**TAGRA ACUTE MLC SUBGROUP Thursday 5th May 2016**

**ANALYSIS OF NEW ACUTE MLC MODEL**

**1. Background and Summary**

Following the paper TAMLC49, AST recommended the needs index consisting of LLTI, All-cause SMR <75 and Ethnicity for the Acute MLC adjustment. The next steps, prior to the analysis to look for evidence of unmet need, were to analyse the chosen model in more detail. Since a decision has not been made on which model to adopt prior to this analysis, this paper presents the results of the recommended model. However, results for other index models explored earlier have already been computed, and similar conclusions are drawn as in this analysis. Given the next likely model to be chosen is the 4-variable model, consisting of LLTI, All-cause SMR <75, Ethnicity and Unpaid care; its results are provided in Annex C to Annex E.

Section 2 shows comparative analysis on explanatory power, coefficient values, and residual outliers, comparing the new model with the old. Section 3 repeats the earlier analysis of model performance in different age groups, with the new model, and concludes that although model performance does appear to vary with age group, applying the adjustment to separate age groups and aggregating the results would not improve the predictive power. Section 4 presents the results of checking for variation in cost with urban-rural setting, by adding urban-rural category indicators to the regression model, as has been done previously for other care programmes. Including these indicators only marginally improves explanatory power, and does not improve predictive power; this indicates that the model performs equally well across urban and rural settings.

**2. Comparison with previous model**

In this section we compare the new Acute MLC model with (1) the ‘reference model’ at the old data zones (DZ2001), and (2) the reference model at the new data zones (DZ2011). We look at adjusted R2, the values of the needs index coefficient, and the number of residual outliers.

Adjusted R2 values – the percentage of variance in the cost ratios that is explained by the model – are used as a goodness of fit measure. These are shown in Table 1 for all diagnostic groups. The differences in performance between the models are small; the new model performs best for Other (by far the largest diagnostic group in terms of spend – see Annex A) and Digestive. The final column of the table shows an average R2, using the spend within the diagnostic groups to weight the average; the highest weighted average is found to be for the new index.

*Table 1. Adjusted R2 for (1) old model at DZ2001, (2) old model at DZ2011, (3) new model at DZ2011. Highest R2 is shown in bold and italics.*

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Model** | **Cancer** | **Heart** | **Digestive** | **Injury** | **Other** | **Respiratory** | **Outpatients** | **Weighted average** |
| Old index + IPACX + OPACX at DZ2001 | 10.8% | ***20.5%*** | 38.4% | ***25.8%*** | 44.8% | ***37.5%*** | 48.9% | 36.6% |
| Old index + IPACX + OPACX at DZ2011 | ***12.8%*** | 18.9% | 38.1% | 24.0% | 42.5% | 37.0% | ***56.3%*** | 37.0% |
| New index + IPACX OR OPACX + prison dummy (OP only), at DZ2011 | 10.7% | 19.5% | ***39.3%*** | 23.9% | ***46.3%*** | 37.3% | 51.5% | ***37.4%*** |

The Acute needs index coefficients (‘*B*’) obtained from fitting the models are shown in Table 2. We can interpret a coefficient value *B* as meaning that a unit increase in the needs index will be associated with an increase of *B* units to the cost ratio. Thus it gives an indication of the cost ratios’ sensitivity to the needs index and the strength of the relationship.

The coefficients for the (old) reference model at DZ2011 are higher than at DZ2001 for all diagnostic groups (although this increase is not significant for Digestive and Respiratory). This suggests the new geography results in a more sensitive response: a bigger increase in cost can be inferred from a given increase in the needs index – possibly because the new geography has resulted in more socio-economic homogeneity within each data zone than before, allowing variation in need to be modelled more effectively. The coefficients are lower for the new model; this is because it contains three components as opposed to two, so the range of values of the index (which is the sum of three z-scores) is larger.

*Table 2. Coefficient of needs indexfor (1) old model at DZ2001, (2) old model at DZ2011, (3) new model at DZ2011*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Model** | **Cancer** | **Heart** | **Digestive** | **Injury** | **Other** | **Respiratory** | **Outpatients** |
| Old index + IPACX + OPACX at DZ2001 | 0.047 | 0.107 | 0.112 | 0.114 | 0.091 | 0.180 | 0.032 |
| Old index + IPACX + OPACX at DZ2011 | 0.054 | 0.115 | 0.116 | 0.120 | 0.097 | 0.184 | 0.037 |
| New index + IPACX OR OPACX + prison dummy (OP only), at DZ2011 | 0.045 | 0.094 | 0.101 | 0.097 | 0.084 | 0.154 | 0.035(prison dummy 0.228) |

Residual outliers – i.e. exceptionally large differences between the 3-year cost ratio and the predicted value from the model – indicate observations which do not fit the model well. Influential points are observations which change the fit of the model in a substantive way. Residual outliers and influential points have been identified using the method previously used in paper TAMLC22. There are no influential points for the old model either at DZ2001 or DZ2011 and also no influential points for the new model.

The numbers of residual outliers are shown in Table 3. The percentage of residual outliers does not vary substantially between the three models.

*Table 3. Number and percentage of residual outliers for (1) old model at DZ2001, (2) old model at DZ2011, (3) new model at DZ2011*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Model** | **Cancer** | **Heart** | **Digestive** | **Injury** | **Other** | **Respiratory** | **Outpatients** |
| Old index + IPACX + OPACX at DZ2001 | **14**0.2% | **18**0.3% | **17**0.3% | **17**0.3% | **12**0.2% | **28**0.4% | **8**0.1% |
| Old index + IPACX + OPACX at DZ2011 | **22**0.3% | **18**0.3% | **15**0.2% | **16**0.2% | **10**0.1% | **27**0.4% | **6**0.1% |
| New index + IPACX OR OPACX + prison dummy (OP only), at DZ2011 | **22**0.3% | **20**0.3% | **15**0.2% | **15**0.2% | **13**0.2% | **28**0.4% | **5**0.1% |

**3. Analysis of performance across age groups**

In this section, the performance of the proposed new Acute needs index in different age groups is checked, using a variety of age group splits. This follows the method of paper TAMLC27: separate cost ratios for ‘older’ and ‘younger’ age groups are calculated, and regressed upon the needs index (along with the supply model, and the prison indicator in the case of Outpatients).

**3.1 Explanatory power**

Adjusted R2 values are shown in Table 4, for regressions on all-ages data, and on data split by age at 65, 70 and 75 years of age. These do not allow comparison of the *overall* explanatory power between an all-ages models and models with an age split, but it can be noted that for almost all cases with an age split, the adjusted R2 is higher for the younger group than for the older group.

Regression coefficients for the Acute needs index (and prison dummy, for Outpatients) are shown in Table 5, along with the 95% confidence intervals. The needs index coefficient for the younger group is significantly higher, while the coefficient for the older group is significantly lower, than the all-ages coefficient (no overlap of the confidence intervals). The older-ages coefficient even becomes negative for Outpatients, which would be counter-intuitive if implemented. The prison dummy coefficient shows the same variation but the differences are not significant.

The lower R2 and lower coefficient values for the older age groups indicates that there is less of a relationship between the needs index and cost for older populations; possibly, as discussed previously, because older age is already a strong predictor of cost (accounted for in the Age-Sex component of the formula) and additional needs become less important at older ages. Another factor is that in many cases, the proportion of activity accounted for by the older age group is relatively low; despite the steep increase in activity rates with age, the population also decreases with age. (Annex A shows the proportion of spend, activity, and population accounted for by each age group considered.) Lower activity levels will mean that there is a larger variance in the cost ratios and the model will explain less of the variation – this is also seen, for example, in R2 differences between large diagnostic groups (such as Outpatients and Other) and smaller ones.

*Table 4. Adjusted R2 values obtained from fitting the proposed needs index model, by diagnostic group and age grouping.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Diagnostic group** | **All-ages model R2** | **<65 R2** | **<70 R2** | **<75 R2** |
| **≥65 R2** | **≥70 R2** | **≥75 R2** |
| **Cancer** | 10.7% | 5.8% | 7.7% | 9.5% |
| 5.7% | 3.4% | 1.6% |
| **Heart** | 19.5% | 18.4% | 21.3% | 22.6% |
| 5.5% | 3.5% | 1.4% |
| **Digestive** | 39.3% | 34.1% | 37.0% | 38.6% |
| 13.9% | 8.7% | 4.4% |
| **Injury** | 23.9% | 24.8% | 26.7% | 27.6% |
| 4.5% | 2.9% | 2.5% |
| **Other** | 46.3% | 43.9% | 47.2% | 48.9% |
| 17.4% | 12.7% | 8.3% |
| **Respiratory** | 37.3% | 20.3% | 26.3% | 31.4% |
| 24.7% | 19.7% | 13.6% |
| **Outpatients** | 51.5% | 54.1% | 54.9% | 55.3% |
| 24.7% | 18.6% | 11.5% |

*Table 5. Acute index regression coefficient values obtained from fitting the proposed index model, along with 95% confidence intervals in brackets, by diagnostic group and age grouping.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Diagnostic group** | **All-ages coefficient** | **<65 coefficient** | **<70 coefficient** | **<75 coefficient** |
| **≥65 coefficient** | **≥70 coefficient** | **≥75 coefficient** |
| **Cancer** | 0.045(0.040, 0.500) | 0.053(0.045, 0.061) | 0.052(0.045, 0.059) | 0.051(0.045, 0.057) |
| 0.036(0.030, 0.043) | 0.035(0.027, 0.043) | 0.026(0.016, 0.036) |
| **Heart** | 0.094 (0.089, 0.099) | 0.154(0.146, 0.162) | 0.144(0.138, 0.151) | 0.133 (0.127, 0.140) |
| 0.057(0.050, 0.064) | 0.047(0.040, 0.054) | 0.035(0.026, 0.044) |
| **Digestive** | 0.101(0.097, 0.105) | 0.122(0.117, 0.127) | 0.121(0.116, 0.126) | 0.116(0.112, 0.121) |
| 0.067(0.061, 0.074) | 0.053(0.045, 0.061) | 0.044(0.034, 0.054) |
| **Injury** | 0.097(0.093, 0.102) | 0.142(0.136, 0.148) | 0.141(0.135, 0.146) | 0.135(0.130, 0.141) |
| 0.044(0.036, 0.052) | 0.031(0.022, 0.039) | 0.024(0.014, 0.034) |
| **Other** | 0.084(0.081, 0.086) | 0.112(0.108, 0.115) | 0.109(0.106, 0.113) | 0.105(0.102, 0.108) |
| 0.049(0.045, 0.053) | 0.041(0.037, 0.046) | 0.033(0.027, 0.038) |
| **Respiratory** | 0.154 (0.149, 0.160) | 0.168(0.160, 0.177) | 0.179(0.171, 0.186) | 0.181(0.174, 0.188) |
| 0.144(0.136, 0.152) | 0.129(0.121, 0.138) | 0.112(0.102, 0.122) |
| **Outpatients** – index | 0.035(0.033, 0.037) | 0.045(0.043, 0.046) | 0.043(0.041, 0.045) | 0.041(0.039, 0.043) |
| 0.005(0.002, 0.008) | -0.001(-0.005, 0.002) | -0.011 (-0.016, -0.006) |
| **Outpatients** – prison dummy | 0.228 (0.149, 0.308) | 0.270(0.183, 0.358) | 0.254(0.170, 0.338) | 0.239 (0.158, 0.321) |
| 0.090(-0.045, 0.225) | 0.086(-0.080, 0.251) | 0.132 (-0.102, 0.366) |

**3.2 Predictive power**

As before, the residual sum of squares (RSS) has been used to compare the model predictions with the 2014/15 cost ratios. This has two purposes: (1) as before, it allows us to check the predictive performance of the model against ‘future’ data; (2) by aggregating the predictions for the two separate age groups, we can directly compare the overall predictive power of an age-split model with that of an all-ages model.

For the models that include an age split, the predictions in the two age groups can be compared with 2014/15 cost ratios calculated for the two separate age groups. The predictions can also be aggregated, to be compared with the overall (all-ages) 2014/15 cost ratios. The procedure for the aggregation is the procedure used in the Mental Health & Learning Difficulties MLC model: by summing the predicted ‘actual’ cost and the expected cost across the diagnostic groups, then dividing one by the other to produce an all-ages predicted cost ratio.

The resulting RSS values are given in Table 6. Low RSS values indicate that the observations are relatively close to the predictions.

*Table 6. RSS values obtained from comparing the proposed needs index model with the 14/15 cost ratios, for various possible age splits. The RSS for the separate age groups is shown, and also the RSS for the overall model after aggregating the age-group predictions.*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Diagnostic group**  | **All-ages RSS – model with no split** | **<65 RSS** | **All-ages RSS – model with split at 65** | **<70 RSS** | **All-ages RSS – model with split at 70** | **<75 RSS** | **All-ages RSS – model with split at 75** |
| **≥65 RSS** | **≥70 RSS** | **≥75 RSS** |
| **Cancer** | 3271 | 7794 | 3271 | 5681 | 3271 | 4481 | 3270 |
| 6173 | 8303 | 13122 |
| **Heart** | 3656 | 11450 | 3660 | 8464 | 3660 | 6456 | 3658 |
| 8886 | 7163 | 11098 |
| **Digestive** | 2143 | 3255 | 2148 | 2945 | 2148 | 2684 | 2146 |
| 6547 | 9062 | 14210 |
| **Injury** | 2916 | 5640 | 2916 | 5154 | 2916 | 4556 | 2915 |
| 7568 | 9779 | 13392 |
| **Other** | 820 | 1401 | 825 | 1196 | 824 | 1074 | 823 |
| 2080 | 2552 | 3442 |
| **Respiratory** | 3626 | 9186 | 3633 | 7104 | 3637 | 5967 | 3638 |
| 7227 | 8993 | 10842 |
| **Outpatients** | 395 | 496 | 396 | 456 | 395 | 427 | 395 |
| 1189 | 1679 | 2842 |

When an age split is implemented, the relative size of the RSS in the older and younger groups merely reflects the relative activity levels in these age groups (see Table A.2 in Annex A). This is because more activity results in lower variance (or scatter) in the cost ratios, and so the distance of the cost ratios from the predictions is smaller. The RSS values resulting from aggregating predictions for the two age groups together – the “all ages” columns – are therefore more meaningful for comparison between models. It is clear from Table 6 that at the “all ages” level, there is very little difference between the predictive power of models with or without an age split. Where the RSS does differ slightly, it favours the model without an age split.

In conclusion, although the needs index explains less of the variation in cost for older populations (Table 4), this is likely to be because older age is already a very strong predictor of cost and additional needs are simply less important. Table 6 shows that there would be no benefit, in predictive power, to fitting the model separately to different age groups.

**4. Analysis of performance across urban-rural settings**

In this section, the proposed new Acute needs index is used to perform analysis across urban-rural settings. Following the method of the 2007 NRAC review and the Mental Health & Learning Difficulties MLC review, this is done by including urban-rural (UR) markers as extra variables in the regression of cost ratios upon the needs index and supply model, which effectively adjust the health care need of each rural area within the same urban-rural category by a constant amount. The analysis involves examining the effect on the coefficient of the needs index, the R2, and the predictive power (measured by RSS).

Although the Excess Costs component of the formula accounts for urban-rural effects, it only does so through allowing for a *unit cost* that varies by urban-rural setting – it does not account for differing activity levels between regions. Including UR markers in the MLC model would accomplish this, if it was found to be the case. (It was decided during the NRAC review in 2007 that urban-rural markers should be included in the MLC model for Maternity.)

Following the previous review methods, four different UR classifications have been tested: a 2-fold, a 4-fold, a 6-fold and an 8-fold classification. Definitions of the classifications are given in Annex B.

The results are shown in Tables 7-9. The inclusion of urban-rural markers (of any classification) does not produce significant differences in the coefficient of the proposed Acute needs index at the 5% level (Table 7). The R2 is increased slightly when urban-rural markers are included, with the biggest difference of 1.1 percentage points being observed (for Outpatients) when including the 8-fold classification indicators (Table 8). These are very modest increases in explanatory power. The predictive power also does not improve substantially when including the urban-rural markers (Table 9).

Table 10 shows the coefficients of the urban-rural indicators from the regressions, with those that were not significantly different from zero indicated in grey. Many are not significant, particularly for Heart and Cancer. There is also no clear pattern. If activity levels varied significantly with urban-rural setting, then it might be expected, for example, that the sign of the coefficient (for a given diagnostic group) was consistently negative for urban categories and positive for more rural categories. No such pattern is evident.

In conclusion, the proposed Acute MLC model appears to perform similarly well across all urban-rural settings. No significant improvement can be anticipated from including urban-rural indicators in the model.

*Table 7. Effect of including urban/rural markers on the proposed Acute needs index coefficient.*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Model** | **Cancer** | **Heart** | **Digestive** | **Injury** | **Other** | **Respiratory** | **Outpatients** |
| Acute index model | 0.045 | 0.094 | 0.101 | 0.097 | 0.084 | 0.154 | 0.035 |
|  +2 fold UR classification | 0.044 | 0.094 | 0.100 | 0.099 | 0.084 | 0.155 | 0.036 |
|  +4 fold UR classification | 0.045 | 0.094 | 0.100 | 0.099 | 0.084 | 0.156 | 0.036 |
|  +6 fold UR classification | 0.045 | 0.095 | 0.101 | 0.099 | 0.084 | 0.156 | 0.035 |
|  +8 fold UR classification | 0.045 | 0.095 | 0.101 | 0.099 | 0.084 | 0.156 | 0.035 |

*Table 8. Effect of including urban/rural markers on the adjusted R2.*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Model** | **Cancer** | **Heart** | **Digestive** | **Injury** | **Other** | **Respiratory** | **Outpatients** |
| Acute index model | 10.7% | 19.5% | 39.3% | 23.9% | 46.3% | 37.3% | 51.5% |
|  +2 fold UR classification | 10.8% | 19.5% | 39.3% | 24.0% | 46.3% | 37.3% | 51.6% |
|  +4 fold UR classification | 10.8% | 19.6% | 39.3% | 24.2% | 46.5% | 37.4% | 51.6% |
|  +6 fold UR classification | 11.2% | 19.9% | 39.4% | 24.2% | 46.5% | 37.4% | 52.6% |
|  +8 fold UR classification | 11.2% | 19.9% | 39.4% | 24.2% | 46.5% | 37.5% | 52.7% |

*Table 9. Effect of including urban/rural markers on the RSS, obtained from comparing model predictions with the 2014/15 cost ratios. In the case of the predictions from aggregated diagnostic groups, the comparison is with the overall Acute 2014/15 cost ratio. Lower values indicate the predictions are closer to the observed values.*

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Model** | **Cancer** | **Heart** | **Digestive** | **Injury** | **Other** | **Respiratory** | **Outpatients** | **Aggregated diagnostic groups** |
| Acute index model | 3271 | 3656 | 2144 | 2916 | 820 | 3626 | 395 | 470 |
|  +2 fold UR classification | 3270 | 3656 | 2143 | 2918 | 820 | 3635 | 398 | 472 |
|  +4 fold UR classification | 3270 | 3655 | 2147 | 2915 | 818 | 3640 | 398 | 475 |
|  +6 fold UR classification | 3237 | 3628 | 2142 | 2911 | 818 | 3632 | 383 | 464 |
|  +8 fold UR classification | 3239 | 3627 | 2144 | 2911 | 818 | 3628 | 382 | 463 |

*Table 10: Coefficients of the urban-rural markers in the regressions (see Annex B for the definitions of the urban-rural classifications). The last category is always redundant and therefore excluded. Coefficients in grey are not significantly different from zero.*

|  |  |
| --- | --- |
| **Model** | **Coefficients of urban-rural indicators** |
| **Cancer** | **Heart** | **Digestive** | **Injury** | **Other** | **Respiratory** | **Outpatients** |
| Acute index model + 2-fold UR classification | **1:** 0.01  | **1:** 0.00 | **1:** 0.01 | **1:** -0.04 | **1:** -0.01 | **1:** -0.04 | **1:** -0.02 |
| Acute index model + 4-fold UR classification | **1:** -0.05 **2:** 0.01 **3:** -0.07  | **1:** -0.02**2:** 0.05**3:** -0.01 | **1:** -0.05**2:** 0.01**3:** -0.07 | **1:** -0.12**2:** -0.03**3:** -0.09 | **1:** -0.06**2:** 0.03**3:** -0.06 | **1:** -0.11**2:** -0.04**3:** -0.09 | **1:** -0.03**2:** -0.02**3:** -0.01 |
| Acute index model + 6-fold UR classification | **1:** 0.06 **2:** -0.06 **3:** -0.04 **4:** 0.01 **5:** -0.06  | **1:** 0.07**2:** -0.04**3:** 0.00**4:** 0.06**5:** 0.00 | **1:** -0.01**2:** -0.05**3:** -0.05**4:** 0.01**5:** -0.06 | **1:** -0.10**2:** -0.12**3:** -0.10**4:** -0.03**5:** -0.09 | **1:** -0.06**2:** -0.06**3:** -0.06**4:** 0.03**5:** -0.06 | **1:** -0.10**2:** -0.12**3:** -0.09**4:** -0.04**5:** -0.09 | **1:** 0.06**2:** -0.03**3:** -0.01**4:** -0.02**5:** 0.00 |
| Acute index model + 8-fold UR classification | **1:** 0.01 **2:** -0.11 **3:** -0.09 **4:** -0.06 **5:** 0.02 **6:** -0.12 **7:** -0.07 | **1:** 0.03**2:** -0.07**3:** -0.03**4:** 0.02**5:** 0.05**6:** -0.04**7:** -0.05 | **1:** -0.05**2:** -0.09**3:** -0.09**4:** -0.04**5:** -0.01**6:** -0.11**7:** -0.06 | **1:** -0.15**2:** -0.17**3:** -0.14**4:** -0.10**5:** -0.01**6:** -0.13**7:** -0.06 | **1:** -0.05**2:** -0.05**3:** -0.06 **4:** 0.04**5:** 0.04**6:** -0.05**7:** 0.01 | **1:** 0.01**2:** -0.02**3:** 0.02**4:** 0.13**5:** -0.11**6:** 0.02**7:** 0.13 | **1:** 0.04**2:** -0.05**3:** -0.03**4:** -0.07**5:** 0.02**6:** -0.02**7:** -0.02 |

**Annex A**

*Table A.1. Total spend for 2012/13 financial year by diagnostic group and age (65, 70 and 75 cut-off points).*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Diagnostic group** | **All ages spend (£millions)** | **<65 spend (£millions)** | **<70 spend (£millions)** | **<75 spend (£millions)** |
| **≥65 spend (£millions)** | **≥70 spend (£millions)** | **≥75 spend (£millions)** |
| **Cancer** | **399.4** | **179.6** (45.0%) | **237.0** (59.4%) | **291.1** (72.9%) |
| **219.8** (55.0%) | **162.3** (40.6%) | **108.3** (27.1%) |
| **Heart** | **407.3** | **127.6** (31.3%) | **175.0** (43.0%) | **229.2** (56.3%) |
| **279.7** (68.7%) | **232.2** (57.0%) | **178.0** (43.7%) |
| **Digestive** | **346.9** | **194.1** (55.9%) | **227.1** (65.5%) | **259.6** (74.8%) |
| **152.8** (44.1%) | **119.8** (34.5%) | **87.3** (25.2%) |
| **Injury** | **390.8** | **168.9** (43.2%) | **194.6** (49.8%) | **224.8** (57.5%) |
| **221.9** (56.8%) | **196.2** (50.2%) | **166.0** (42.5%) |
| **Other** | **1,314.7** | **698.5** (53.1%) | **801.5** (61.0%) | **909.3** (69.2%) |
| **616.1** (46.9%) | **513.2** (39.0%) | **405.3** (30.8%) |
| **Respiratory** | **291.5** | **111.3** (38.2%) | **137.6** (47.2%) | **169.1** (58.0%) |
| **180.1** (61.8%) | **153.9** (52.8%) | **122.3** (42.0%) |
| **Outpatients** | **582.7** | **396.2** (68.0%) | **445.4** (76.4%) | **489.7** (84.0%) |
| **186.5** (32.0%) | **137.3** (23.6%) | **93.1** (16.0%) |

*Table A.2. Number of episodes in 2012/13 financial year by diagnostic group and age; final row shows population by age.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Diagnostic group** | **All ages activity** | **<65 activity** | **<70 activity** | **<75 activity** |
| **≥65 activity** | **≥70 activity** | **≥75 activity** |
| **Cancer episodes** | **199,581** | **96,677** (48.4%) | **126,547** (63.4%) | **153,182** (76.8%) |
| **102,904** (51.6%) | **73,034** (36.6%) | **46,399** (23.2%) |
| **Heart episodes** | **148,762** | **55,782** (37.5%) | **73,135** (49.2%) | **92,304** (62.0%) |
| **92,980** (62.5%) | **75,627** (50.8%) | **56,458** (38.0%) |
| **Digestive episodes** | **193,086** | **122,076** (63.2%) | **139,877** (72.4%) | **156,164** (80.9%) |
| **71,010** (36.8%) | **53,209** (27.6%) | **36,922** (19.1%) |
| **Injury episodes** | **118,641** | **70,741** (59.6%) | **77,638** (65.4%) | **85,040** (71.7%) |
| **47,900** (40.4%) | **41,003** (34.6%) | **33,601** (28.3%) |
| **Other episodes** | **684,139** | **406,546** (59.4%) | **460,840** (67.4%) | **516,126** (75.4%) |
| **277,593** (40.6%) | **223,299** (32.6%) | **168,013** (24.6%) |
| **Respiratory episodes** | **133,220** | **61,031** (45.8%) | **72,535** (54.4%) | **86,151** (64.7%) |
| **72,189** (54.2%) | **60,685** (45.6%) | **47,069** (35.3%) |
| **Outpatient new appointments** | **1,411,707** | **997,445** (70.7%) | **1,114,331** (78.9%) | **1,214,710** (86.0%) |
| **414,262** (29.3%) | **297,376** (21.1%) | **196,997** (14.0%) |
| ***Population*** | ***5,313,600*** | ***4,387,849*** *(82.6%)* | ***4,673,581*** *(88.0%)* | ***4,895,114*** *(92.1%)* |
| ***925,751*** *(17.4%)* | ***640,019*** *(12.0%)* | ***418,486*** *(7.9%)* |

**Annex B: Urban-rural classifications used**

2013/14 Scottish Government Urban-Rural Classification – 8-fold version:

* 1: Large urban areas - settlements of 125,000 or more people.
* 2: Other urban areas - settlements of 10,000 to 124,999 people.
* 3: Accessible small towns - settlements of 3,000 and 9,999 people and within 30 minutes drive of a settlement of 10,000 or more.
* 4: Remote small towns - settlements of between 3,000 and 9,999 people and with a drive time of over 30 minutes to a settlement of 10,000 or more.
* 5: Very remote small towns - settlements of 3,000 and 9,999 people and with a drive time of over 60 minutes to a settlement of 10,000 or more.
* 6: Accessible rural - areas with a population of less than 3,000 people, and within a 30 minute drive time of a settlement of 10,000 or more.
* 7: Remote rural - areas with a population of less than 3,000 people, and with a drive time of over 30 minutes but less than 60 minutes to a settlement of 10,000 or more.
* 8: Very remote rural - areas with a population of less than 3,000 people, and with a drive time of over 60 minutes to a settlement of 10,000 or more.

2013/14 Scottish Government Urban-Rural Classification – 6-fold version:

* 1: Large urban areas - settlements of 125,000 or more people.
* 2: Other urban areas - settlements of 10,000 to 124,999 people.
* 3: Accessible small towns - settlements of 3,000 to 9,999 people and within 30 minutes drive of a settlement of 10,000 or more.
* 4: Remote small towns - settlements of 3,000 to 9,999 people and with a drive time of over 30 minutes to a settlement of 10,000 or more.
* 5: Accessible rural - areas with a population of less than 3,000 people, and within a 30 minute drive time of a settlement of 10,000 or more.
* 6: Remote rural - areas with a population of less than 3,000 people, and with a drive time of over 30 minutes to a settlement of 10,000 or more.

NHS Highland 4-fold classification, based on combining categories 1, 2 and 3 in the 6-fold classification above:

* 1: Urban areas - settlements of at least 10,000 people or at least 3,000 people within 30 min drive to a settlement of at least 10,000 people.
* 2: Accessible rural - areas with a population of less than 3,000 people, and within a 30 minute drive time of a settlement of 10,000 or more.
* 3: Remote small towns - settlements of 3,000 to 9,999 people and with a drive time of over 30 minutes to a settlement of 10,000 or more.
* 4: Remote rural - areas with a population of less than 3,000 people, and with a drive time of over 30 minutes to a settlement of 10,000 or more.

A 2-fold classification based on combining categories 2, 3 and 4 in the 4-fold classification above:

* 1: Urban areas - settlements of at least 10,000 people or at least 3,000 people within 30 min drive to a settlement of at least 10,000 people.
* 2: Rural areas - accessible rural areas, remote small towns and remote rural areas combined.

**Annex C: Comparison with previous model using 4 variables index**

*Table C.1. Adjusted R2 for (1) old model at DZ2001, (2) old model at DZ2011, (3) new model at DZ2011. Highest R2 is shown in bold and italics.*

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Model** | **Cancer** | **Heart** | **Digestive** | **Injury** | **Other** | **Respiratory** | **Outpatients** | **Weighted average** |
| Old index + IPACX + OPACX at DZ2001 | 10.8% | ***20.5%*** | 38.4% | ***25.8%*** | 44.8% | ***37.5%*** | 48.9% | 36.6% |
| Old index + IPACX + OPACX at DZ2011 | ***12.8%*** | 18.9% | 38.1% | 24.0% | 42.5% | 37.0% | ***56.3%*** | 37.0% |
| New index + IPACX OR OPACX + prison dummy (OP only), at DZ2011 | 10.4% | 19.5% | **39.5%** | 23.0% | **46.8%** | 37.4% | 53.2% | **37.8%** |

*Table C.2. Coefficient of needs indexfor (1) old model at DZ2001, (2) old model at DZ2011, (3) new model at DZ2011*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Model** | **Cancer** | **Heart** | **Digestive** | **Injury** | **Other** | **Respiratory** | **Outpatients** |
| Old index + IPACX + OPACX at DZ2001 | 0.047 | 0.107 | 0.112 | 0.114 | 0.091 | 0.180 | 0.032 |
| Old index + IPACX + OPACX at DZ2011 | 0.054 | 0.115 | 0.116 | 0.120 | 0.097 | 0.184 | 0.037 |
| New index + IPACX OR OPACX + prison dummy (OP only), at DZ2011 | 0.032 | 0.071 | 0.076 | 0.071 | 0.064 | 0.116 | 0.028(prison dummy 0.236) |

*Table C.3. Number and percentage of residual outliers for (1) old model at DZ2001, (2) old model at DZ2011, (3) new model at DZ2011*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Model** | **Cancer** | **Heart** | **Digestive** | **Injury** | **Other** | **Respiratory** | **Outpatients** |
| Old index + IPACX + OPACX at DZ2001 | **14**0.2% | **18**0.3% | **17**0.3% | **17**0.3% | **12**0.2% | **28**0.4% | **8**0.1% |
| Old index + IPACX + OPACX at DZ2011 | **22**0.3% | **18**0.3% | **15**0.2% | **16**0.2% | **10**0.1% | **27**0.4% | **6**0.1% |
| New index+ IPACX OR OPACX + prison dummy (OP only), at DZ2011 | **22**0.3% | **19**0.3% | **14**0.2% | **15**0.2% | **13**0.2% | **26**0.4% | **5**0.1% |

**Annex D: Age-split & Urban Rural settings investigation for 4 variables index**

*Table D.1. Adjusted R2 values obtained from fitting the 4 variables**index model, by diagnostic group and age grouping.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Diagnostic group** | **All-ages model R2** | **<65 R2** | **<70 R2** | **<75 R2** |
| **≥65 R2** | **≥70 R2** | **≥75 R2** |
| **Cancer** | 10.4% | 5.5% | 7.4% | 9.0% |
| 5.7% | 3.5% | 1.7% |
| **Heart** | 19.5% | 18.2% | 20.9% | 22.1% |
| 5.7% | 3.6% | 1.5% |
| **Digestive** | 39.5% | 34.1% | 36.9% | 38.6% |
| 13.9% | 8.9% | 4.5% |
| **Injury** | 23.0% | 23.8% | 25.6% | 26.3% |
| 4.4% | 2.9% | 2.5% |
| **Other** | 46.8% | 44.7% | 47.8% | 49.1% |
| 17.3% | 12.6% | 8.3% |
| **Respiratory** | 37.4% | 20.3% | 26.0% | 30.8% |
| 24.8% | 19.9% | 13.9% |
| **Outpatients** | 53.2% | 55.6% | 56.5% | 56.8% |
| 24.8% | 18.6% | 11.4% |

*Table D.2. Acute index regression coefficient values obtained from fitting the 4 variables**index model, along with 95% confidence intervals in brackets, by diagnostic group and age grouping.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Diagnostic group** | **All-ages coefficient** | **<65 coefficient** | **<70 coefficient** | **<75 coefficient** |
| **≥65 coefficient** | **≥70 coefficient** | **≥75 coefficient** |
| **Cancer** | 0.032(0.029, 0.036) | 0.037(0.031, 0.043) | 0.036(0.031, 0.042) | 0.036(0.032, 0.041) |
| 0.028(0.022, 0.033) | 0.027(0.021, 0.033) | 0.023(0.015, 0.030) |
| **Heart** | 0.071(0.067, 0.075) | 0.115(0.109, 0.121) | 0.108(0.102, 0.113) | 0.099(0.094, 0.104) |
| 0.044(0.039, 0.049) | 0.036(0.031, 0.041) | 0.028(0.021, 0.034) |
| **Digestive** | 0.076(0.073, 0.079) | 0.092(0.088, 0.096) | 0.091(0.087, 0.094) | 0.087(0.084, 0.091) |
| 0.051(0.046, 0.056) | 0.041(0.035, 0.047) | 0.034(0.027, 0.042) |
| **Injury** | 0.071(0.068, 0.075) | 0.104(0.100, 0.109) | 0.103(0.099, 0.108) | 0.099(0.095, 0.103) |
| 0.031(0.026, 0.037) | 0.022(0.015, 0.029) | 0.018(0.010, 0.025) |
| **Other** | 0.064(0.062, 0.066) | 0.085(0.082, 0.088) | 0.083(0.081, 0.085) | 0.079(0.077, 0.082) |
| 0.036(0.033, 0.039) | 0.031(0.027, 0.034) | 0.025(0.021, 0.029) |
| **Respiratory** | 0.116(0.112, 0.120) | 0.126(0.120, 0.133) | 0.133(0.128, 0.139) | 0.134(0.129, 0.139) |
| 0.109(0.103, 0.115) | 0.098(0.092, 0.105) | 0.086(0.079, 0.093) |
| **Outpatients** – index | 0.028(0.027, 0.030) | 0.035(0.034, 0.037) | 0.034(0.033, 0.035) | 0.032(0.031, 0.034) |
| 0.006(0.004, 0.008) | 0.001(-0.001, 0.004) | -0.006 (-0.010, -0.002) |
| **Outpatients** – prison dummy | 0.236 (0.158, 0.315) | 0.281(0.195, 0.368) | 0.264(0.182, 0.347) | 0.249 (0.169, 0.329) |
| 0.090(-0.045, 0.225) | 0.084(-0.081, 0.250) | 0.128 (-0.106, 0.362) |

*Table D.3. RSS values obtained from comparing 4 variables**index model with the 14/15 cost ratios, for various possible age splits. The RSS for the separate age groups is shown, and also the RSS for the overall model after aggregating the age-group predictions.*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Diagnostic group**  | **All-ages RSS – model with no split** | **<65 RSS** | **All-ages RSS – model with split at 65** | **<70 RSS** | **All-ages RSS – model with split at 70** | **<75 RSS** | **All-ages RSS – model with split at 75** |
| **≥65 RSS** | **≥70 RSS** | **≥75 RSS** |
| **Cancer** | 3270 | 7801 | 3270 | 5684 | 3270 | 4479 | 3269 |
| 6169 | 8301 | 13125 |
| **Heart** | 3658 | 11466 | 3664 | 8468 | 3664 | 6467 | 3662 |
| 8888 | 7166 | 11101 |
| **Digestive** | 2134 | 3244 | 2138 | 2939 | 2139 | 2676 | 2137 |
| 6541 | 9052 | 14199 |
| **Injury** | 2921 | 5670 | 2924 | 5185 | 2924 | 4590 | 2923 |
| 7567 | 9778 | 13387 |
| **Other** | 816 | 1393 | 822 | 1193 | 822 | 1074 | 821 |
| 2082 | 2552 | 3439 |
| **Respiratory** | 3621 | 9216 | 3627 | 7118 | 3631 | 5983 | 3632 |
| 7198 | 8974 | 10812 |
| **Outpatients** | 391 | 491 | 391 | 452 | 391 | 422 | 391 |
| 1186 | 1677 | 2840 |

**Annex E: Urban Rural settings investigation for 4 variables index**

*Table E.1. Effect of including urban/rural markers on the 4 variables**index coefficient.*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Model** | **Cancer** | **Heart** | **Digestive** | **Injury** | **Other** | **Respiratory** | **Outpatients** |
| Acute index model | 0.032 | 0.071 | 0.076 | 0.071 | 0.064 | 0.116 | 0.028 |
|  +2 fold UR classification | 0.032 | 0.071 | 0.076 | 0.072 | 0.063 | 0.116 | 0.029 |
|  +4 fold UR classification | 0.032 | 0.071 | 0.076 | 0.072 | 0.063 | 0.117 | 0.029 |
|  +6 fold UR classification | 0.032 | 0.071 | 0.076 | 0.072 | 0.063 | 0.117 | 0.028 |
|  +8 fold UR classification | 0.032 | 0.071 | 0.076 | 0.072 | 0.063 | 0.117 | 0.028 |

*Table E.2. Effect of including urban/rural markers on the adjusted R2.*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Model** | **Cancer** | **Heart** | **Digestive** | **Injury** | **Other** | **Respiratory** | **Outpatients** |
| Acute index model | 10.4% | 19.5% | 39.5% | 23.0% | 46.8% | 37.4% | 53.2% |
|  +2 fold UR classification | 10.5% | 19.5% | 39.6% | 23.0% | 46.8% | 37.4% | 53.3% |
|  +4 fold UR classification | 10.6% | 19.6% | 39.6% | 23.2% | 47.0% | 37.5% | 53.3% |
|  +6 fold UR classification | 10.9% | 19.8% | 39.6% | 23.2% | 47.0% | 37.5% | 54.2% |
|  +8 fold UR classification | 10.9% | 19.9% | 39.6% | 23.2% | 47.0% | 37.6% | 54.3% |

*Table E.3. Effect of including urban/rural markers on the RSS, obtained from comparing model predictions with the 2014/15 cost ratios. In the case of the predictions from aggregated diagnostic groups, the comparison is with the overall Acute 2014/15 cost ratio. Lower values indicate the predictions are closer to the observed values.*

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Model** | **Cancer** | **Heart** | **Digestive** | **Injury** | **Other** | **Respiratory** | **Outpatients** | **Aggregated diagnostic groups** |
| Acute index model | 3270 | 3658 | 2134 | 2921 | 816 | 3621 | 391 | 463 |
|  +2 fold UR classification | 3267 | 3657 | 2131 | 2923 | 816 | 3624 | 394 | 463 |
|  +4 fold UR classification | 3268 | 3656 | 2136 | 2920 | 814 | 3629 | 394 | 466 |
|  +6 fold UR classification | 3235 | 3630 | 2131 | 2918 | 816 | 3628 | 378 | 456 |
|  +8 fold UR classification | 3237 | 3629 | 2133 | 2917 | 816 | 3625 | 377 | 455 |

*Table E.4: Coefficients of the urban-rural markers in the regressions (see Annex B for the definitions of the urban-rural classifications). The last category is always redundant and therefore excluded. Coefficients in grey are not significantly different from zero.*

|  |  |
| --- | --- |
| **Model** | **Coefficients of urban-rural indicators** |
| **Cancer** | **Heart** | **Digestive** | **Injury** | **Other** | **Respiratory** | **Outpatients** |
| Acute index model + 2-fold UR classification | **1:** 0.02  | **1:** 0.01 | **1:** 0.02 | **1:** -0.02 | **1:** 0.01 | **1:** -0.02 | **1:** -0.02 |
| Acute index model + 4-fold UR classification | **1:** -0.04 **2:** 0.03 **3:** -0.07  | **1:** 0.00**2:** 0.09**3:** 0.00 | **1:** -0.02**2:** 0.04**3:** -0.05 | **1:** -0.09**2:** 0.01**3:** -0.07 | **1:** -0.04**2:** 0.06**3:** -0.04 | **1:** -0.07**2:** -0.02**3:** -0.06 | **1:** -0.02**2:** -0.01**3:** 0.00 |
| Acute index model + 6-fold UR classification | **1:** 0.07 **2:** -0.04 **3:** -0.03 **4:** 0.03**5:** -0.05  | **1:** 0.09**2:** -0.01**3:** 0.03**4:** 0.09**5:** 0.01 | **1:** 0.01**2:** -0.02**3:** -0.02**4:** 0.04**5:** -0.05 | **1:** -0.08**2:** -0.09**3:** -0.07**4:** 0.01**5:** -0.07 | **1:** -0.04**2:** -0.03**3:** -0.04**4:** 0.06**5:** -0.04 | **1:** -0.07**2:** -0.08**3:** -0.05**4:** 0.02**5:** -0.06 | **1:** 0.06**2:** -0.02**3:** -0.01**4:** -0.01**5:** 0.01 |
| Acute index model + 8-fold UR classification | **1:** 0.02 **2:** -0.10 **3:** -0.08 **4:** -0.04 **5:** 0.04**6:** -0.11 **7:** -0.07 | **1:** 0.05**2:** -0.05**3:** -0.01**4:** 0.04**5:** 0.09**6:** -0.02**7:** -0.05 | **1:** -0.03**2:** -0.07**3:** -0.07**4:** -0.01**5:** 0.03**6:** -0.09**7:** -0.07 | **1:** -0.13**2:** -0.14**3:** -0.12**4:** -0.07**5:** 0.04**6:** -0.12**7:** -0.06 | **1:** -0.04**2:** -0.03**3:** -0.04 **4:** 0.06**5:** 0.07**6:** -0.04**7:** 0.01 | **1:** 0.04**2:** 0.02**3:** 0.05**4:** 0.17**5:** -0.04**6:** 0.04**7:** 0.13 | **1:** 0.04**2:** -0.04**3:** -0.03**4:** -0.06**5:** 0.03**6:** -0.01**7:** -0.02 |