

### **Appendix 3 (as supplied by the authors): Sensitivity analyses**

A number of sensitivity analyses were conducted to examine whether the manner in which conditions were counted or choice of condition might influence the effect of deprivation, physical multimorbidity or mental health. In all the additional models, there is at most a modest attenuation in the effect size of deprivation, supporting the argument that although clinical conditions and health behaviours may vary to some degree with deprivation, deprivation still appears to convey additional hospitalisation risk. However, there may still be other unmeasured health factors such as disease severity which account for at least some of the deprivation effect. Using alternative physical condition counts resulted in little change in the magnitude of effect size for physical multimorbidity. Of note, increasing numbers of “non-serious” physical conditions still conveyed additional risk, over and beyond that of “serious” conditions. Furthermore, the effect of multimorbidity persisted (albeit considerably attenuated) even after adjustment for individual conditions. Finally, recoding mental health as a count rather than yes/no variable demonstrated a noticeable increase in admission risk for  $\geq 2$  mental health conditions. The additional models are shown below in the accompanying Table A and Table B; further details and interpretation of each of the models as given after the tables.

**Table A. Sensitivity analyses – unplanned admissions**

Covariate	Model using simple count of physical conditions (Original model) <sup>a</sup>	Model using separate behavioural risk factors <sup>b</sup>	Model using modified original Charlson weightings <sup>c</sup>	Model using separate counts of “serious” and “non-serious” conditions <sup>d</sup>	Model using count of mental health conditions <sup>e</sup>	Model including all separate physical and mental health conditions <sup>f</sup>
Male gender	1.22 (1.17-1.27)	1.16 (1.11-1.21)	1.15 (1.1-1.2)	1.2 (1.15-1.25)	1.23 (1.18-1.28)	1.08 (1.04-1.13)
Age (years)						
20-34	1.15 (1.05-1.24)	1.18 (1.08-1.28)	1.02 (0.94-1.11)	1.15 (1.06-1.24)	1.15 (1.05-1.24)	1.11 (1.02-1.2)
35-44	1.03 (0.95-1.12)	1.04 (0.96-1.13)	0.97 (0.89-1.05)	1.02 (0.94-1.11)	1.03 (0.95-1.12)	1.01 (0.93-1.1)
45-54	Reference	Reference	Reference	Reference	Reference	Reference
55-64	1.12 (1.04-1.21)	1.14 (1.06-1.23)	1.18 (1.09-1.27)	1.12 (1.04-1.21)	1.13 (1.05-1.22)	1.13 (1.05-1.23)
65-74	1.41 (1.30-1.52)	1.47 (1.36-1.59)	1.5 (1.39-1.62)	1.38 (1.28-1.49)	1.43 (1.32-1.55)	1.36 (1.25-1.47)
75+	2.59 (2.40-2.79)	2.87 (2.67-3.10)	2.72 (2.52-2.93)	2.59 (2.4-2.79)	2.64 (2.45-2.85)	2.38 (2.19-2.59)
Scottish Index of Multiple Deprivation quintile						
1	Reference	Reference	Reference	Reference	Reference	Reference
2	1.08 (1.00-1.18)	1.07 (0.98-1.16)	1.07 (0.99-1.16)	1.06 (0.98-1.15)	1.08 (1-1.18)	1.06 (0.98-1.15)
3	1.23 (1.13-1.33)	1.19 (1.10-1.29)	1.22 (1.13-1.32)	1.18 (1.09-1.28)	1.22 (1.13-1.32)	1.18 (1.09-1.28)
4	1.32 (1.21-1.43)	1.25 (1.15-1.35)	1.3 (1.2-1.41)	1.25 (1.15-1.35)	1.31 (1.21-1.42)	1.25 (1.15-1.35)
5	1.56 (1.43-1.70)	1.41 (1.30-1.54)	1.55 (1.42-1.68)	1.44 (1.33-1.57)	1.54 (1.42-1.68)	1.43 (1.31-1.56)
Physical condition count						
0	Reference	Reference	Reference	Reference	Reference	} Reference
1	1.70 (1.59-1.82)	1.68 (1.57-1.79)	2.19 (2.07-2.32)	2.1 (1.98-2.22)	1.69 (1.58-1.8)	
2	2.69 (2.50-2.89)	2.66 (2.47-2.86)	3.38 (3.16-3.61)	3.11 (2.91-3.33)	2.66 (2.47-2.86)	1.65 (1.53-1.78)
3	3.47 (3.21-3.76)	3.44 (3.18-3.73)	4.21 (3.88-4.57)	4.38 (4.05-4.73)	3.42 (3.16-3.7)	1.73 (1.57-1.9)
≥4	5.87 (5.45-6.32)	5.90 (5.48-6.36)	6.07 (5.58-6.61)	6.23 (5.74-6.76)	5.77 (5.36-6.22)	1.72 (1.5-1.97)
“Non-serious” condition count						
0	-	-	-	Reference	-	-
1	-	-	-	1.22 (1.15-1.29)	-	-
2	-	-	-	1.34 (1.25-1.43)	-	-
3	-	-	-	1.53 (1.4-1.66)	-	-
≥4	-	-	-	1.66 (1.5-1.84)	-	-
Alcohol misuse	-	2.30 (2.13-2.47)	-	-	-	2.36 (2.18-2.56)
Drug misuse	-	1.39 (1.25-1.56)	-	-	-	1.49 (1.33-1.68)
Mental health condition count						
0	Reference	Reference	Reference	Reference	Reference	} Reference
1 / ≥1	2.01 (1.92-2.09)	1.66 (1.59-1.74)	2.08 (2-2.17)	1.94 (1.86-2.02)	1.75 (1.66-1.84)	
≥2	-	-	-	-	2.59 (2.44-2.75)	0.86 (0.78-0.96)

**Table B. Sensitivity analyses – potentially preventable unplanned admissions**

Covariate	Model using simple count of physical conditions (Original model) <sup>a</sup>	Model using separate behavioural risk factors <sup>b</sup>	Model using modified original Charlson weightings <sup>c</sup>	Model using separate counts of “serious” and “non-serious” conditions <sup>d</sup>	Model using count of mental health conditions <sup>e</sup>	Model including all separate physical and mental health conditions <sup>f</sup>
Male gender	1.26 (1.15-1.38)	1.19 (1.08-1.30)	1.16 (1.06-1.27)	1.21 (1.1-1.32)	1.27 (1.16-1.39)	1.14 (1.03-1.26)
Age (years)						
20-34	1.34 (1.09-1.67)	1.37 (1.10-1.7)	1.11 (0.90-1.37)	1.33 (1.08-1.65)	1.35 (1.09-1.67)	1.19 (0.96-1.47)
35-44	1.07 (0.87-1.33)	1.07 (0.86-1.33)	0.96 (0.78-1.19)	1.05 (0.85-1.3)	1.06 (0.86-1.32)	1.01 (0.81-1.25)
45-54	Reference	Reference	Reference	Reference	Reference	Reference
55-64	1.22 (1.01-1.46)	1.24 (1.03-1.49)	1.32 (1.10-1.58)	1.2 (1-1.45)	1.23 (1.02-1.48)	1.28 (1.06-1.54)
65-74	1.56 (1.30-1.87)	1.65 (1.38-1.98)	1.75 (1.46-2.09)	1.51 (1.26-1.8)	1.6 (1.33-1.91)	1.61 (1.34-1.94)
75+	2.39 (2.01-2.84)	2.73 (2.29-3.25)	2.64 (2.22-3.13)	2.4 (2.02-2.86)	2.45 (2.06-2.91)	2.63 (2.18-3.19)
Scottish Index of Multiple Deprivation quintile						
1	Reference	Reference	Reference	Reference	Reference	Reference
2	1.33 (1.10-1.61)	1.33 (1.10-1.62)	1.31 (1.08-1.59)	1.27 (1.05-1.54)	1.33 (1.1-1.61)	1.27 (1.05-1.54)
3	1.62 (1.35-1.94)	1.59 (1.32-1.91)	1.62 (1.35-1.94)	1.51 (1.26-1.82)	1.62 (1.34-1.94)	1.48 (1.23-1.78)
4	1.63 (1.34-1.97)	1.53 (1.26-1.86)	1.6 (1.32-1.94)	1.46 (1.21-1.77)	1.62 (1.33-1.96)	1.43 (1.18-1.74)
5	1.98 (1.63-2.41)	1.76 (1.45-2.15)	1.97 (1.62-2.39)	1.72 (1.42-2.09)	1.96 (1.61-2.38)	1.64 (1.34-1.99)
Physical condition count						
0	Reference	Reference	Reference	Reference	Reference	} Reference
1	2.50 (2.07-3.03)	2.45 (2.03-2.97)	3.75 (3.27-4.3)	3.74 (3.19-4.38)	2.48 (2.05-3)	
2	4.93 (4.06-5.99)	4.83 (3.97-5.86)	5.15 (4.42-6)	7.08 (5.96-8.4)	4.86 (4-5.91)	2.2 (1.85-2.61)
3	6.82 (5.55-8.37)	6.67 (5.43-8.20)	6.76 (5.66-8.06)	11.93 (9.93-14.33)	6.69 (5.44-8.21)	2.38 (1.95-2.92)
≥4	14.38 (11.87-17.43)	14.29 (11.80-17.32)	11.79 (9.95-13.97)	19.59 (16.29-23.54)	14.07 (11.61-17.06)	2.63 (2.03-3.41)
“Non-serious” condition count						
0	-	-	-	Reference	-	-
1	-	-	-	1.12 (0.99-1.27)	-	-
2	-	-	-	1.15 (0.99-1.33)	-	-
3	-	-	-	1.31 (1.1-1.55)	-	-
≥4	-	-	-	1.3 (1.05-1.59)	-	-
Alcohol misuse	-	2.04 (1.75-2.38)	-	-	-	2.02 (1.71-2.4)
Drug misuse	-	1.44 (1.14-1.83)	-	-	-	1.43 (1.11-1.85)
Mental health condition count						
0	Reference	Reference	Reference	Reference	Reference	} Reference
1 / ≥1	1.80 (1.64-1.97)	1.48 (1.35-1.63)	1.88 (1.71-2.06)	1.7 (1.55-1.87)	1.54 (1.38-1.71)	
2	-	-	-	-	2.36 (2.09-2.67)	1.05 (0.84-1.32)

Additional details of models presented in Tables A and B of Appendix 3, labelled *a* through *f*:

- a. The original multivariable models are presented to facilitate comparison (duplicated from Table 2 and Table 3)
- b. Models were constructed to examine whether behavioural factors which one might expect to be associated with deprivation, are driving the observed association between hospitalisation and deprivation. This was done by including alcohol misuse, drug misuse, and smoking status as additional binary factors (removing the first two from the binary mental health variable). A 6-category index of urban-rural status (not shown) was also included to examine whether proximity to hospitals and access to services might account for the observed association. There was a positive association between smoking and hospitalisation (unplanned admissions OR 1.30, 1.24-1.37 ( $p < 0.001$ ); potentially preventable unplanned admissions OR 1.41, 1.27-1.57 ( $p < 0.001$ ). There was no evidence of an association between urban-rural index and admissions ( $p = 0.7$  and  $p = 0.3$  for unplanned and potentially preventable unplanned admissions respectively). There is a small attenuation in the effect size of deprivation, supporting the argument that although clinical conditions and health behaviours may vary to some degree with deprivation, deprivation still appears to convey additional hospitalisation risk. In addition, the effect size of the presence of any of the remaining six mental health conditions was attenuated somewhat, suggesting that alcohol misuse in particular may be particularly important.
- c. Further models were constructed replacing the simple physical condition count with a weighted count of certain conditions based on the original Charlson Index. This index is weighted based on mortality. A pragmatic approach was used in developing modified weightings, as the list of conditions included in the Charlson Index is not concordant with the list of 32 physical conditions included in our own analysis. For example, we cannot include HIV/AIDS (albeit rare in Scotland, and probably less strongly associated with admission since highly active anti-retroviral therapy use became routine), and are unable to distinguish solid/blood cancers, severity of liver disease, complications of diabetes, or hemiplegia resulting from stroke. The following conditions were included to create a weighted count (weightings in brackets as per the original Charlson Index): ischaemic heart disease (1), heart failure (1), stroke (1), dementia (1), COPD (1), connective tissue/rheumatological conditions (1), viral hepatitis or chronic liver disease (1), diabetes (1), chronic kidney disease (2) and cancer (2). In the revised models, the effect size of both weighted physical condition counts was of a similar magnitude to that observed in the original models. In addition, the association with deprivation was virtually unchanged.
- d. Additional models were constructed by separating the single physical condition list into two individual counts of physical conditions, one “serious” and one “non-serious”, based on expert clinical opinion. The following conditions were considered “serious”: bronchiectasis, viral hepatitis, Parkinson’s disease, multiple sclerosis, chronic liver disease, epilepsy, inflammatory bowel disease, heart failure, chronic kidney disease, peripheral vascular disease, stroke, cancer, diabetes, asthma, ischaemic heart disease, COPD, connective tissue/rheumatological conditions and pain. These again showed similar results to the original models (in particular physical condition count and

deprivation). Interestingly, increasing numbers of non-serious conditions still has a moderately large effect on hospitalisation, even after adjusting for serious conditions. Further models were constructed using only the “serious condition” count, but showed similar findings and are not reported.

- e. Alternative models were constructed including a mental health condition count of 0, 1, or  $\geq 2$  conditions (as opposed to the simple binary variable used in the original models). This demonstrated a noticeable increase in admission risk for 2 mental health conditions, compared with a single condition. This difference persisted when substance and alcohol misuse was included added, although effect sizes were again attenuated somewhat (models not shown).
- f. Finally, models were constructed including all 40 clinical conditions as separate fixed covariates. Odds ratios for individual conditions (except alcohol/drug misuse) are not reported. Physical condition count was recoded with 0 or 1 condition as the reference category. Mental health was recoded as a binary variable, but with 0 or 1 condition as the reference category, and  $\geq 2$  conditions as the comparator group. Unsurprisingly, the effect of including all conditions in the model markedly attenuates the effect size of physical condition count, but it is evident that multimorbidity still appears to convey risk above and beyond the effect of individual conditions. Furthermore, the effect of deprivation remains considerable. Of note, with respect to mental health conditions, in both unplanned and potentially preventable unplanned models alcohol appeared to have a larger effect (OR 2.35 and 2.02 respectively). However, the effect of the other mental health factors was largely consistent, with the OR ranging from 1.29 to 1.43 for unplanned admissions, and 1.42 to 1.75 for potentially preventable unplanned admission (the exception was learning difficulties with an OR of 0.93, 0.67-1.33, for potentially preventable unplanned admissions only, although this may reflect uncertainty in the estimate due to small numbers).