the Mater site.

Table 4 shows the proportion of the three population groups defined previously that are located closest in terms of travel time to the Tallaght and Mater sites. As might be expected from Figure 5, by far the largest percentage of the population located outside the Dublin region is assigned to the Tallaght site. The percentages closest to the Tallaght site increase when those aged 0-15 are considered which reflects the fact that this group is relatively under-represented in those parts of the rest of the country that are assigned to the Mater site. The foregoing analysis leads to the conclusion that for the rest of Ireland and within the context of travel by car, the Tallaght site is the most accessible.

Table 4: Percentage of the total population, of children aged 0-15 years and of females aged 15-35 years located outside the Dublin region and closest in terms of travel time by car to the Tallaght and Mater sites.

	Total Population	0-15 Years	Females 15-35 Years
Tallaght	83.1%	89.7%	83.3%
Mater	16.9%	10.3%	16.7%

Figure 5. Car journey time advantage to Tallaght, Mater and St. James's hospital by place of origin



The rest of Ireland: access by public transport

Each town with a population in excess of 3,000 in 2002 (*Census of Population, Volume 1, 119 et seq.*) that has at least one inter-city train service or Bus Eireann bus service to Dublin, either direct or *via* a published connection involving one change was considered. In each case, the average travel time to each of the three hospital sites by bus (where available) and by train (where available) was calculated. In order to do this, it was necessary to derive transfer times from each of the three public transport arrival points (Connolly Station, Busarus and Heuston Station) to each of the three hospital sites. In the case of St. James's and Tallaght, it was assumed that onward travel from Busarus, Heuston Station or Connolly Station would be by Luas. Five minutes were allowed to reach the Luas stop and a further five minutes of waiting time; to this was then added the relevant travel time by Luas as given the published timetable. In the case of trips to the Mater site, it was assumed that onward travel would be by taxi taking 10 minutes from Busarus/Connolly and 15 minutes from Heuston Station. Five minutes were allowed to reach the taxi rank and a further five minutes for engaging the taxi. The foregoing gave the total transfer times shown in Table 5.

Table 5: Transfer times between public transport arrival nodes and the three hospital sites

	TO	Tallaght	Mater	St. James's
FROM	Connolly	53 Mins.	20 Mins.	30 Mins.
	Busarus	52 Mins.	20 Mins.	29 Mins.
	Heuston	36 Mins.	25 Mins.	13 Mins.

The results indicate that for passengers arriving at Connolly Station or Busarus, the Mater site is the most accessible site while the St. James's site is the most accessible for those arriving at Heuston Station.

The total population in 2002 of all of the towns considered was 942,186. Of this population, 68.0 per cent is closest in terms of average travel time by public transport to the St. James site and 32.0 per cent to the Mater site. No town is closest to the Tallaght site. Thus one can conclude that the St. James's site is the most accessible. The fact that access to this site is by Luas, a sustainable form of transport that is modestly priced, rather than by taxi, enhances its advantage. Even if the proposed metro line that will serve the Mater site is completed, it will not connect that site directly to Connolly or Heuston stations or to Busarus; therefore its impact on the site's accessibility to public transport users from outside the Dublin region will be limited.

Access by car: the national context

In order to investigate accessibility by car in a national context, the percentages in Tables 1 and 4 were amalgamated to produce figures for the population of the Republic of Ireland as a whole (Table 6). As can be seen, the percentage of the total population that is closest in terms of journey time by car to the Tallaght site is considerably greater than for the Mater site. When the potential clients of the new hospital are considered, the figures for the Tallaght site are also considerably greater than for the Mater site. The results suggest that taking the population of the Republic as a whole, the Tallaght site is the most accessible. However, the significant secondary position of the Mater site suggests that as far as maximizing accessibility by car is concerned, there is an argument for splitting the new paediatric hospital between the Tallaght and Mater sites.

Table 6: Percentage of total population, of children aged 0-15 years and of females aged 15-35 years in the Republic of Ireland and located closest in terms of travel time by car to the three hospital sites.

	Population	0-15 Years	Females 15-35 Years
Peak Period			
Tallaght	67.0%	73.5%	64.3%
Mater	24.8%	20.1%	25.7%
St. James's	8.3%	6.4%	10.0%
Off-Peak Period			
Tallaght	65.3%	71.9%	62.4%
Mater	24.6%	19.8%	25.3%
St. James's	10.1%	8.3%	12.3%

Discussion and conclusions

Table 7 summarises the main results emerging from this study.

Table 7: Summary of main results.

	Dublin Region	Rest of Ireland
Private Car	Mater site most accessible followed by Tallaght site	Tallaght site superior
Public Transport	St. James's site most accessible followed by Mater site	St. James's site followed by Mater site

It is striking that the results emerging in this study differ significantly by mode of transport. They suggest that an important consideration in reaching a decision *vis-à-vis* the optimum location for the new children's hospital relates to the proportion of those who will travel to the new hospital by car and by public transport. No information was available to the authors on the extent to which these modes are being used currently to reach hospital sites.

It is clear from Table 7 that if the majority of trips to the new children's hospital will be by public transport, then the St. James site is more accessible. If, as seems more likely, the majority of trips to the new facility will be by car, then the Tallaght site is superior followed by the Mater. It is important to note that the foregoing conclusion arises within the context of choosing between the three sites that have been identified. An interesting question for further research concerns how these results would change if one of the sites were to be withdrawn from consideration or others were to be added. In terms of access, the major finding of this study calls into question the decision of government, announced in June 2006 to locate the new national children's hospital at the Mater site.

Given the existing traffic conditions in the Dublin region and nationally, the importance of considering accessibility issues for all major new facilities can hardly be overstated. The methodology employed in this study could be used to assess the accessibility of any proposed location for a new national facility. Moreover, alternative cost metrics such as distance and generalised cost could be incorporated into any future analysis. The methodology could be used also to assess the accessibility of possible sites for a new facility within a regional context. Undoubtedly, this would facilitate more informed decisions in terms of transportation issues for both planners and policy makers.

On a policy level, and in terms of maximising accessibility, the results have potentially broad ranging implications for the optimum location of new facilities in the Dublin region. They provide evidence that a case exists for locating services that attract trips from all areas of the country e.g. national hospitals, national sports stadia, national conference centres on the western outskirts of Dublin at a location that is adjacent to the major national routes and is well served by public transport. By way of contrast, our results suggest that single facilities that are to serve the Dublin region only should be located adjacent to the city centre.

Notes

- 1 It is also possible to conceive of journey distance or a generalised cost measure as being an appropriate determinant of accessibility.
- 2 The Dublin Transportation simulation model has been independently validated (WSP, 2003).
- 3 The peak period data relates to 0800 – 0900 hours; the off-peak data relates to 1400 – 1500 hours.
- 4 Zones without shading have equal travel times to the St. James's and Mater sites.

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