

**CURRENT AND PROJECTED FINANCIAL BURDEN OF EMERGENCY GENERAL  
SURGERY FOR ADULTS IN SCOTLAND'S SINGLE PAYER HEALTHCARE SYSTEM:  
A COST ANALYSIS OF HOSPITAL ADMISSIONS**

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## INTRODUCTION

Emergency General Surgery (EGS) is an important acute care service, which demands significant healthcare resources.<sup>1</sup> In Scotland, there were 81,446 EGS admissions involving 66,498 patients in 2016,<sup>2</sup> thus, based on unadjusted population estimates, the UK-wide figure may be nearly 1 million annual EGS admissions. National Health Service (NHS) costs are increasing,<sup>3</sup> while the number of EGS admissions are also increasing over time,<sup>4</sup> associated with an ageing demographic.<sup>5</sup> Though several studies have examined population-based EGS outcomes in Scotland,<sup>2,4,6-8</sup> and England,<sup>9</sup> no study has evaluated the costs of EGS in the UK, with its single-payer National Health Service, or estimated future financial burden.

EGS epidemiology<sup>10-11</sup> and cost<sup>12-14</sup> are now well-established in the literature in the context of the United States (US). In the US, there were an estimated 2.3 million EGS admissions in 2009,<sup>10</sup> and 27.7 million admissions between 2001 and 2010, representing 7.1% of all hospital admissions, with a population-adjusted case rate of 1,290 admissions/100,000 people.<sup>11</sup> Furthermore, over the course of a decade, EGS admissions in the US increased by 27.5% and operations by 32.3%.<sup>11</sup> The mean cost per EGS admission in the US (which required an operation within 2 days of admission) was \$13,241 between 2008 and 2011.<sup>12</sup> Nation-wide costs are projected to increase substantially, by 45%, from \$28.4 billion in 2010 to \$41.2 billion by 2060, largely due to an ageing US population.<sup>15</sup>

There are major differences in the structure and financing of healthcare between the UK, with its single-payer National Health Service, and the United States. The impact of these differences on the future financial burden of EGS is important to the public, healthcare providers, and decision makers, in both countries. The aim of this study was to calculate the current and projected financial burden of EGS hospital admissions in Scotland.



## METHODS

### Population

Population estimates from 2016 to 2041 were obtained from the National Records of Scotland ~~(NRS)~~, overall and for each age group. Estimates obtained included a principal projection (best-estimate), a high population estimate (in the event of high fertility, high migration and high life expectancy), and a low population estimate (low fertility, low migration and low life expectancy).<sup>16</sup>

### EGS admissions

Data including all Scottish EGS hospital admissions between 1997 and 2016, coded by ICD-10 (International Statistical Classification of Diseases and Related Health Problems 10th Revision) were obtained from Information Services Division (ISD).<sup>4,17</sup> An EGS episode was defined as **an unplanned (emergency) admission of a** patient aged 16 years or older, to a Scottish hospital, under the care of a consultant general surgeon.<sup>4</sup> **A “general surgeon” refers to surgeons who hold a “Certificate of Completion of Training” in general surgery, as captured by the “C1” specialty code in the database held by the Information Services Division of the Scottish Government.** Anonymized data were transferred to the Data Safehaven (DaSH) of the University of Aberdeen for analysis. Annual EGS admissions were determined by our previous work, which examined secular trends in EGS admission rates per 100,000 population over a 20-year time period.<sup>4</sup> Incidence rates for each sex and age group (16-30, 31-45, 46-60, 61-75, >75), for individual conditions and EGS admissions overall, were determined and linear regression (using an ordinary least squares [OLS] regression model) was used to estimate the future incidence rates of EGS admissions,

projected to 2041, using SPSS (IBM Corporation, Armonk, NY). The full model specification is provided in Equation 1 (Supplementary Material).

### **Length of Hospital Stay**

An OLS linear regression model was initially considered to project historical trends in length of hospital stay (LOS) into the future. This model generated implausible results, as by 2041, the length of stay for several age and sex groups fell below zero, reflecting the downward trend in observed LOS. Therefore, we used an exponential function, to extrapolate the historical trend data for each sex and age group. The exponential function is advantageous because it is the best statistical fit to the historical data, and it generated the most clinically plausible future projections, capturing a continuing reduction in LOS, but at a reducing rate over time. The calculations of annual LOS out to 2041 were performed in Excel (Microsoft, Redmond, Washington, USA), and the underlying formulae are provided in Equation 2 (Supplementary Material).

### **Cost Per Bed Day**

Historical hospital costs data (unit cost per bed day) were obtained from ISD from 2000 to 2017,<sup>18</sup> and were also projected to 2041, using an OLS linear regression model (Equation 3, Supplementary Material). ISD produces a detailed annual document describing costs of acute inpatient specialties by hospital, NHS board, and specialty which incorporates the cost of nursing, medical, pharmacy, allied healthcare professionals, theatre, laboratory, and length of hospital stay. From this, the cost per bed day is derived for each specialty, and we have used the value for General Surgery (excluding Vascular Surgery) from 2000 to 2017.<sup>18</sup> The calculation for discounted costs per bed day are shown in supplementary material (Equation 4).

### **Projected EGS Cost**

The projected annual cost of EGS admissions was derived from multiplying the expected number of EGS admissions (projected population multiplied by admission rate for each age and sex group), by the admission cost per patient (projected cost per bed day, multiplied by expected LOS for each age and sex group), according to Equation 5 (Supplementary Material). The total annual EGS cost was calculated by adding the projected cost of each age and sex subgroup for each year.

### **Sensitivity analysis**

A range of sensitivity analyses were carried out to test the impact of the base case calculation assumptions on total cost projections.

First, there is uncertainty regarding the impact of future population projections on admission rates, and hence costs as the true value will depend on unknown political and economic shocks that are as yet unobserved, but may impact on future population estimates. Therefore, the low and high population estimates from National Records for Scotland were used in sensitivity analysis to cover the most likely range of future possibilities regarding population growth (by age and sex group).<sup>16</sup>

Secondly, length of stay projections are heavily influenced by historical trends. Any future constraints on the availability of community and social care that were not observed by the last historical data point (2016) would not be accounted for in the exponential extrapolations. For example, the more elderly group in society may not experience a reduction in LOS if suitable discharge facilities are not available. Therefore, we conducted a sensitivity analysis where the LOS observed in 2016 remains unchanged into the future for each age and sex group, for comparison.

Thirdly, the base case analysis projects future costs according to the cost value in the year when costs are incurred (**“nominal” cost projections**). For example, the projected costs in 2035 are in 2035 values. However, as a society, we place less value on costs that occur into the future, and one may be indifferent between spending £100 now or £105 in a years’ time. In this case the annual discount rate would be 5%. To make healthcare decisions, decision making bodies such as the National Institute for Health and Care Excellence (NICE) consider the time value of money, and make cost-effectiveness decisions based on future costs being discounted to present day values.<sup>19</sup> To capture the impact of discounting on our findings, sensitivity analysis discounts future costs to present values at a rate of 3.5% per annum, in accordance with NICE recommendations (**“real” cost projections**).<sup>19</sup> The discounting formula applied can be found in Equation 4 (Supplementary Material).



## RESULTS

### Population

The adult (aged >15) population of Scotland is projected to increase from 4.5 million to 4.8 million in the principal projection, to 5.1 million in the high projection, and remain 4.5 million in the low projection (Figure 1, Panel A). Between 2016 and 2041, based on the principal, high and low projections, the population of those aged 16-30 will change by -8.0%, +0.8%, or -16.2%, with compound annual growth rates (CAGR) of -0.3%, 0.0%, and -0.7%, respectively; those aged 31-45 will change by -0.3%, +8.3%, or -9.0% (CAGR 0.0%, 0.3%, -0.4%), respectively; those aged 46-60 will change by -4.0%, +0.1%, or -8.2% (CAGR -0.2%, 0.0%, -0.3%), respectively; those aged 61-75 will change by +13.5%, +16.0%, or +10.4% (CAGR 0.5%, 0.6%, 0.4%), respectively; and those aged >75 will change by +79.8%, +89.3%, or +65.9% (CAGR 2.4%, 2.6%, 2.0%) (Figure 1, Panels B-D).

### EGS Admissions

EGS admissions projections incorporate the change in population and changes in age- and sex-stratified admissions rates. EGS admissions of adults in Scotland are projected to increase between 2016 and 2041, from 83 132 adults (>15) to 101 909 in the principal projection (+22.6%, CAGR 0.8%), to 108 047 in the high projection (+30.0%, CAGR 1.1%), and 95 386 in the low projection (+14.7%, CAGR 0.6%), respectively (Figure 2, Panel A). See Table 1 (Supplementary Material) for age- and sex-specific projections, and CAGR. The number and rate of admissions by gender and age group per 100,000 population, as well as the age- and sex-standardised rates per 100,000 population, from 1997-2016, using this data has been published previously by our group.<sup>4</sup>

### Length of Hospital Stay

By 2041, the mean length of stay of EGS patients, is projected to reduce for each age and sex group with the most marked reduction expected to take place in the elderly population: LOS in females aged >75 is projected to decrease from 5.1 days in 2016 to 2.0 days in 2041, and LOS in males aged >75 from 3.8 days to 1.5 days (Figure 3).

### Cost per Bed Day

Based on our extrapolations, the undiscounted **nominal** cost of EGS patients per bed day is anticipated to increase from £786 in 2016, to £1534 by 2041 (95.2% 25-year increase, 2.71% CAGR), while the undiscounted (real) cost is anticipated to decrease to £695 (11.5% decrease, -0.49% CAGR)(Figure 4).

### EGS Cost Projection

Our primary outcome, the cost of EGS in Scotland projected to 2041, is presented based on high, principal and low population projections (Figure 5). Panel A shows the undiscounted **(nominal)** projections, assuming future LOS is determined using an exponential extrapolation of historical trends. Panel A shows that from £187.3 million in 2016, the projected **nominal** cost of EGS hospital care for Scottish adults is projected to increase to £202.5 million in the principal population projection (CAGR 0.3%), to £214.1 million in the high population projection (CAGR 0.5%), and will increase to £189.3 million in the low population projection (CAGR 0.0%).

### Sensitivity Analyses

Figure 5, panel B illustrates the impact of assuming that there are no further decreases in average LOS for each age and sex group beyond the mean LOS observed in 2016. **Because this overall EGS cost equation uses observed LOS in 2016, as opposed to calculated LOS via**

exponential equations, for each age/gender category, the 2016 values differ. Therefore, instead of £187.3 million, the cost for 2016 using observed LOS values is £157.8 million. By 2041, the total annual **nominal** cost of EGS care is projected to increase to £398.1 million in the principal population projection (CAGR 3.8%), to £418.9 million in the high population projection (CAGR 4.0%), and to £373.4 million in the low population projection (CAGR 3.5%)(Panel B).

When a 3.5% annual discount rate is applied to represent these future projections in present day values, annual discounted (**real**) costs are projected to be £91.8 million in the principal population projection (CAGR -2.8%), £97.0 million in the high population projection (CAGR -2.6%), and £85.8 million in the low population projection (CAGR -3.1%)(Figure 5, Panel C). Finally, when applying discounting to the assumption that future average LOS will remain unchanged from 2016, the **real** cost by 2041 could equal £180.4 million in the principal population projection (CAGR 0.5%), £189.9 million in the high population projection (CAGR 0.7%), and £169.2 million in the low population projection (CAGR 0.3%)(Figure 5, Panel D).

## DISCUSSION

This is the first study to examine the current and projected financial burden of emergency general surgery hospital admissions in the context of a single-payer healthcare system, using high-quality, population-based, patient-level Scottish data. Given the increasing concerns regarding the cost of healthcare, and the impact of different models of funding health services, these data are timely.

We found that the **nominal** cost of EGS admissions in Scotland's National Health Service will, most likely, increase only modestly, from £187.3 million in 2016 to £202.5 million in 2041, **if LOS reduction continues. However, discounting to 2016 values, and assuming LOS remains static from 2016 figures, EGS cost would be £180.4 million in the principal projection, which also increases modestly from £157.8 million and a CAGR of 0.5%.** These findings contrast sharply with those of Ogola, *et al*, who calculated that the projected costs **(discounted to 2010 US Dollars)** of EGS hospitalizations in the United States – with its insurance-based healthcare system – will increase by 45% over the 40 years.<sup>15</sup> While health economic studies are notoriously difficult to compare, due to variations of healthcare systems, or differences in methodology of cost projections,<sup>15,20-23</sup> these results provide food for thought.

Our findings are corroborated by a number of sensitivity analyses, which confirm the robustness of our results, to a range of plausible assumptions around population growth projections, future trajectory of changes in LOS and the impact of discounting **(real)** projections to present day values. The most striking finding in the population projection is that, regardless of the low, principal, or high population projections, the population of those aged over 61 years old will dramatically increase between now and 2041. Our data projections assume a reduction in the length of stay among all age and sex groups.

However, the largest reduction is also predicted to occur in the elderly population. The mean LOS of EGS patients for each age and sex group has been decreasing.<sup>4</sup> The exponential extrapolations fitted to the historic data suggest a continuing reduction in average LOS but at a reducing rate over time. This captures a plateauing effect suggesting that it is unlikely that average LOS would fall below 1-2 days in any of the age groups by 2041. These exponential projections are used as the primary method because they are the best statistical fit to the historical data, and are the most clinically plausible (e.g. compared to a linear trend which would suggest negative LOS). This problem of linear future projections of LOS resulting in negative values was also identified by Kitazawa, *et al*, who utilised several models including fixed, linear, logarithmic, and a combination of these methods for estimation of future prediction.<sup>23</sup>

In our study, the latest (2016) mean LOS for each age and sex group are used in sensitivity analyses, as well as using discounted (real) values. With no further reduction in LOS, the nominal cost may increase to £398.1 million in the principal scenario, with a CAGR of 3.8%. Some readers may attribute more worth to this 'no-change' LOS, as well as the standard discounted (real) values, as a more likely projection scenario, as mentioned above, with EGS costing £180.4 million in the principal projection, a modest increase from £157.8 million and a CAGR of 0.5%. Finally, in the event that LOS continues to reduce in an exponential manner, the discounted (real) cost of EGS is remarkably reduced to £91.8 million (CAGR - 2.8%) in the principal projection. Between 1963 and 2018, Scotland's Gross Domestic Product (GDP) grew at a CAGR of 1.97% {{163 Scottish Government Sept 18, 2019;}}. These results indicate that real (discounted) spend growth for EGS service will most likely be slower than GDP growth overall.

Our results suggest that the **nominal** cost per bed day will nearly double between 2016 and 2041. Base case results are undiscounted **(nominal)**, reflecting the projected annual cost over time (values in the year that they occur). As a sensitivity analysis, we explore the impact of using a 3.5% annual discount rate to discount **(real)** future costs to 2018 values. The discounting approach is provided for completeness and is in line with NICE recommendations for the methods of economic evaluation.<sup>19</sup> Recent similar studies have discounted costs<sup>15</sup> or cost of labour.<sup>23</sup> **Though undiscounted (nominal) cost per bed day increased significantly (CAGR 2.7%), the discounted (real) cost decreased (CAGR -0.5%). For comparison, historic GDP for Scotland over the past 55 years, had a CAGR 1.97%.<sup>24</sup> The annual UK public healthcare expenditure overall may increase from £177.2 billion to £314.40 billion (CAGR 2.7%) between 2016 and 2041 using an undiscounted (nominal) projection, and decrease to £158.2 billion (CAGR -0.45%) using a 3.5% discounted (real) projection.<sup>18</sup>**

### **Limitations**

There are several limitations to this study. First, our projection was derived from historical data to inform future estimates of Scottish population, EGS admissions, length of hospital stay and costs per bed day. Thus, any, as yet unobserved factors that may have a future effect on these parameters will impact on the accuracy of the overall projection. It is probably unlikely that secular trends of EGS admissions would drastically change between the preceding 20 years and the subsequent 20 years, however changes in incidence or in the management of certain conditions will have an effect on admissions,<sup>4</sup> for example as a result of novel evidence or guidelines.

**In addition, this work focuses on inpatient EGS admissions. Although many EGS diagnoses necessitate inpatient care, some may not. There are efforts to shift care delivery to**

substitute inpatient admissions with 'ambulatory' services, including 'surgical assessment units' and 'emergency day surgery'.<sup>25-27</sup> Therefore, our admission projections may underestimate future EGS services. These care episodes may represent a large and potentially dramatically growing form of EGS expenditure not captured by this analysis, which would nonetheless be of great importance to society and to policy-makers.

This relates also to our LOS estimates, as continued reduction of LOS is highly dependent on whether there is continued migration to non-inpatient care, which may make the sensitivity LOS analysis (2016 figures) the most accurate projection. Reductions in length of stay may be due to improvements in efficiency of diagnostic tests and imaging, or it may be due to recent pressures on the healthcare system which could lead to patients being offered discharge home earlier than if there were no pressure for inpatient beds. The exponential extrapolations will reflect this. However, evidence shows that there is a rising incidence of patients who are not discharged home,<sup>4</sup> and have prolonged stays in hospital due to shortages of suitable discharge facilities in the community (for example, rehabilitation, nursing homes, hospices, or awaiting occupational therapy interventions in patients' own homes).<sup>28</sup> Therefore, the 2016 LOS values may be seen as more accurate for the elderly patients in particular, or perhaps the LOS will even increase for this group of patients if investment is not allocated for greater community bed capacity.<sup>28</sup> Lastly, our results are very dependent on the cost per bed day, which includes the cost of staffing, operating rooms, pharmaceuticals, laboratory services, and consumable equipment.

## CONCLUSIONS

The spiralling cost of healthcare provision is a major issue. This analysis demonstrates that the **nominal** cost of **adult** EGS admissions in Scotland's National Health Service will, most likely, increase only modestly, between now and 2041. These findings contrast sharply with projections from other settings, and particularly those with insurance-based healthcare systems. However, these results are highly dependent on continued reduction in length of hospital stay. If length of stay trends were to plateau or increase, especially for elderly patients, the cost of EGS **would** rise dramatically.



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## FIGURES

**Figure 1:** Scotland's population projection from 2016-2041. Panel A: Principal, High and Low projections. Panel B: Principal projection by age and sex category. Panel C: High population projection by age and sex category. Panel D: Low population projection by age and sex category.

**Figure 2:** Scotland's EGS admissions projection from 2016-2041. Panel A: EGS admissions based on Principal, High and Low population projections. Panel B: EGS admissions based on Principal projection by age and sex category. Panel C: EGS admissions based on High population projection by age and sex category. Panel D: EGS admissions based on Low population projection by age and sex category.

**Figure 3:** Projected EGS Mean LOS for each age/sex group.

**Figure 4:** Projected EGS Cost per bed day, including undiscounted (nominal) and 3.5% discounted (real) values.

**Figure 5:** EGS Cost Projections 2016 to 2041, based on projections of population (Principal, High, and Low). Panel A: Undiscounted (nominal) and Exponential LOS calculation; Panel B: Undiscounted (nominal) and 2016 LOS values; Panel C: 3.5% Discounted (real) and Exponential LOS calculations; Panel D: 3.5% Discounted (real) and 2016 LOS values.

## SUPPLEMENTARY MATERIAL

**Equation 1.** Annual EGS Admissions

**Equation 2.** Length of Hospital Stay

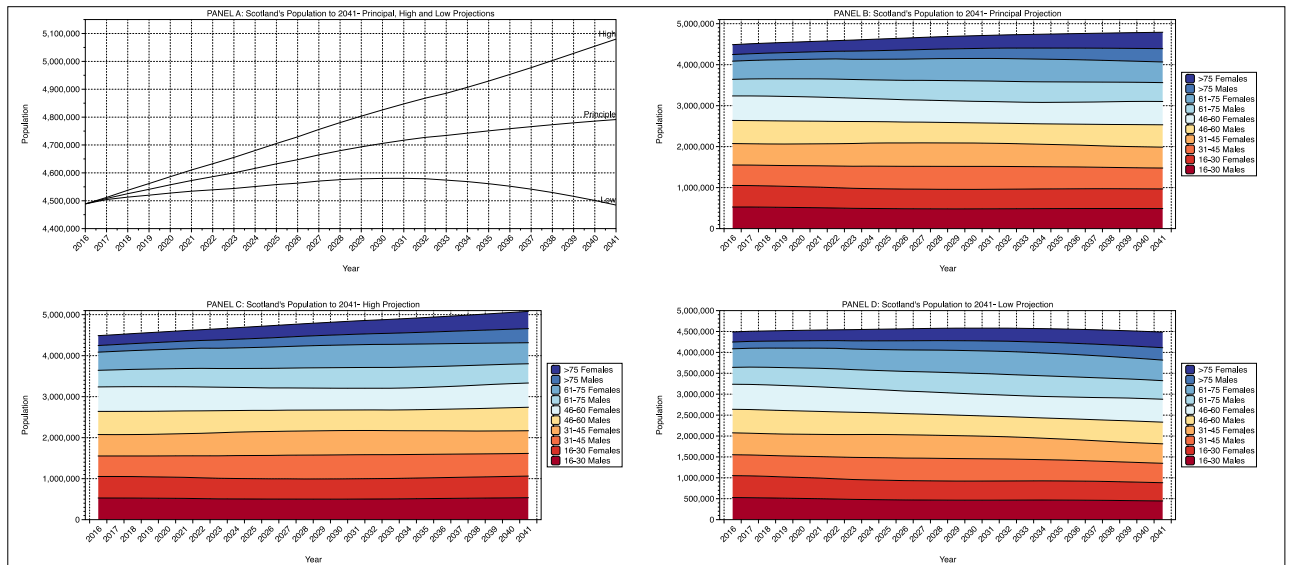
**Equation 3.** Cost per Bed Day

**Equation 4.** Discounted (real) Cost per Bed Day

**Equation 5.** Projected Annual EGS Cost

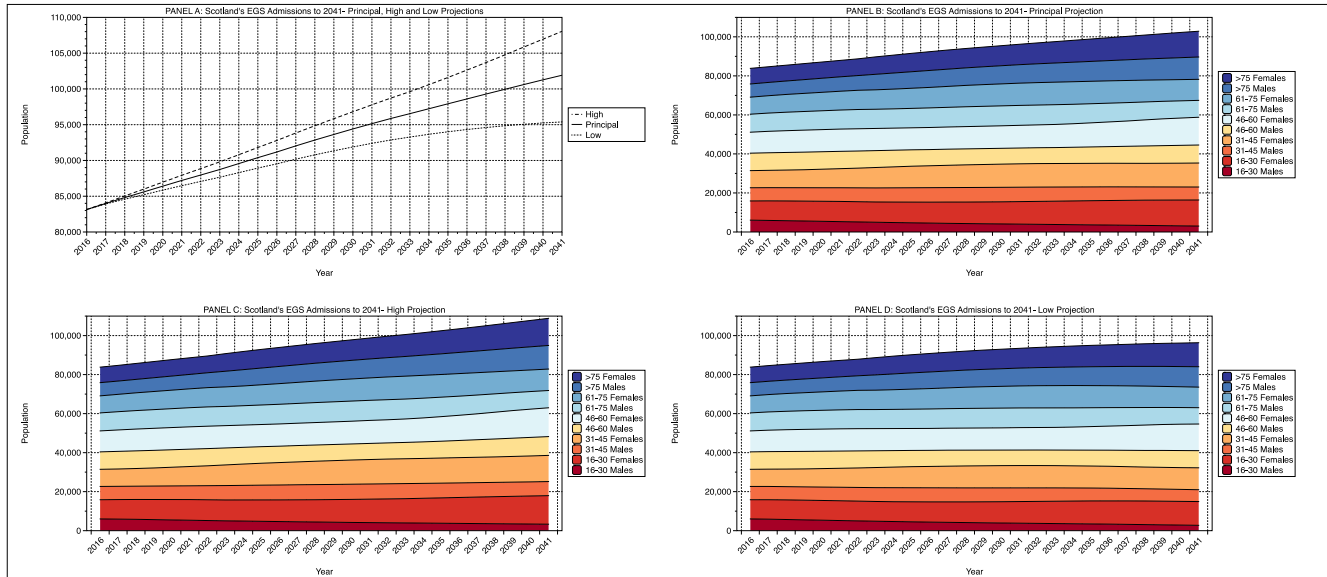
**Supplementary Table 1:** EGS admissions projection between 2016 and 2041, based on the principal, high and low population projections.

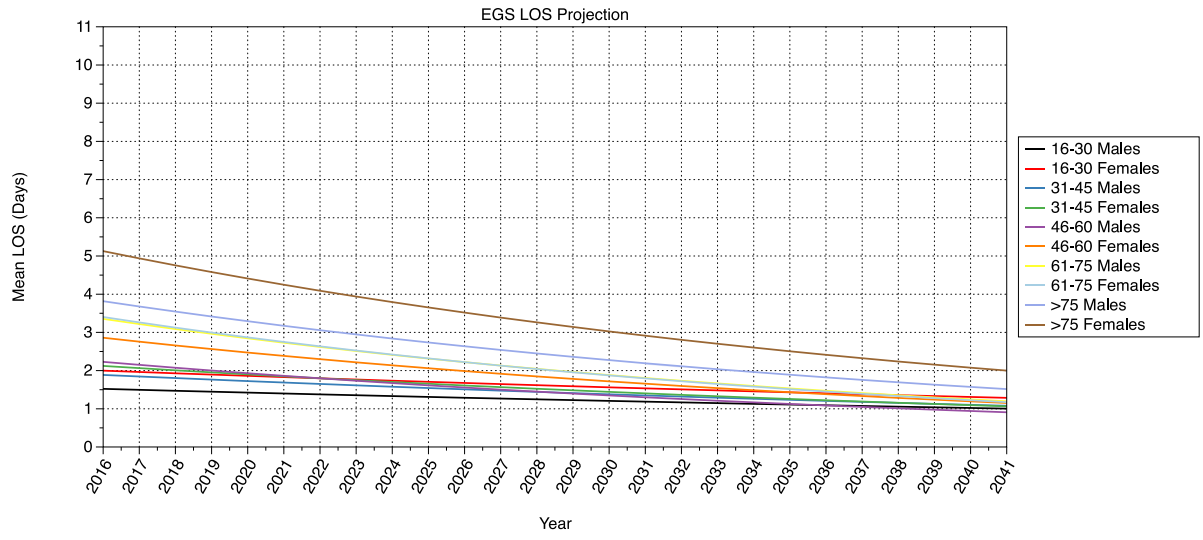
**Figure 1: Scotland’s population projection from 2016-2041. Panel A: Principal, High and Low projections. Panel B: Principal projection by age and sex category. Panel C: High population projection by age and sex category. Panel D: Low population projection by age and sex category.**

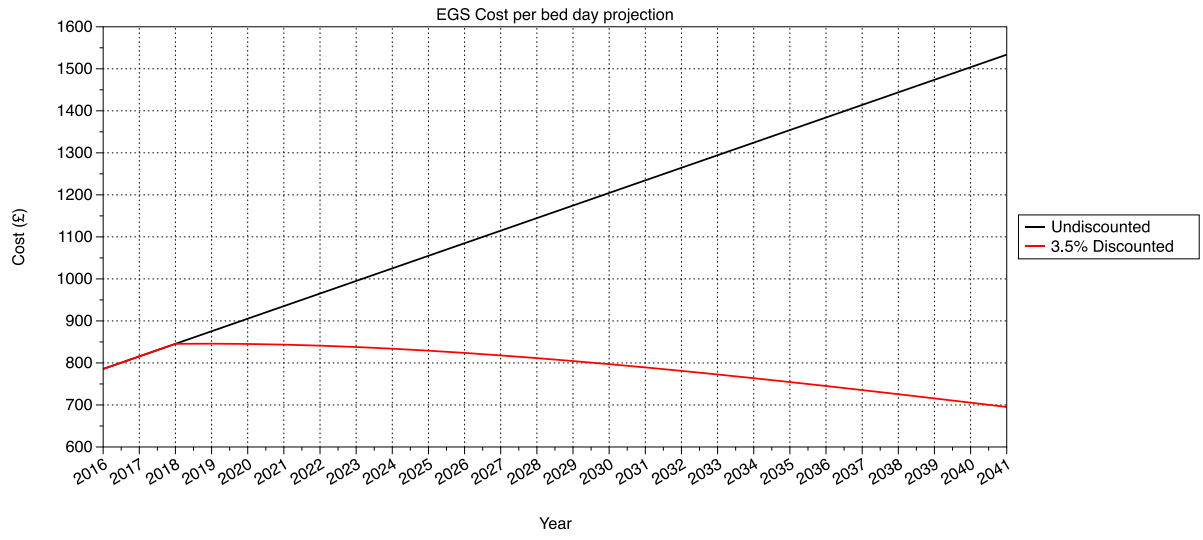




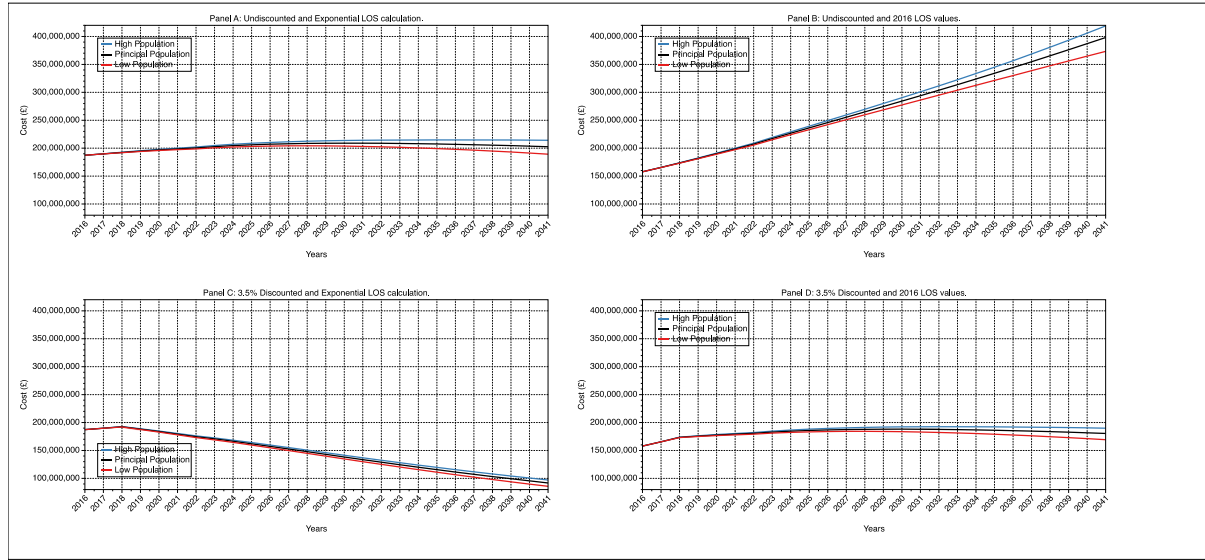
**Figure 2: Scotland’s EGS admissions projection from 2016-2041. Panel A: EGS admissions based on Principal, High and Low population projections. Panel B: EGS admissions based on Principal projection by age and sex category. Panel C: EGS admissions based on High population projection by age and sex category. Panel D: EGS admissions based on Low population projection by age and sex category.**







**Figure 5: EGS Cost Projections 2016 to 2041, based on projections of population (Principal, High, and Low). Panel A: Undiscounted (nominal) and Exponential LOS calculation; Panel B: Undiscounted (nominal) and 2016 LOS values; Panel C: 3.5% Discounted (real) and Exponential LOS calculations; Panel D: 3.5% Discounted (real) and 2016 LOS values.**



## SUPPLEMENTARY MATERIAL

### Equation 1. Annual EGS Admissions

$$Y = \alpha + \beta_1 X_1$$

Where Y, the dependent variable (number of EGS admissions), is a linear additive function of the model constant ( $\alpha$ ) and ( $X_1$ ), representing the additional effect of each subsequent historical year (between 1997 and 2016) on admissions. The model was used to generate future projections of EGS admission rates by multiplying the predicted admissions in any given future year (using the estimated co-efficients from Equation 1) by the predicted population in that year, divided by 100,000 (to get the rate per 100,000 general population). The analyses were repeated separately for each age (16-30, 31-45, 46-60, 61-75, >75) and sex (male, female) subgroup in the Scottish adult population.

### Equation 2. Length of Hospital Stay

To enable projections of length of stay into the future, a range of alternative functions were explored, fitted to the historical data between the years 1997 and 2016 (linear, exponential, logistical, polynomial). All analyses were fitted in Excel (Microsoft, Redmond, Washington, USA). The trend line that best fit the historical data (based on r squared) and also generated sensible future predictions (i.e was always non-negative in the future) was an exponential function. Thus, the exponential trend line function was calculated for each age (16-30, 31-45, 46-60, 61-75, >75) and sex (male, female) subgroup, and overall. Length of stay (y) in any future year X, was calculated using the fitted exponential equation for each subgroup:

<u>Age</u>	<u>Sex</u>	<u>LOS equation</u>	<u>R squared</u>
<u>All Adults (&gt;15)</u>	<u>All</u>	<u><math>y = 9E+29e^{-0.034x}</math></u>	<u>0.94447</u>
	<u>Male</u>	<u><math>y = 8E+26e^{-0.03x}</math></u>	<u>0.9369</u>

	<u>Female</u>	$y = 2E+33e^{-0.037x}$	<u>0.94988</u>
<u>16-30</u>	<u>All</u>	$y = 7E+13e^{-0.016x}$	<u>0.67969</u>
	<u>Male</u>	$y = 5E+14e^{-0.017x}$	<u>0.76892</u>
	<u>Female</u>	$y = 5E+15e^{-0.018x}$	<u>0.68126</u>
<u>31-45</u>	<u>All</u>	$y = 7E+21e^{-0.025x}$	<u>0.8784</u>
	<u>Male</u>	$y = 7E+19e^{-0.022x}$	<u>0.8678</u>
	<u>Female</u>	$y = 3E+24e^{-0.028x}$	<u>0.88235</u>
<u>46-60</u>	<u>All</u>	$y = 5E+31e^{-0.036x}$	<u>0.94866</u>
	<u>Male</u>	$y = 6E+31e^{-0.036x}$	<u>0.95067</u>
	<u>Female</u>	$y = 2E+32e^{-0.036x}$	<u>0.93714</u>
<u>61-75</u>	<u>All</u>	$y = 1E+37e^{-0.042x}$	<u>0.95764</u>
	<u>Male</u>	$y = 4E+36e^{-0.041x}$	<u>0.9525</u>
	<u>Female</u>	$y = 7E+37e^{-0.043x}$	<u>0.95767</u>
<u>&gt;75</u>	<u>All</u>	$y = 6E+33e^{-0.038x}$	<u>0.96001</u>
	<u>Male</u>	$y = 9E+32e^{-0.037x}$	<u>0.94926</u>
	<u>Female</u>	$y = 5E+33e^{-0.038x}$	<u>0.95916</u>

### Equation 3. Cost per Bed Day

$$Y_1 = \alpha + \beta X_1$$

Where  $Y$  is the dependent variable (cost per bed day of EGS admissions),  $\alpha$  is the y intercept of the model,  $X_1$  is the linear additive impact of each subsequent year between 2000 and 2017 on cost, and  $\beta$  is the slope. The rate of cost per bed day change (projected to 2041) was calculated in SPSS using the above regression results. In this case,  $\alpha$  was equivalent to -59533.051, and  $\beta$  was equivalent to £29.92.

### Equation 4. Discounted Cost per Bed Day

$$Yx = Cx(1 + r)^{-(x-2018)}$$

Where the dependent variable ( $Y$ ), discounted future cost per bed day, in a given year ( $x$ ), is a linear function of explanatory variables of the cost per bed day ( $C$ ), multiplied by the addition of 1 and the discounted rate ( $r$ ), to the negative power of the difference between

the year (x) minus the index discounted year, which was 2018. The discounted rate (r), was assumed to be 3.5% per annum in accordance with national economic evaluation guidelines and n represents the number of discount years.<sup>19</sup>

**Equation 5. Projected Annual EGS Cost**

$$EGS\ Cost_x = \Sigma(Population_{xjt} * Admission\ Rate_{xjt} * Cost\ Per\ Bed\ Day_x * LOS_{xjt})$$

Where (x) is the given year, (j) is the given gender, (t) is the given age category (ie males aged 16-30). We calculated undiscounted and 3.5% discounted cost projections, and incorporated low, principal and high population projections. LOS was calculated as either 2016 levels for each age/sex group, or calculated using Exponential Trendline function on Excel (Microsoft, Redmond, Washington, USA), according to Equation 2.

**Supplementary Table 1.** EGS admissions projection between 2016 and 2041, based on the principal, high and low population projections. \*CAGR= compound annual growth rate.

Admissions Projection	Age group	Sex	2016	2020	2025	2030	2035	2040	2041	% change (2016-2041)	CAGR*
Principal	All (>15)	M	37180	37480	37741	37952	37914	37777	37738	1.5%	0.1%
		F	47716	50672	54357	58118	61615	65031	65699	37.7%	1.3%
	16-30	M	6039	5446	4666	4093	3640	3120	3014	-50.1%	-2.7%
		F	9839	10281	10613	11334	12371	13221	13377	36.0%	1.2%
	31-45	M	6797	6917	7386	7456	7083	6694	6645	-2.2%	-0.1%
		F	8759	9519	11020	11893	12088	12217	12303	40.5%	1.4%
	46-60	M	8957	8953	8412	8124	8379	9149	9234	3.1%	0.1%
		F	10738	11353	11307	11498	12342	14003	14221	32.4%	1.1%
	61-75	M	9238	9640	9940	10228	9830	8809	8640	-6.5%	-0.3%
		F	8732	9457	10314	11281	11512	10882	10786	23.5%	0.8%
	>75	M	6751	7238	8486	9299	10192	11237	11440	69.5%	2.1%
		F	7993	8356	9426	10294	11446	12925	13235	65.6%	2.0%
High	All (>15)	M	37180	37732	38363	38966	39407	39998	40117	7.9%	0.3%
		F	47716	50985	55176	59536	63830	68520	69481	45.6%	1.5%
	16-30	M	6039	5522	4798	4237	3809	3388	3300	-45.4%	-2.4%
		F	9839	10441	10956	11780	12989	14383	14673	49.1%	1.6%
	31-45	M	6797	6974	7567	7797	7563	7259	7221	6.2%	0.2%
		F	8759	9580	11245	12393	12887	13255	13375	52.7%	1.7%
	46-60	M	8957	8975	8477	8252	8608	9545	9671	8.0%	0.3%
		F	10738	11375	11371	11630	12592	14479	14761	37.5%	1.3%
	61-75	M	9238	9661	9995	10325	9977	9016	8860	-4.1%	-0.2%
		F	8732	9474	10360	11364	11645	11074	10991	25.9%	0.9%
	>75	M	6751	7279	8603	9524	10573	11842	12098	79.2%	2.4%
		F	7993	8398	9541	10511	11815	13522	13887	73.7%	2.2%
Low	All (>15)	M	37180	37227	37105	36894	36330	35426	35212	-5.3%	-0.2%
		F	47716	50358	53520	56636	59263	61328	61674	29.3%	1.0%
	16-30	M	6039	5371	4534	3949	3474	2873	2749	-54.5%	-3.1%
		F	9839	10121	10269	10888	11768	12146	12174	23.7%	0.9%
	31-45	M	6797	6859	7204	7115	6602	6125	6066	-10.8%	-0.5%
		F	8759	9458	10794	11391	11287	11175	11226	28.2%	1.0%
	46-60	M	8957	8930	8346	7993	8144	8740	8781	-2.0%	-0.1%
		F	10738	11331	11241	11363	12086	13512	13664	27.3%	1.0%
	61-75	M	9238	9618	9880	10117	9650	8552	8367	-9.4%	-0.4%
		F	8732	9440	10266	11186	11353	10644	10530	20.6%	0.8%
	>75	M	6751	7196	8351	9014	9668	10363	10483	55.3%	1.8%
		F	7993	8312	9293	10017	10934	12056	12278	53.6%	1.7%



