**Desk Review of Developments in Formula Methodology**

**1. Introduction:**

1. This note reports work undertaken for Work Programme item SM-4 to review developments in allocation formulae methods. The aim is to help inform discussions regarding the scope and content of the formula review by identifying potential improvements to the methods used in the NRAC formula.
2. The review is limited to formulae used in the rest of the UK as the health service, data availability and capitation formula approaches there are most relevant to the context in Scotland. In practice this means focussing primarily on England and Northern Ireland, as health funding allocations in Wales have been based on an epidemiological approach (though a needs formula based on NRAC has recently been introduced).
3. The methods which are discussed below are not necessarily applicable to the whole formula. They may be relevant only to one care programme, as the service structure and data availability vary across care programmes and care settings.
4. The three main improvements identified were:
* refining the case-mix adjustment for calculating acute unit costs;
* estimating age/sex and morbidity and life circumstances effects (MLC) simultaneously rather than sequentially;
* analysing need using person-level morbidity indicators as well as area based indicators.
1. The following sections describe each of these areas in turn. For additional information a final section notes a number of minor areas where there are differences between the NRAC formula and formulae used in the other parts of the UK.
2. The innovations described in this note could be incorporated into the NRAC formula subject to research on feasibility and on whether the change would yield sufficient improvement in predictive precision to warrant the additional work and complexity. Adoption of these changes would crucially depend on data availability. However, if appropriate data are not currently available it would be open to TAGRA to recommend the collection (or estimation) of necessary data to the prospective costing review.
3. **TAGRA are invited to discuss these findings and to consider whether further work is justified to explore the usefulness and feasibility of incorporating any of these methodological changes into the NRAC formula. And, if so, how should the different innovations be prioritised?**

**2. Estimating Unit Costs of Acute Activity**

*The use of costing in the formula:*

1. The objective of the formula is to predict relative need for healthcare across small area populations (SAP), to facilitate equal access to health care for equal need. It does this in two steps: first, analysing the objective determinants of the variation in actual utilisation of health services to derive weights “explaining” that variation; second, predicting need by applying those weights to the demographic and Morbidity and Life Circumstances (MLC) of the small area populations.
2. In practical terms, taking one determinant of need – age – as an example, this means first analysing how utilisation has varied with age to calculate national average relative weights for each age cohort. Then predicting relative need by applying those weights to each small area population age structure, for the target share year.
3. Costed utilisation is used as the measure of observed need because it reflects the resource intensity of the services used and indicates the relative funding required to provide the services. In the absence of prices for the healthcare services provided, unit costs are calculated using a combination of expenditure data and information on the number and type of activities which have been funded by that expenditure. The reliability of the calculated target shares depends ultimately on the accuracy of the costing methods.
4. The method for calculating unit costs varies across care programmes, depending on the type of healthcare provided and the availability of data. As the most detailed data are available for hospital care, and the variation in the resource intensity is typically much greater for admitted patient care than for other types of care, this discussion will focus on that aspect of the formula. And, in particular, on the case-mix adjustment which is crucial for incorporating an adequate reflection of the variation in resource use intensity.

*The NRAC method:*

1. The most common approach to estimating unit costs for the episodes of care for NRAC is to combine the cost data from the Costs Book with activity data from the Scottish Morbidity Record (SMR) datasets. The Costs Book provides cost data at the hospital and speciality level and for different patient types. The SMR datasets provide the age, sex, data zone of residence of the patient and hospital of treatment, as well as diagnostic and treatment information including length of stay (LOS). The demographic information allows the calculation of costs by age-sex cohorts (using 20 age groups: 0-1, 2-4, 5-9, 10-14, etc, up to 85-89, 90 years and over) and allocation to data zone of residence; the treatment information allows the episode to be mapped to the Costs Book speciality categories and gives length of stay.
2. The total inpatient speciality costs are divided into a fixed cost component and a variable cost component. Fixed costs are those incurred by the fact of providing an episode of care and variable costs are the costs which vary by length of stay during that episode (i.e. cost per day). The method of achieving the fixed/variable split was revised during the review of the Acute MLC in 2015 and now uses a factor derived from the Patient Level Information and Costing System (PLICS). Basically the variable component share is estimated for each specialty using the share of the PLICS costs in that speciality which are thought to be related to length of stay.
3. For each relevant speciality the fixed component is divided by the number of episodes to get an average cost per episode; the variable cost component is divided by the total number of bed days to get an average cost per day. The cost of an episode of care is the sum of the fixed cost per episode and the average cost per day times the length of stay for that episode of care.
4. The casemix adjustment therefore reflects the speciality of treatment and the length of stay.

*Alternative Methods:*

1. For both England and Northern Ireland the costing casemix adjustment uses the Health Care Resource Group (HRG) classification. The Healthcare Resource Groups (HRGs) are developed and maintained by the National Casemix Office, part of NHS Digital. The classification covers admitted patient care, outpatient consultations, A&E and Critical Care and are the basis for the Payment By Results (PbR) system of provider remuneration. HRGs are clinically meaningful groupings of patient activity derived primarily from procedure (OPCS-4) and diagnosis (ICD-10) codes within patient records. A extract of the HRG for hip procedures is provided in the annex as an illustration of the level of detail embodied in the classification.
2. The HRG approach constitutes a complex casemix adjustment which takes account of the type of diagnosis, procedure and morbidity and resource use.

*Discussion:*

1. At the time of the review of the MLC for the Acute Care Programme in 2015 it was judged that it would be premature to use the full PLICS approach for costing as it was still classed as developmental. In addition, the lack of a detailed Costs Book for 2020/21 and 2021/22 would preclude calculation of PLICS for those years. It would, however, be possible to revisit this issue to determine whether it would now be feasible to move to a PLICS-based approach for the formula costing.

1. Alternatively the HRG approach would potentially provide a much richer casemix adjustment than does the current NRAC method. At present HRG costing in Scotland relies on making use of detailed cost relativities from the English data to disaggregate the available Scottish cost data (which is less detailed than required). However, the costing review provides an opportunity for TAGRA to recommend the acquisition of more detailed cost data to facilitate HRG costing using only Scottish data.
2. It should also be noted that the method used in the NRAC formula for estimating the cost of an episode of care is unique to the formula. The method is not used for calculating the cost of cross-boundary flows of patients, when patients are treated in a board other than the one in which they are resident. In principle the methods used for the allocation formula should be the same as those used to determine inter-board payments for treatment.
3. This lack of consistency within Scotland between the NRAC formula and the methods used to cost cross-boundary patient treatments is a further motivation to review the formula costing method. This could involve discussions with boards to determine the details of the methods which they use and whether improvements in consistency could be achieved.

**3. Estimating the Age/Sex and MLC coefficients:**

*Basic approaches:*

1. The formula incorporates weights which reflect the relative need across age/sex cohorts and due to different Morbidity and Life Circumstances (MLC). These are applied to the small area population data to predict the relative need by geographical area. The main alternatives for estimating the formula weights are a one-stage or a two-stage method. In a one-stage method both the age and sex and Morbidity and Life Circumstances (MLC) are estimated simultaneously. In the two stage method the first step identifies the costs due to age and sex; the second step estimates the (residual) effects due to MLC.

*NRAC:*

1. The NRAC formula uses a two-stage method. The first stage identifies the national average costs separately for males and females in 20 age cohorts (mostly 5-year age bands – see para. 12). These costs per capita per age/sex (AS) cohort are then applied to the small area population (SAP) demographic data to estimate the expected costs of providing health services to the local (typically data zone) populations contingent on the AS structure of those populations. (Effectively these are indirectly age-sex standardised cost-weighted utilisation estimates for the local populations.)
2. At the second stage the ratio of these estimated costs to the actual observed cost (for those local populations) is calculated. This ratio, which captures the variation of the actual costs relative to the expected costs (based on the AS structure of the population alone), reflects the effects of the different MLC across the SAP. The ratio is regressed on the indicators of need (representing the MLC) to identify the relative effect which they have on need (having controlled for the effect of AS).
3. This two-stage method produces AS need weights which vary by AS cohort but are the same for any individual AS cohort across SAP; and MLC weights which vary across SAP but which are the same for all ages in any individual SAP.

*Alternative:*

1. The alternative one-stage approach is used in the Scottish Workload Formula (SWF), which allocates the Global Sum to primary care practices, and was developed for the allocation formulae in England with the CARAN Report[[1]](#footnote-1). In this method the costed utilisation is regressed directly on AS and MLC variables simultaneously to calculate the weights. Two ways of doing this were compared in CARAN: an additive one-stage method and a stratified one-stage method. The former yields MLC weights which do not vary across ages, whilst the latter yields MLC weights which are specific to the stratified age cohorts.

1. The CARAN report compares the theoretical and statistical properties of the three methods: one-stage additive; one-stage stratified; and, two-stage. They conclude that the one-stage stratified approach is the most flexible specification which allows the effects of additional need variables to vary with age. They recommended the use of the one-stage stratified model.

*Discussion:*

1. The use of the one-stage stratified method could be explored for the NRAC formula using the data which is already used in the formula. It should be feasible to text the accuracy of the predictive power of the alternative approaches to determine whether it would be an appropriate change to introduce.

**4. Modelling Need with Patient-Level Data:**

*Area-level modelling:*

1. The NRAC modelling of Morbidity and Life Circumstances (MLC) uses small area geographies as the basic unit of observation. This is typically the Data Zone (DZ), of which there are almost 7,000 in Scotland, or the Intermediate Geography (almost 1,300 in Scotland). The indicators of need for the MLC are all area-based, e.g. the Standardised Mortality Ratio for the relevant DZ, or the rate of Limiting Long-Term Illness for the DZ. These indicators are therefore (age-standardised) averages across the populations in those areas.

*Patient-level modelling:*

1. An approach using patient-level morbidity modelling was developed for the General and Acute component of the allocations formula in England by the Nuffield Trust[[2]](#footnote-2). (The England Mental Health formula now also uses patient-level modelling.) The underlying assumption is that morbidities recorded from previous hospital care are indicative of future need for care. The basic starting population is the general practice registered patient list. This provides a set of patient-level observations including the age, sex and location of each person whether they used secondary care or not. The registered list is linked with secondary care data (either the Hospital Episode Statistics (HES) or the Secondary Users Service (SUS) Payment by Results (PbR) dataset). Both datasets and the linkage are anonymised by NHS digital to protect patient confidentiality. The HES/SUS datasets have information on the episodes of care, diagnoses, procedures, tariff cost, etc. which relate to patients who have had admitted patient care, outpatient or A&E episodes of care.
2. The dependant variable for this (regression) model is the total cost of providing the acute hospital care for an individual in a specific year. The cost is provided by the SUS dataset, mostly using the PbR tariff but, if that is not available, using the reference costs. In some cases, where neither of these is available, the average speciality costs are used.
3. The individual-level morbidity component of the model is constructed using variables which reflect the diagnoses recorded in SUS for the patients who had received secondary care. The period from which the diagnoses data are taken is the two years prior to the year of the costed dependent variable. That is the cost of providing a patient with secondary care is explained by the diagnoses recorded (the morbidity) during the previous two years.
4. The patient-level diagnoses data are grouped according to the sub-chapters of the International Classification of Disease (ICD) giving 152 groups. ICD10 sub-chapters were used as individual codes were considered to give rise to volatility in the model. The morbidity is included in three ways:
* the morbidity diagnosis recorded (the dataset includes up to 13 diagnostic codes per episode: analysis determined that the optimum number of diagnostic codes to be included was 9);
* morbidity interactions (as co-morbidities are expected to affect the cost of treatment);
* a count of the number of morbidities (because more than one condition can be treated in a single hospital spell);
1. As with the NRAC model the dependant variable set also includes area variables representing the demographic and socio-economic characteristics of the area of residence of these individual patients. However, the findings of the research were that, after age, the most powerful predictors of costs were the diagnostic groups that described individual-level morbidity.

*Discussion:*

1. Similar individual-level data are collected in Scotland: the practice list is available via the Community Health Index (CHI) and the Scottish Morbidity Record (SMR) is completed for admitted patient care. Subject to satisfying information governance requirements it may be possible to link these datasets in order to undertake a feasibility study.
2. However, one potential challenge is that the extent of list inflation is much higher in Scotland than is the case in England. The difference between the NRS population and the practice patient list was 6.4% in the 2021/22 Costs Book, whereas the gap between the registered list and the ONS population in England is claimed to be 2%. It may be necessary to clean the patient list before attempting such an analysis or find an alternative means of reconciling the list population to the NRS data which is used in NRAC.

**5. Other potential areas of difference:**

1. The three areas cited above are instances of methodological development which could be considered for adoption in the NRAC formula. In addition there are a number of differences between the approach taken in NRAC and in other UK formulae. A (non-exhaustive) number of these are listed here for information.
* Geographical variation in the unit cost of providing services is represented by a Market Forces Factor (and other specific adjustments) in England formulae; whereas the NRAC formula uses the revealed average ratio of local to national unit costs by Urban-Rural category;
* Elective and non-elective admitted patient care is modelled separately in the Northern Ireland formula but not in the England formula nor in NRAC;
* The progression to parity is managed through an explicit ‘Pace of Change’ policy in England whereas Scotland has explicit targets for the parity gap;
* England have recently utilised new community care activity data, whereas the NRAC formula still mostly relies proxies from other activity;
* The formula in England has a separate component on inequalities and unmet need, based on variation in the Standardised Mortality Ratio, whereas NRAC has adjustments in the Circulatory and Other diagnostic groups using the shortfall method;
* For the England formula refresh two samples (of circa 15% each) were drawn from the available datasets. This allowed the weights to be estimated on one (estimation) sample and then applied on the second (validation) sample, with the results of the predicted need on the second sample compared to actual need to test the performance of the model.

**Annex: List of HRG relating to Hip procedures, trauma and non-trauma**

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| HN12A | Very Major Hip Procedures for Non-Trauma with CC Score 10+ |
| HN12B | Very Major Hip Procedures for Non-Trauma with CC Score 8-9 |
| HN12C | Very Major Hip Procedures for Non-Trauma with CC Score 6-7 |
| HN12D | Very Major Hip Procedures for Non-Trauma with CC Score 4-5 |
| HN12E | Very Major Hip Procedures for Non-Trauma with CC Score 2-3 |
| HN12F | Very Major Hip Procedures for Non-Trauma with CC Score 0-1 |
| HN13A | Major Hip Procedures for Non-Trauma, 19 years and over, with CC Score 10+ |
| HN13B | Major Hip Procedures for Non-Trauma, 19 years and over, with CC Score 6-9 |
| HN13C | Major Hip Procedures for Non-Trauma, 19 years and over, with CC Score 4-5 |
| HN13D | Major Hip Procedures for Non-Trauma, 19 years and over, with CC Score 2-3 |
| HN13E | Major Hip Procedures for Non-Trauma, 19 years and over, with CC Score 1 |
| HN13F | Major Hip Procedures for Non-Trauma, 19 years and over, with CC Score 0 |
| HN13G | Major Hip Procedures for Non-Trauma, 18 years and under, with CC Score 1+ |
| HN13H | Major Hip Procedures for Non-Trauma, 18 years and under, with CC Score 0 |
| HN14A | Intermediate Hip Procedures for Non-Trauma, 19 years and over, with CC Score 6+ |
| HN14B | Intermediate Hip Procedures for Non-Trauma, 19 years and over, with CC Score 4-5 |
| HN14C | Intermediate Hip Procedures for Non-Trauma, 19 years and over, with CC Score 2-3 |
| HN14D | Intermediate Hip Procedures for Non-Trauma, 19 years and over, with CC Score 1 |
| HN14E | Intermediate Hip Procedures for Non-Trauma, 19 years and over, with CC Score 0 |
| HN14F | Intermediate Hip Procedures for Non-Trauma, between 6 and 18 years, with CC Score 1+ |
| HN14G | Intermediate Hip Procedures for Non-Trauma, between 6 and 18 years, with CC Score 0 |
| HN14H | Intermediate Hip Procedures for Non-Trauma, 5 years and under |
| HN15A | Minor Hip Procedures for Non-Trauma, 19 years and over |
| HN15B | Minor Hip Procedures for Non-Trauma, 18 years and under |
| HN16A | Minimal Hip Procedures, 19 years and over |
| HN16B | Minimal Hip Procedures, between 6 and 18 years |
| HN16C | Minimal Hip Procedures, 5 years and under |
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| HT12A | Very Major Hip Procedures for Trauma with CC Score 12+ |
| HT12B | Very Major Hip Procedures for Trauma with CC Score 9-11 |
| HT12C | Very Major Hip Procedures for Trauma with CC Score 6-8 |
| HT12D | Very Major Hip Procedures for Trauma with CC Score 3-5 |
| HT12E | Very Major Hip Procedures for Trauma with CC Score 0-2 |
| HT13A | Major Hip Procedures for Trauma with CC Score 12+ |
| HT13B | Major Hip Procedures for Trauma with CC Score 9-11 |
| HT13C | Major Hip Procedures for Trauma with CC Score 6-8 |
| HT13D | Major Hip Procedures for Trauma with CC Score 3-5 |
| HT13E | Major Hip Procedures for Trauma with CC Score 0-2 |
| HT14A | Intermediate Hip Procedures for Trauma with CC Score 4+ |
| HT14B | Intermediate Hip Procedures for Trauma with CC Score 2-3 |
| HT14C | Intermediate Hip Procedures for Trauma with CC Score 0-1 |
| HT15Z | Minor Hip Procedures for Trauma |

Note: CC refers to complications and co-morbidities

**References:**

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Morris, S. et al (2007), *Combining Age Related and Additional Needs Report: review of the needs formulae for hospital services and prescribing activity in England*,

NHS England (2015), *Refreshing the Formulae for CCG Allocations For allocations to Clinical Commissioning Groups from 2016-17: Report on the methods and modelling*

NHS England (2023), *Technical guide to allocation formulae and convergence: For 2023/24 and 2024/25 allocations*

NHS England (2023), *Update of the formula for general and acute hospital services for 2022/23 allocations*

1. Combining Age Related and Additional Needs Report: review of the needs formulae for hospital services and prescribing activity in England, November 2007. [↑](#footnote-ref-1)
2. See for example: Bardsley and Dixon, (December 2011), Person-based Resource Allocation: New approaches to estimating commissioning budgets for GP practices. [↑](#footnote-ref-2)