

## **23 EQUALITY IMPACT ASSESSMENT OF THE CAPITATION FORMULA**

### **Background**

23.1 Section 75 of the Northern Ireland Act 1998 requires public authorities in carrying out their functions relating to N Ireland to have due regard to the need to promote equality of opportunity between:

- Persons of different religious belief, political opinion, racial group, age, marital status or sexual orientation;
- Men and women generally;
- Persons with a disability and persons without; and
- Persons with dependants and persons without.

Without prejudice to these obligations, a public authority is also required, in carrying out its functions, to have regard to the desirability of promoting good relations between persons of different religious belief, political opinion or racial group.

23.2 The 3<sup>rd</sup> Report of the CFRG (October 2000) contained a summary of an equality assessment conducted by the Centre for Public Services. Whilst the assessment generally endorsed the capitation approach, further data and research requirements were identified to improve the information and analysis which underpinned the assessment of equality issues.

The full list of recommendations can be found in Annex 5 of the Third Report; listed below is progress made towards meeting those recommendations:

- An unmet need methodology has been developed (although further work is required in this area);

- Data on political opinion has been acquired;
- Age/gender cost relationships, additional needs indices, and unmet need tests have been developed for the Physical and Sensory Disability PoC; and
- Age/gender cost relationships, additional needs indices, and unmet need tests have been developed for the Learning Disability PoC.

The Centre for Public Services assessment also included a recommendation that equality implications regarding private payers be considered. This will be considered when new research into the Elderly PoC is conducted. There was a further recommendation about producing an informal carers profile and needs assessment. The DHSSPS strategy for carers can be found in the DHSSPS document “Valuing Carers (2004)”.

The work programme recommended in this report will continue to improve the Formula’s effectiveness in meeting equality requirements.

23.3 The purpose of the analysis in this chapter is to examine the potential impact of the revised formula on the above equality categories at N Ireland level in order to ensure that it still provides a fair and equitable allocation of resources across all equality categories. It should be noted that the analysis assesses the effect on each equality category as a whole, not the geographic distribution of people in the category nor the effect on pockets of a group in particular localities or small areas. For all equality categories, equality analysis for the testing of the separate effects of age/gender and additional need has been carried out at synthetic electoral ward level (the geographical level at which the formula was constructed), except in the case for political opinion which is assessed at Local Government District level due to the unavailability of data at smaller geographical levels.

## Approach

23.4 Numerical data was obtained at electoral ward level in respect of seven of the nine equality categories (see Annex 6). This was then aggregated to SEW level. The data source was the 2001 Census. For disability, a second measure was available from the Department of Social Development – that of the number of claimants of Attendance Allowance and Disability Living Allowance at February 2002. Political opinion data was available from the Electoral Office at Local Government District level by obtaining the first preference votes cast within District Electoral Areas in the June 2001 local council elections. No data were available for sexual orientation.

23.5 The analysis was carried out in the following stages:

- (i) The percentage share each SEW would receive on the basis of crude population only was calculated.
- (ii) The percentage share each SEW would receive on the basis of weighting its crude population for differences in age/gender structure;
- (iii) The percentage share each SEW would receive on the basis of weighting its crude population for differences in age/gender structure and for differences in need;
- (iv) The separate effects of age/gender weighting and additional needs weighting – above that of crude population - can therefore be deduced by subtraction;
- (v) As the equality dataset is available at SEW level, it was possible to map the equality data to the percentage shares at SEW level. Each equality category could then be analysed in terms of change in share when moving from population shares only to weighted population shares. The percentage gained/lost was calculated for each SEW and

two categories were created: those whose percentage share increased or did not change, and those whose share decreased.

- (vi) The make-up of these wards with regards to equality categories were examined by looking at the percentage of each equality category within each category of ward. This allows us to make statements such as “51% of males live in wards which gain or are unchanged when the crude population is weighted for additional need, and 49% of males live in wards which lose”.

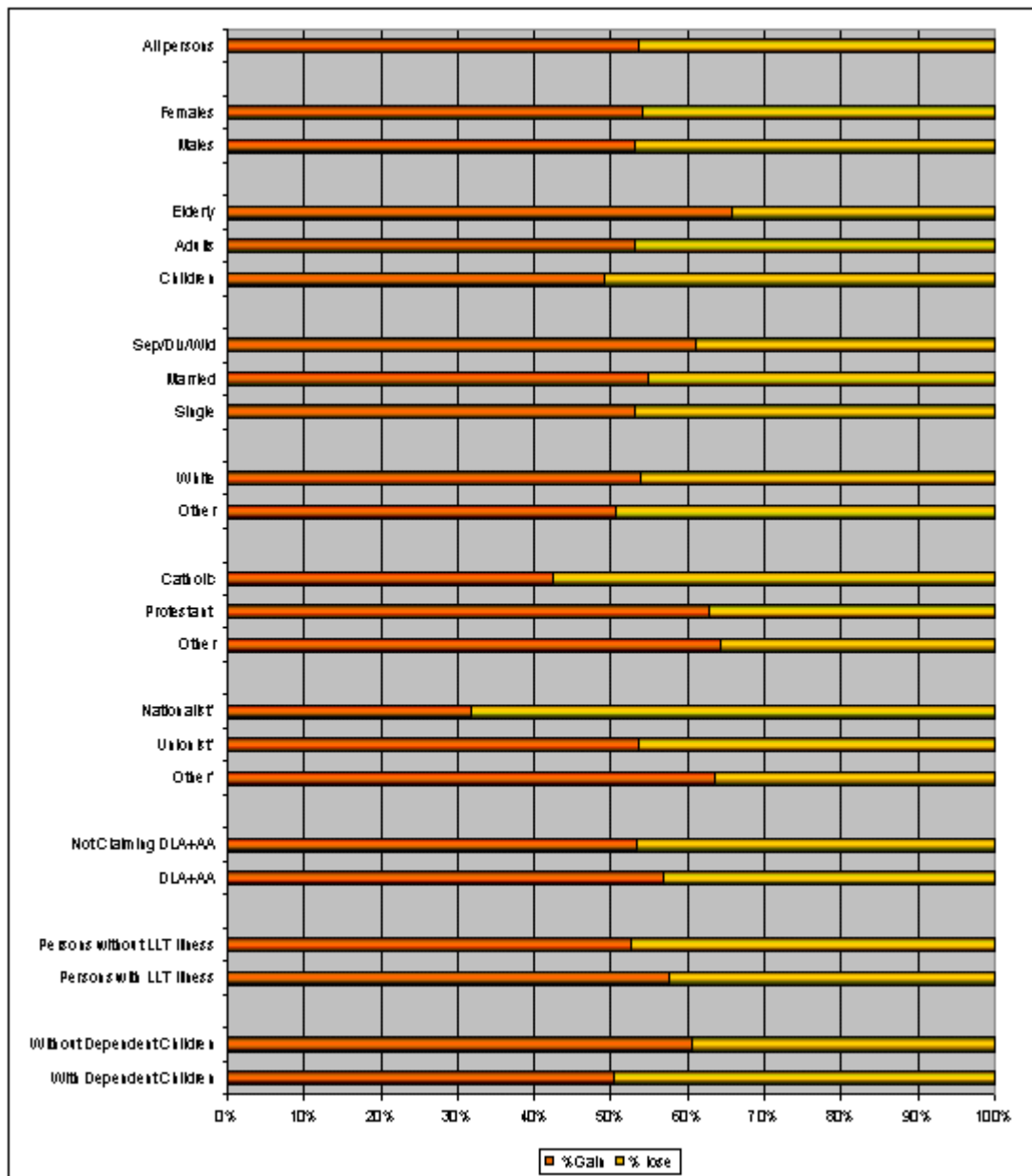
23.6 The following results constitute an equality assessment of the various elements of the capitation formula. The elements are considered in the following order:

- Age/gender weighting;
- Additional needs weighting;
- Rurality adjustment; and
- Economies Of Scale adjustment.

**Results**

**Equality Assessment of the Age/gender Weighting**

**Figure 23.1 Impact of Age/gender Weighting on Equality Categories – Impact of Moving From Crude Population Shares to Age/genderWeighted Population Shares**



\* Analysis at Local Government District

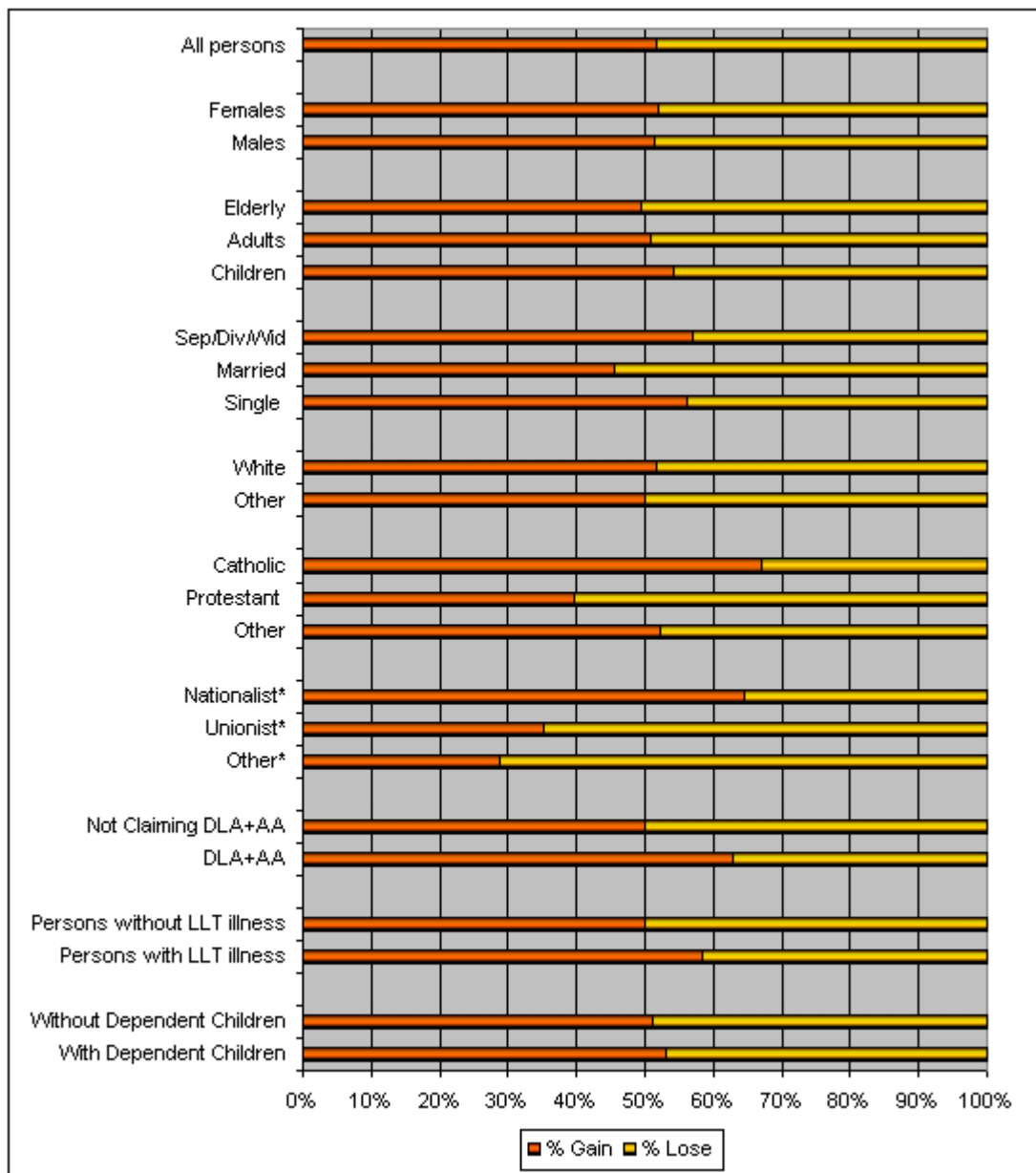
- 23.7 The impact of moving from crude population based shares to age/gender-weighted shares is summarised in Figure 23.1.
- 23.8 The use of age/gender weights has differential impacts across a number of the equality categories. The main differentials are as follows:
- Elderly people gain over younger adults by a differential of 12.7%, and gain by a differential of 16.5% over children;
  - Unionists gain over Nationalists by a differential of 21.9%;
  - Protestants gain over Catholics by a differential of 20.5%; and
  - People without dependant children gain over those with dependant children by a differential of 10.2%.
- 23.9 The differentials between elderly people and the rest appear plausible given the fact that older populations will gain more under age/gender weights (the age/gender weights reflect the higher cost of providing services to older people). Regarding the differential between Protestants and Catholics, it is known from the Census that the demographic structure of the Protestant population is older than the Catholic population. This will therefore mean that areas where the Protestant population is concentrated will benefit under the age/gender adjustment. A similar argument applies to the differential between Unionist and Nationalists (it is known that there is a close correlation between political opinion and religion – See Social Attitudes in N Ireland, Eighth Report p41). The differential between people with dependent children and those without can be explained by the fact that people without dependent children will comprise the vast majority of the elderly population. All of the above therefore suggests that the age/gender element of the formula directs resources in accordance with the principle of equal resources for equal need.

23.10 Overall, the age/gender weights would result in 53.7% of the N Ireland population living in wards, which would gain in terms of money being skewed due to age/gender. As mentioned, weighting the population for age/gender is only one component of the Capitation Formula; the individual effects of the other components will be discussed in subsequent sections.

**Equality Assessment of the Additional Needs Weighting**

23.11 The impact of moving from crude population based shares to the additional needs weighted shares is summarised in Figure 23.2.

**Figure 23.2 Impact of Additional Needs Weighting on Equality Categories – Impact of Moving From Crude Population Shares to Additional Needs Weighted Population Shares**



\* Analysis at Local Government District

23.12 The use of additional needs weights has differential impacts across a number of the equality categories. The main differentials are as follows:

- Separated/Divorced/Widowed and single people gain over married people by a differential of over 10%;
- Catholics gain over Protestants by a differential of 27.2%;
- Nationalists gain over Unionists by a differential of 29.7%; and
- Regarding people with a disability and those without, there are two proxy measures. People claiming Disability Living Allowance and Attendance Allowance gain over those who do not by a differential of 13.0%. People with a long term limiting illness gain over those who do not have a long term limiting illness by a differential of 8.4%.

23.13 The above differentials are in line with what would be expected because additional need is known to be closely correlated with socio-economic measures. Areas which are deprived have a higher additional needs index. The largest differential is between Catholics and Protestants. Internal analysis of Noble Measures of Multiple Deprivation shows that the Catholic population is over-represented in the most deprived wards. Other analysis cited in the “Equality and Inequalities in Health and Social Care in N Ireland: A Statistical Overview (2004)” report shows that Catholics are more likely than Protestants to live in wards with the highest Standardised Mortality Ratios for people aged under 75.

The above results are similar in direction and degree to the findings from an exercise carried out into the impact of allocating General Medical Services resources (see GMS Equality Impact Assessment, DHSSPS, October 2003).

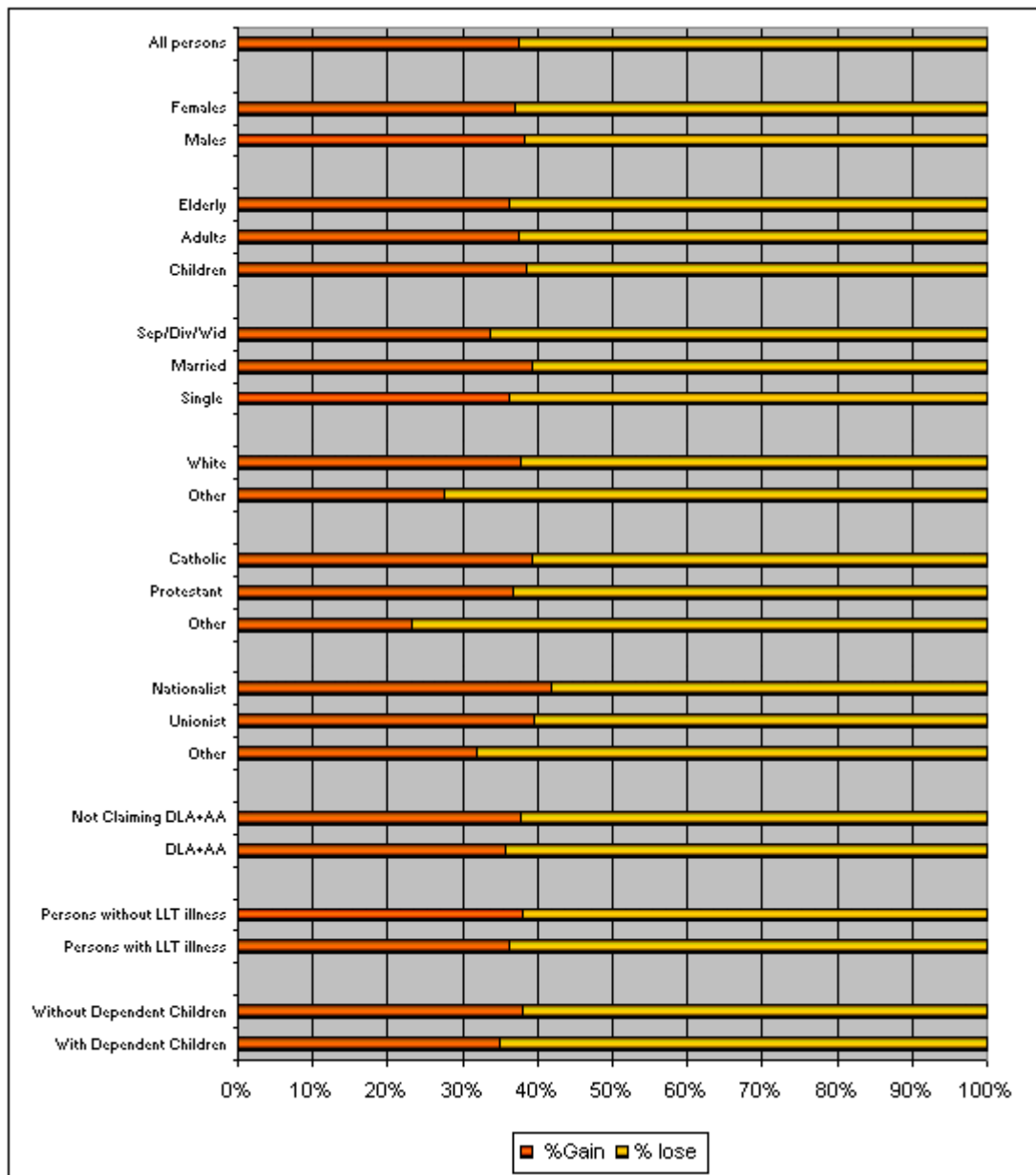
The additional needs element of the formula therefore appears to be directing resources in accordance with the principle of equal resources for equal need.

- 23.14 Overall, the additional needs weights would result in 51.6% of the N Ireland population living in wards, which would gain in terms of money being skewed due to additional need.

### Equality Assessment of the Rurality Adjustment

23.15 The impact of moving from crude population based shares to rurality weighted shares is summarised in Figure 23.3.

**Figure 23.3 Impact of Rurality Adjustment on Equality Categories – Impact of Moving From Crude Population Shares to Rurality Weighted Population Shares**



All analysis carried out at Local Government District level.

23.16 The rurality adjustment has differential impacts across a number of equality groups. It should be borne in mind, however, that the rurality adjustment redistributes a relatively small amount of money when compared with the redistributive effects of applying age/gender and additional needs weightings. The main differentials due to the rurality adjustment are as follows:

- Married people gain over separated/widowed/divorced people by a differential of 5.6%, and they gain over single people by a differential of 3.0%;
- White people gain over other ethnic groups by a differential of 10.1%; and
- People without dependent children gain over those with dependent children by a differential of 3.1%.

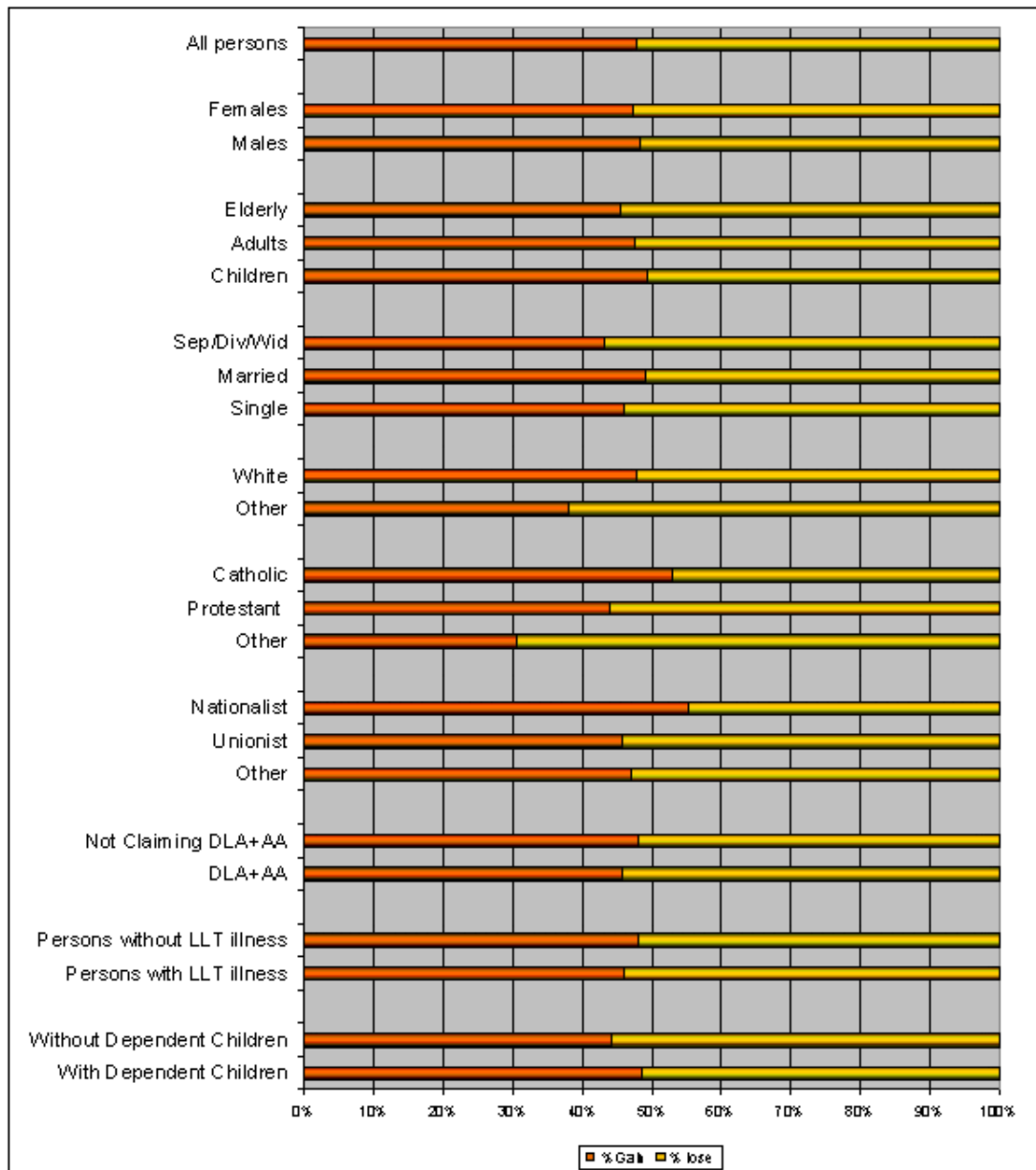
23.17 As can be seen, the differentials are small with the exception of the differential between white people and those from other ethnic groups. This is explained by the fact that non-white ethnic people tend to live in urban areas in N Ireland. According to the 2001 Census, over 60% of persons belonging to non-white ethnic groups lived in Belfast, Castlereagh, Craigavon, Derry, Lisburn, Newtownabbey, and North Down. As can be seen from Figure 22.4, these areas have the lowest values of the rurality index.

23.18 Overall, the rurality adjustment would result in 37.6% of the N Ireland population living in wards, which would gain in terms of money being skewed on account of rurality.

### Equality Assessment of the Economies of Scale Adjustment

23.19 The impact of moving from crude population based shares to economies of scale weighted shares is summarised in Figure 23.4.

**Figure 23.4 Impact of the Economies of Scale Adjustment on Equality**  
**Categories- Impact of Moving From Crude Population Shares to Economies of Scale Weighted Population Shares**



All analysis carried out at Local Government District level.

23.20 The economies of scale adjustment has differential impacts across a number of equality groups. It should be borne in mind, however, that the economies of scale adjustment redistributes a relatively small amount of money when compared with the redistributive effects of applying age/gender and additional needs weightings. The main differentials due to the economies of scale adjustment are as follows:

- White people gain over other ethnic groups by a differential of 9.8%;
- People with dependent children gain over those without dependent children by a differential of 4.4%;
- Catholics gain over Protestants by a differential of 8.9%; and
- Nationalists gain over Unionists by a differential of 9.5%

23.21 As can be seen, the differentials are small with the exception of the differential between white people and those from other ethnic groups and the differential between Catholics and Protestants. This is explained by the fact that non-white ethnic people tend to live in urban areas in N Ireland, which, as can be seen from Figure 22.5, generally do not benefit from the economies of scale adjustment. The differential between the two main religious groupings can be explained by the fact that Protestants are concentrated in the east of N Ireland and these areas tend to correspond with areas which do not benefit from the economies of scale adjustment.

23.22 Overall, the economies of scale adjustment would result in 47.7% of the N Ireland population living in wards, which would gain in terms of money being skewed on account of economies of scale.

**Conclusion**

- 23.23 Significant progress has been made in implementing the recommendations made by the Centre for Public Services in the 3<sup>rd</sup> Report, and their implementation has added to the evidence base upon which the capitation formula is built.
- 23.24 The Group is mindful, however, that the formula can only ever be as good as the data which informs it, and that there are limitations with data whether it is measuring utilisation, socio-economic characteristics, supply, or, indeed, equality categories. It is inevitable that there will not be a wholly precise way of targeting resources to all who need them, and it can therefore be expected that some differential impacts on various sections of the population will occur.
- 23.25 Equality assessment of the age/gender element of the formula has demonstrated differential impacts on some of the equality categories, but the more marked differentials can be explained by differences in age structures of the affected equality categories.
- 23.26 Equality assessment of the additional needs element of the formula has also shown that there are differences in the impacts on some of the equality categories. However, it is to be expected that this will be the case: the additional needs index is informed by socio-economic and morbidity/mortality data and the index will be higher – i.e. suggest more resources are needed – in deprived areas.
- 23.27 The formula therefore is directing resources in accordance with the principle of equal resources for equal need.
- 23.28 It should be noted that there is very often a ‘cancelling out’ effect when the age/gender weighting is combined with the additional needs weighting, with areas scoring highly on one measure scoring low on the other. Such examples are common in North Down, where many wards score highly due to their older

demographic structure, but the low levels of deprivation mean that they also have a low additional needs weight.

- 23.29 Analysis of the rurality and economies of scale adjustments shows that, in general, the differences between categories are smaller. It should also be remembered that these adjustments are minor in nature when compared with age/sex and additional needs weighting.
- 23.30 In overall terms, the Group believes its proposals are regarded as providing for improved equality of opportunity when compared to the formula currently in use. The formula is constructed on a better evidence base and where people in the various equality categories are affected differentially this is expected in terms of the requirement to provide equal resources for equal need. The new needs indices for Learning and Physical and Sensory Disability POCs are increasing the allocations towards populations with higher levels of disabilities. In addition, the improved targeting of resources in a fair and transparent way, on the basis of evidence, may also help to promote good relations between persons of different religious beliefs, political opinions or ethnic origins.
- 23.31 The Group recognises the importance of continuing to monitor the impact of the formula over time and of the need to commission further research in the Elderly and Acute POCs in order to minimize the possibility of future adverse impacts.

### **Recommendations:**

23.32 The CFRG recommends that:

- the formula continues to be refined so that it meets its objective of allocating equal resources for equal need; and

- all comments regarding equality implications of the application of the formula will continue to be given full consideration by the Group.

## 24 WAY FORWARD

24.1 This latest report is now the Fourth in a series produced by CFRG since it was first established in 1994. In that time significant progress has been made in ensuring that DHSSPS has one of the most sophisticated and sensitive allocation formulae currently in use in the public sector. The work also has unearthed a number of technical and data quality issues which have implications far beyond resource allocation. Major improvements to the formula over the 10 year period include the following:

- Evidence based needs indicators and age/gender cost weights now cover over 95% of all expenditure;
- Ground-breaking research on unavoidable costs arising from rurality and economies/diseconomies of scale has been incorporated;
- Unmet need has been investigated and emerging methodologies for adjustment have been developed; and
- Other sources of income, which can affect a HSS Board's purchasing power, have been taken into account in the allocation process.

24.2 There comes a point in this process, however, where one must consider whether the cost of additional research is justified in terms of its likely impact on formula sensitivity and, in particular, whether the outcome is likely to materially affect allocations. Certainly, no methodology can ever be perfect and a range of limitations have been highlighted during the course of the current work programme with appropriate recommendations having been made for further research. However, this work will need to be prioritised based on potential impact, data quality and cost considerations. On this basis, it is accepted that both the Acute and Elderly needs formulae need to be re-estimated at the earliest opportunity but the order in which other work is progressed is not so clear-cut. There is a case that further work should be

undertaken into unmet need as this has the potential to significantly impact on the Acute and Elderly work. There is also the complex issue of supply and whether the current method of adjustment is optimum. Already the work programme is starting to build, and it is likely that HSS Boards will have their own topics, which they will wish to see included.

- 24.3 One of the lessons learnt from this most recent work programme is the need for the Group to devote sufficient time and scrutiny to datasets in order to ensure that all data quality issues have been thoroughly resolved before commencing statistical modelling. The ability to do this is seriously curtailed if the work programme is too broad but, if not properly addressed, can lead to much additional re-modelling work late in the process. This suggests that the next work programme should be more focussed than previously, particularly given the importance of the PoCs being researched.
- 24.4 Once the next work programme has been completed, all PoCs will be on a common 1992 based electoral ward geography, will be based on reasonably up-to-date data sources, and any remaining 1991 Census indicators will have been replaced by 2001 based indicators. The unmet needs test should be further improved and new thinking on the treatment of supply can be taken into account. At this point, it would seem logical to undertake a more fundamental review of the formula. This would include an evaluation of the existing PoC structure and possible simplifications, which could be made by combining services. The Group may wish to consider whether, like Scotland, a single composite needs index would be suitable for all services (the weight attached to the indicator would be statistically determined for each service). All such simplifications, however, would need to be balanced against possible loss of sensitivity.
- 24.5 Perhaps the biggest challenge for the CFRG in the immediate future is to devise a strategy to deal with the significant population shifts which are occurring across N Ireland. The extent of these shifts has recently far outweighed the impact of the other formula adjustments, and they are making it increasingly difficult to move HSS Boards quickly to their target allocation

shares. The latest population projections show that the latest trends are likely to continue with significant implications for resource allocation policy.

## **Recommendations**

24.6 The CFRG recommends that:

- a review of the quality and scope of all datasets, which might be used in future modelling, be undertaken by suitably qualified staff in the DHSSPS, HSS Boards and Trusts before any further research is commissioned. This review should commence as a matter of urgency;
- the Elderly and Acute additional needs formulae be re-estimated; and
- a fundamental review of the formula be undertaken when the above have been completed.

**ANNEX 1****GROUP MEMBERSHIP**

**(If the role of a member has changed in the period since the publication of the 'Third Report' of CFRG, then their name may appear more than once, as it will be listed under each appropriate heading.)**

**CHAIR**

Mr A Hamilton                      Director of Financial Management (to June 2003)  
Deputy Secretary, Primary Secondary and Community  
Care Group (from June 2003),  
DHSSPS

**Northern HSS Board Representatives**

Mr W Matthews                      Director of Finance  
Northern Health and Social Services Board

Mrs C Frazer                          Senior Accountant,  
Northern Health and Social Services Board

Mr K Keenan                          Social Services Directorate,  
Northern Health and Social Services Board

**Southern HSS Board Representatives**

Mr S McKeever                      Director of Finance,  
Southern Health and Social Services Board

Miss C Anderson                      Project Accountant,  
Southern Health and Social Services Board

(from December 2001)

### **Eastern HSS Board Representatives**

Mr C McCloskey                      Assistant Director of Finance,  
Eastern Health and Social Services Board

Dr D Stewart                         Director of Public Health,  
Eastern Health and Social Services Board

### **Western HSS Board Representatives**

Mr P McLaughlin                    Director of Finance and Information,  
Western Health and Social Services Board

Mr P Ballentine                      Senior Accountant,  
Western Health and Social Services Board  
(From October 2001)

Mrs M McDaid                        Senior Accountant,  
Western Health and Social Services Board  
(To March 2002)

### **Departmental Representatives**

Mrs K Campbell                      Finance Directorate,  
DHSSPS (from November 2002)

Dr C Mason                            Nursing Officer, DHSSPS

Mrs S Barfoot                        General Medical Services Branch,  
DHSSPs (responsibility moved to the GMS Contract  
Unit, headed by Dr I McMaster, from April 2004)



**ANNEX 2****MODELLING OF ADDITIONAL NEED****Introduction**

This section aims to illustrate, in a non-technical way, the key concepts used in the statistical modelling of need. Detailed technical descriptions of the modelling work are contained within (or referenced in) the individual research reports.

**Background**

The fact that populations living in different geographical areas could have varying levels of need for health and social care services had been recognised and allowed for to an extent in resource allocation processes for some time. A new approach to modelling need was developed by York University for the Department of Health (DoH) in England in 1994. This involved a number of improvements on previous methods:

- a. A wide range of possible needs indicators and supply variables was tested;
- b. An improved costing methodology for hospital inpatients was incorporated, which recognised that 10 episodes of 2 days each would have a greater cost than 1 episode of 20 days since, in most cases, much of the more expensive investigation and treatment occurs in the early stages of inpatient care;
- c. The underlying model of interaction between needs, supply and utilisation, whilst still a simplification of the real world, was more complex than that used before. In particular it employed techniques to attempt to allow for feedback from utilisation to supply; and

- d. An allowance was made for variations in utilisation between Health Authorities arising from local decisions on policy implementation.

Full details of the York methodology are contained in a report of their work “A Formula for Distributing NHS Revenues Based on Small Area Use of Hospital Beds” (1994).

In Northern Ireland (NI) when the Group reconvened in 1996 it was decided to replicate the York University analysis for the Acute Programme of Care (PoC) using NI data. The Health and Social Care Research Unit (HSCRU) at Queen’s University Belfast, in conjunction with Professor Roy Carr-Hill of York University, was commissioned to undertake this work.

Based on the underlying model of utilisation, supply and needs as proposed by York University the work undertaken by HSCRU was:

- a. To assemble Northern Ireland specific data on costs, inpatient utilisation, morbidity, mortality, socio-economic indicators and service supply at small area level;
- b. To develop an age/gender cost relationship for Northern Ireland inpatient utilisation; and
- c. To analyse data to develop a Northern Ireland needs index for acute services.

In undertaking their task, HSCRU was able to make a number of improvements to the methodology employed by York University because:

- a. Better, more disaggregated data on costing were available;
- b. More complete information was available on access to private hospital beds; and

- c. Income Support and Family Credit benefit data were available as additional possible indicators of need for acute services.

In addition, they were able to undertake more sophisticated modelling on the influence of distance on attractiveness of supply.

Technical details of the work undertaken by HSCRU and York University are contained in their report - "A study to Devise a Formula to Assist in Allocating Resources for Acute Hospital Services within Northern Ireland" (1997). The general approach has been extended to other POCs through the work of a number of research groups. The NI research has taken account of the integrated nature of service provision in NI where health care and social services are incorporated within each POC where this is feasible.

## **Method**

### **General Approach**

The aim of the modelling is to estimate the need for health and social services over and above the need demanded by the size and age/gender structure of the population in an area. Unfortunately, there is no direct way of being able to measure this additional need without doing detailed assessments of individual members of the population. As an alternative, the York method tries to estimate it indirectly, by looking at the information that is available on the utilization of services and the supply (or accessibility to) services. For a range of relatively small geographical areas, the ratio of the actual cost or level of utilization compared to that which would be expected given the age, gender and size of the population in the area, is examined using a statistical modelling technique to see how it relates to socio-economic and morbidity factors.

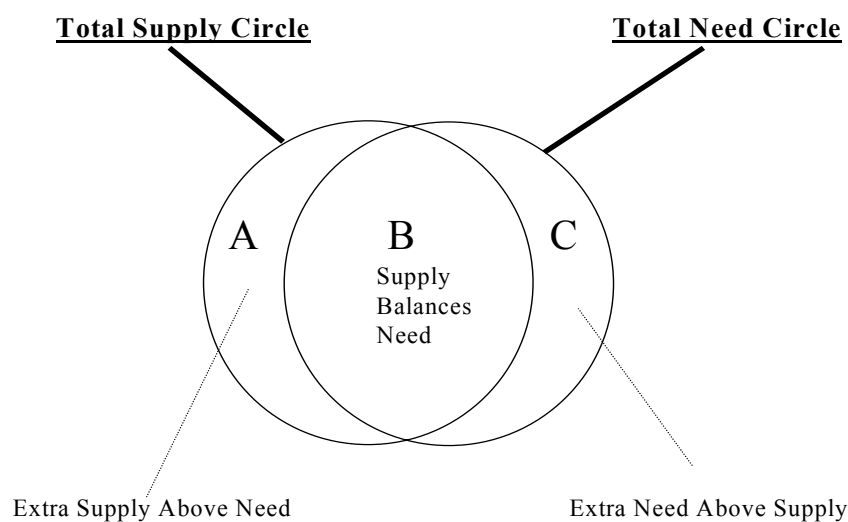
If all utilisation were a response to need then the statistical modelling would be simple. However, it is known for acute services that good accessibility can create higher levels of demand for the same level of need. Therefore, it is important to

consider the effect of differential historic levels of supply and to neutralise this as far as possible so that resources are allocated equitably on the basis of need alone.

### **How the historic supply effect is minimized**

Cost weighted utilization (services used adjusted for differences in cost of different types of service) can be represented for illustrative purposes by two overlapping circles (see Fig. 1). In the area of overlap in the centre (B), supply and need for services are in balance and this area can be described by either supply or needs factors. Supply factors relate to accessibility of services, e.g. in the Acute POC these would include the numbers of available acute beds at a location and the distance a patient would have to travel (from their electoral ward) to that facility. Not all supply is a problem, as most of it will exist because of the need in an area. It is only the utilization created by the extra supply that should be removed (A).

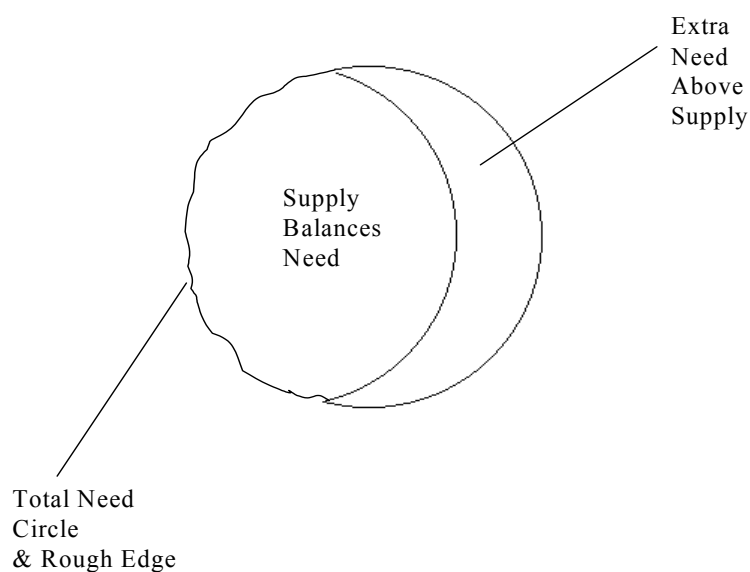
**Fig. 1 Cost Weighted Utilisation**



If supply matched need perfectly then the two circles would overlap completely. However, if there are historic supply effects where supply is relatively greater than need and this is not adjusted for, then resources would be allocated on the basis of an historic level of utilization partly produced by the level of supply itself, rather than need.

The relationship between supply, utilisation and need is in fact very complex. Supply can increase or decrease utilisation, for example, proximity to hospital beds can increase the demand for hospital services whereas the proximity of nursing home beds can decrease demand, as elderly patients who need to recuperate have access to more appropriate nursing home care. Also, areas of greater need can have higher or lower levels of supply than areas with lesser need. If supply were not to be included, then the model would assume that the current levels of supply were appropriate and there was no problem with the historical distribution of supply. If supply were kept in the model until the end but not used to calculate budgets, then this would equalise supply in each of the small areas within a Board. However, as mentioned above, not all supply is appropriate and balances need. The relationship between appropriate supply and the rest is likely to vary within a Board and so this approach would also have difficulties. The York approach is an attempt to find a third way through removing the utilisation created by the extra supply, to produce a more equitable budget allocation.

A formula is developed with supply present, to describe the ratio of the actual compared to the expected cost or level of utilisation. It will include supply factors about accessibility and, needs factors such as the socio-economic conditions and morbidity indicators. The supply factors are then dropped out of the formula and only the needs factors left, this would equate to crescent (C) in Fig.1. In order to allocate resources to meet the needs of the whole of the population, it is only crescent (A) in Fig.1, which should be removed, to produce the total needs circle as illustrated in Fig. 2 overleaf. Having identified needs factors, which are as independent of supply as possible, the supply factors are dropped and the values which show the importance of each of the needs factors (coefficients) are re-estimated. During this stage the coefficients of the selected needs factors alter to cover that area which can be described by either supply or needs factors.

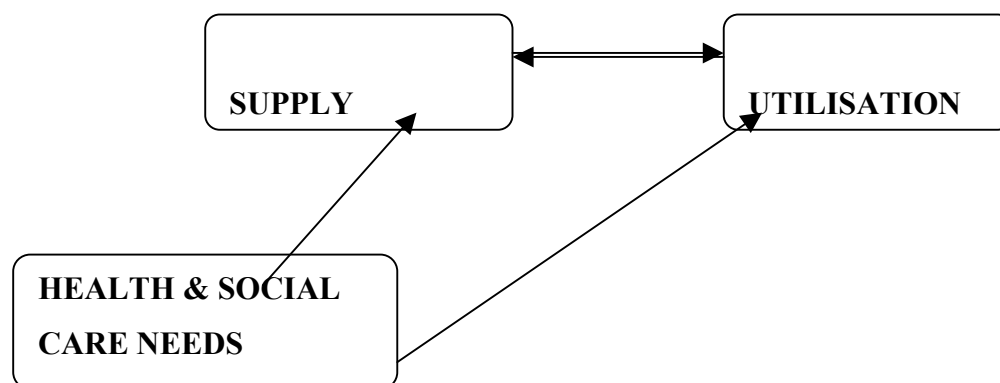
**Fig. 2 Total Needs Circle**

Since the needs factors should not be separately connected to supply, when the coefficients are re-estimated they shouldn't cover that part of utilisation, which is a response to historic supply and not to need (crescent A in Fig. 1). As it is not possible to get factors, which are completely independent of each other, there can be some small part of the undesirable supply, which comes back with the real need. This is represented in Fig. 2 by the rough edging on the needs circle.

This approach of identifying supply factors and needs factors, then dropping the supply factors and re-estimating the coefficients of the needs factors, was incorporated in the additional needs modelling research described in this report.

## The impact of endogeneity

**Fig. 3 Feed Back Loop**



Endogeneity is present where there is a feedback loop in the system being modelled e.g. where need for services is linked to utilization and to supply, and utilization is related to supply, but supply is also related to utilization creating a feedback loop.

The modelling for some PoCs where endogeneity was found required the use of a technique called ‘2 stage least squares’ regression in order to cope with this at the first stage, while for other PoCs which were not endogenous, the first stage was simpler. In either case ordinary weighted least squares regression was used for the last stage of the process, when supply factors are dropped and the coefficients are re-estimated. (Weighted least squares allow larger areas to have a bigger “say” in determining the relative importance of the needs patterns in the final model.)

It has already been mentioned that research shows that increased levels of supply can encourage greater utilisation of services. However, questions have been asked about whether utilisation can really have an impact on supply at local level within the time frame of the research (generally 1-3 years depending on service volumes). Supply of hospital beds is a combination of the number of available beds and their attractiveness or distance from the patient. There is not a fixed level of available beds in a particular facility; in fact, the number can fluctuate rapidly if the staff are there to support their use. For example, trolleys can be counted as ‘beds’ if they are used in that way and extra beds can be brought into a ward, or a ward reopened, if the beds can be staffed. Alternatively, beds can be taken out of commission if they are not needed or cannot

be staffed. In this situation, it is reasonable to suggest that the supply of available beds could be altered within a year to respond to the level of utilization required. The same could be said about nursing home beds. However, this type of feedback loop may not exist for all types of service.

### **The use of ‘dummies’ to remove policy differentials**

The modelling work links differential ratios of actual to expected costs within an area, to appropriate needs (and supply) factors. Differences between areas which may be created by policy (e.g. a different mix of community and inpatient services) are controlled for through the use of “dummies”. The purpose of a “dummy” is to indicate whether the small area being examined is part of a particular administrative area. If all the electoral wards in a specific area had higher levels of utilization than expected then the “dummy” for that area would be significant but it would be the underlying level of utilisation that would be used to determine the relationship with need. The “dummies” are not used in calculating budgets, as allocations should not be based on different historical levels of utilisation caused by different policies in different areas. The amount of variation explained by the “dummies” is nevertheless examined to ensure that it is not too large. There is a risk that if policy is set for areas that are very similar within themselves, i.e. largely deprived or largely affluent, then what appear to be policy differences between areas could actually be masking differences in real need.

The original York research used a statistical technique termed multi-level modelling rather than “dummies” to control for differential policy effects. It was not possible to use this technique when developing the NI Acute Needs formula as policy differences in respect of Acute Services are likely to operate at HSS Board level. As there are only four HSS Boards in NI, this was not a sufficient number for the technique to be reliably used. Even when the policy differences are thought to operate at Trust level (e.g. in respect of Elderly Care), there would not be enough distinct areas to justify the use of this technique (independent advice received by the Group suggested that, as a rule of thumb, multi-level modelling should be considered when there are 20 or more higher level geographical units and that below this number the use of “dummies” is a legitimate alternative).

## **Reliability of the statistical models**

When the statistical models are being developed, a range of tests is carried out to see what type of model would be appropriate and the reliability of the final formula. The R squared statistic indicates how much of the variation that existed (in the relative sizes of the actual and expected levels of utilisation) could be explained by the model. Values of between 0.3 and 0.6 are expected for this type of exercise. The higher the R-squared value the more reliable the formula should be. If a lot of the variation cannot be explained, it could be because the differences are random. On the other hand, if there seems to be a systematic difference but it doesn't link to any of the needs factors being used, then this could mean that it is necessary to look for another needs factor which has been missed. A model is said to be mis-specified when this happens. The researchers decide on a strategy to select the needs factors to produce the highest R squared value and the best specified model. Depending on the strategy it may be possible to produce different models in terms of the selected needs factors but if the models are equally reliable then the results produced should be broadly the same.

## **Counter-intuitive Factors**

Counter-intuitive factors look like they don't make sense, as the relationship with needs seems to be opposite to what is generally believed. For example, you would think that a higher level of long-term unemployed would indicate a greater than average need for health and social services (if there are no other differences). But, if it seems to indicate a lower level of need, then the researchers can exclude that factor and see what else gets included in its place. It may have been acting as a proxy for some other factor that does make sense in the model. Alternatively, the Scottish work, described in, "Fair Shares for All", took the view that counter-intuitive factors should only be excluded where they weren't closely related to other factors which were intuitive. In the above example, if "persons under 65 on income support" was strongly linked with need for extra service then the negative relationship with the long term unemployed might be compensating for some excess effect. Including the counter-intuitive factor and allowing negative feedback increases the sensitivity of the formula

and its predictive power. Against this, there would be some loss of transparency and intuitive plausibility.

The research reported here has generally used the strategy of excluding counter-intuitive factors. In the Elderly PoC a counter-intuitive age factor was retained, as it was believed that there is an interaction between age and need in this PoC and that it was not catered for adequately in the separate standardisation for age/gender.

### **Parsimony**

A statistical model may have a large number of significant factors explaining the variation but some of these may be only just statistically significant and have little influence in predicting the appropriate shares of resources. To simplify a formula for resource allocation to make it more manageable and easily understood, the researchers may decide that factors, which have little influence, should be left out. This makes the model more parsimonious but it is important to ensure that the overall impact on results is not large.

### **Data Quality**

The usefulness of the model is dependent on the quality of the data from which it is developed. The more complex the model, the more intensive the data requirements. As noted in the limitations listed in the relevant chapters, there were concerns at times about whether the data were of sufficient quality for the modelling approach.

### **Calculation of the Needs Formula at HSS Board level**

The additional needs factors are produced by modelling data for small areas (synthetic electoral wards). When applying a formula to larger areas such as HSS Boards it is statistically correct to combine the results produced for the small areas rather than calculating the results directly by using the HSS Board values in the formula. The disadvantage, which has to be worked around, with this is that at present the populations of the small areas are only available from the Census of Population and

even needs factors, which are not from the Census, cannot be updated if population is used to calculate the relative effect.

At the time the Acute needs formula was being developed, the desire to incorporate needs factors, which could be updated, was paramount. The 'Second Report' therefore recommended that the Acute formula should be calculated directly using Board data and the latest SMR (calculated over five years to ensure stability). The Group have maintained this approach for the Acute POC, as the method was an interim position agreed until further work could be done to address some of the limitations. There is, however, increasing concern about updating one element of a formula if the other factors cannot be updated (coming for example from the Census) or if the model is not re-run to check what impact the new data would have on the coefficients of the other factors. On statistical advice the Group has taken the view that, for the newly completed NI based needs research, individual factors should not be updated without re-running the model. This means that the HSS Board needs factors can be produced more correctly by combining the results for the small areas. It is important that adjustment factors are calculated and applied in the same order i.e. the need adjustment should follow the age adjustment consistently.