Outcome of intensive care in the elderly

G. Djaiani and S. Ridley

Intensive Care Unit, Norfolk & Norwich Hospital, Brunswick Rd, Norwich NR1 3SR, UK

Summary

The long-term survival of elderly patients following critical illness in the United Kingdom has not previously been studied. The demographic (age, sex, diagnosis, severity of illness) and treatment details (admission type, length of treatment, prior surgery) of all critically ill patients aged over 70 years were recorded. The 1-year survival of such patients was measured and compared with that of a matched normal population. Of 474 patients aged over 70 years, 88 patients died on the intensive care unit (19% mortality) and a further 133 died within 1 year (total mortality 47%). The 1-year survival of patients aged < 85 years was 56% which was significantly better than that of patients over 85 years (27%). The survival of all critically ill elderly patients was significantly poorer than that of a matched normal population (1-year survival 93%). Logistic regression revealed that age, diagnosis and severity of illness are independent predictors of 1-year survival.

Keywords *Intensive care. Age factors.*

Correspondence to: Dr George Djaiani, Senior Registrar, Department of Anaesthesia, Morriston Hospital, Swansea SA6 6NL, UK
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There is considerable interest in measuring the effectiveness of intensive care services. Such interest has focused on quantifying cost and outcome, as reflected by long-term survival and survivors' quality of life. The cost of intensive care is high, making the accurate prediction of mortality on the intensive care unit (ICU) and following discharge a worthwhile goal.

A large number of elderly patients are treated in ICU. They often have severe underlying chronic illnesses that influence their outcome [1–5]. The elderly (over 70 years old) comprised 13% of the UK population in 1994 [6] and this figure is increasing. Advances in surgical and medical technology, high safety standards in anaesthesia and an ageing population will increase the number of elderly patients using health care resources such as intensive care. In an era of managed health care in which budgets and contracts govern medical activities, the effect of intensive care on the elderly deserves to be examined and a scientific basis concerning patient selection and care established. There have been a few studies elsewhere in the world [5–9] examining the long-term survival after intensive care in elderly patients. However, the outcome of elderly patients following critical illness in the UK is unknown and the prognostic features determining their long-term survival are not clear.

Therefore, the aims of this study were to examine the 1-year survival of critically ill elderly patients, to compare the survival of such patients to an age- and sex-matched normal population and to identify the most salient clinical features which determined 1-year survival.

Methods

All patients aged over 70 years admitted to ICU at the Norfolk and Norwich Hospital between 1 April 1993 and 31 March 1995 were studied. At the time of admission demographic details (age, sex, diagnosis, acute physiology score (APS) and number of chronic health evaluation (CHE) points) and treatment details (type of admission [planned or unplanned], length of ICU management, surgery prior to ICU admission) were recorded. The APS and numbers of CHE points were derived from the three components of the patients' APACHE II scores (the third being a weighted score for age) [10]; the APS was calculated using variables measured within the first 24 h of admission and CHE points were allocated as defined by the APACHE II score. Patients' survival was followed until 1 April 1996: the minimum length of follow up was therefore 1 year for all patients. One year after admission, survival was checked by reviewing the patients' medical

Table 1 Demographic and treatment details of the patients studied. The APS score is the physiological component of the APACHE II score and CHE points were allocated according to the presence of (2 CHE points) or absence of (0 CHE points) chronic ill health for elective postoperative patients as defined by the APACHE II score. Five CHE points represent the combination of chronic ill health and either emergency surgery or nonoperative admission.

	Age group (years)			
	70–74	75–79	80–84	≥ 85
Number	193	128	109	44
Male: Female ratio	2:1	2.1:1	1.8:1	0.6:1
ICU mortality (%)	12	17	26	34
1 year mortality (%)	46.1	42.2	42.2	72.7
APS (median & 95% CI)	7 (5.8–8.1)	8 (6.9–9.0)	7 (5.8–8.1)	9 (6.8–11.1)
CHE points [0: 2: 5] (%)	89: 3: 8	83: 4: 13	88: 4: 8	91: 0: 9
Planned: Unplanned (%)	33: 67	26: 74	18: 82	9: 91
Elective: Emergency surgery (%)	61: 39	48: 52	41: 59	37: 63
Surgery: No surgery (%)	78: 22	80: 20	85: 15	87: 13

records, by reviewing the hospital's information system and by contacting the general practitioners' surgeries by post. If the date of death could not be confirmed, then the patient was assumed to be alive. The 1-year survival of an age- and sex-matched normal population in East Anglia was obtained from death rates and population sizes supplied by the General Office for National Statistics over the same period [6].

Statistical analysis

The survival of patients was examined graphically using Kaplan–Meier survival curves censored at 1 year. As all patients were followed for a minimum of 1 year, differences in survival times were explored using the Wilcoxon rank sum test. When multiple comparisons were performed, the p value was adjusted downwards according to the formula $1 - (1 - \text{alpha})^c$ where c is the number of independent contrasts and alpha is set at 0.05. Best subset regression was used to identify demographic and treatment details which predicted 1-year survival most accurately. Binary logistic regression was used subsequently to develop a model to predict 1-year survival. These statistical analyses were performed using 'Minitab' version 11.12 software and an IBM compatible computer. The 95% confidence limits (95% CI) are shown in parentheses where appropriate.

Table 2 Different diagnostic groups of the patients recruited in the study. *n* (%)

	Age group			
Diagnostic group	70–74	75–79	80–84	≥ 85
Respiratory	41 (22)	30 (25)	23 (22)	14 (35)
Emergency aortic aneurysm	15 (8)	15 (13)	23 (22)	4 (10)
Elective aortic aneurysm	22 (12)	12 (10)	13 (12)	1 (3)
Sepsis	7 (4)	13 (11)	8 (7)	4 (10)
Trauma	17 (9)	9 (8)	6 (6)	3 (7)
Head injuries	12 (7)	5 (4)	2 (2)	0
Gastrointestinal	58 (32)	30 (25)	25 (24)	12 (30)
Cardiac arrest	11 (6)	5 (4)	5 (5)	2 (5)

Results

Patients

During the 2-year study period 474 patients aged over 70 years were admitted. The demographic details of these patients are shown in Table 1.

During the study period, 88 patients died on ICU (18.6% mortality) and a further 133 died within 1 year (total number of deaths 221, 46.6% 1-year mortality). The different diagnostic groups of the patients enrolled are shown in Table 2.

Survival

The patients were stratified by age into four groups (70–74 years, 75–79, 80–84, ≥85) and their 1-year survival is shown in Table 3. There was no significant difference between the 1-year survival of patients aged less than 85 years. However, the 1-year survival of those over 85 years old was significantly poorer than the other three groups (27.3% (95% CI: 14.2–40.4) ($H = 16.85$, d.f. $= 3$, $p = 0.001$)). Figure 1 shows the Kaplan–Meier survival curves of the different groups of critically ill patients stratified according to age.

Table 3 The 1-year survival of critically ill patients stratified by age.

Age group	No.	1-year survival (%)	95% CI
70–74	193	54.4	47.4–61.4
75–79	128	57.8	49.3–66.3
80–84	109	57.7	48.4–67.0
≥ 85	44	27.3	14.2–40.4

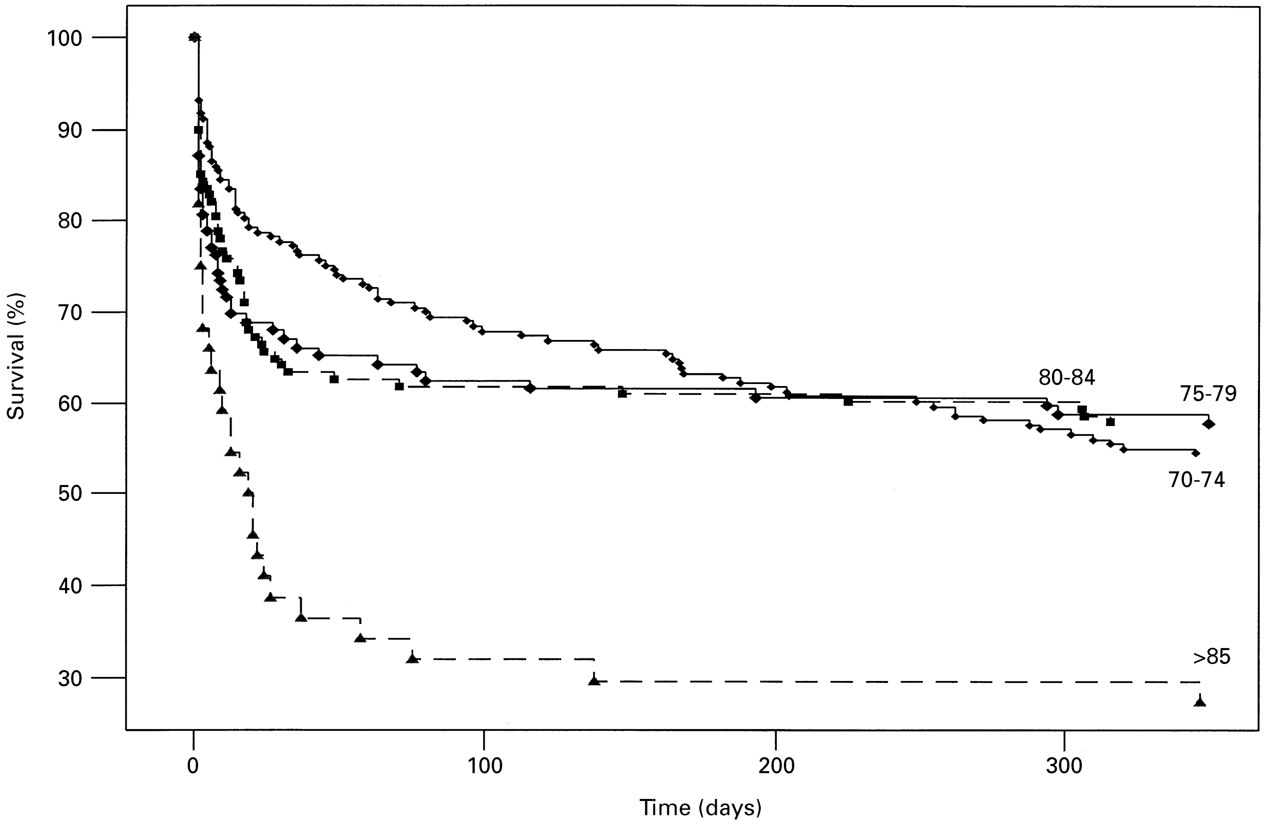

Figure 1 Kaplan–Meier survival curves of the different groups of critically ill patients stratified according to age group.

Comparison with an age- and sex-matched population

Kaplan–Meier survival curves for a normal population and for critically ill patients aged less than and over 85 years are shown in Fig. 2. The 1-year survival of a matched population of elderly patients is 93.3% (95% CI: 91.0–96.6) while that of the critically ill patients aged less than 85 years is 56.0% (95% CI: 51.3–60.7) and that of the over 85 year olds is 27.3%. The survival of critically ill patients is significantly poorer than that of an age- and sex-matched population (Chi-squared = 135, d.f. = 1, $p < 0.001$). Table 4 shows the proportion of critically ill patients surviving 1 year and the standardised mortality ratio (SMR) between the observed and expected mortality using the predicted death rate of the normal population. The SMR suggests that survivors of critical illness remain at risk from a greater mortality for at least 1 year following admission to ICU.

Prognostic features

Univariate analysis revealed that unplanned (as opposed to planned) admission ($H = 22.2$, d.f. = 1, $p < 0.001$), emergency or no (versus elective) surgery ($H = 35.4$, d.f. = 2, $p < 0.001$), diagnostic code (respiratory, elective aneurysm, emergency aneurysm, sepsis, trauma, head injuries, gastro-intestinal, cardiac arrest) ($H = 49.2$, d.f. = 7, $p < 0.001$), increasing APS ($H = 50.3$, d.f. = 2, $p < 0.001$) and 5 CHE (as opposed to 0 or 2 CHE) points ($H = 11.3$, d.f. = 2, $p < 0.01$) all significantly and adversely affected outcome. The sex of the patient did not influence outcome.

Best subset regression was then used to identify which

Table 4 The survival of all patients in the 1st year following critical illness and the standardised mortality ratio comparing their survival to that of an age- and sex-matched normal population.

Month of death	At risk at start of period	Deaths within period	Proportion remaining (95% CI)	SMR (95% CI)
1	474	151	68.1 (63.9–72.3)	56.7 (48.0–66.1)
2	323	17	64.6 (59.3–69.8)	6.4 (3.7–10.2)
3	306	12	62.0 (56.6–67.5)	4.5 (2.3–7.9)
6	294	15	58.9 (53.2–64.5)	1.9 (1.1–3.1)
12	279	26	53.4 (47.5–59.2)	1.6 (1.1–2.4)

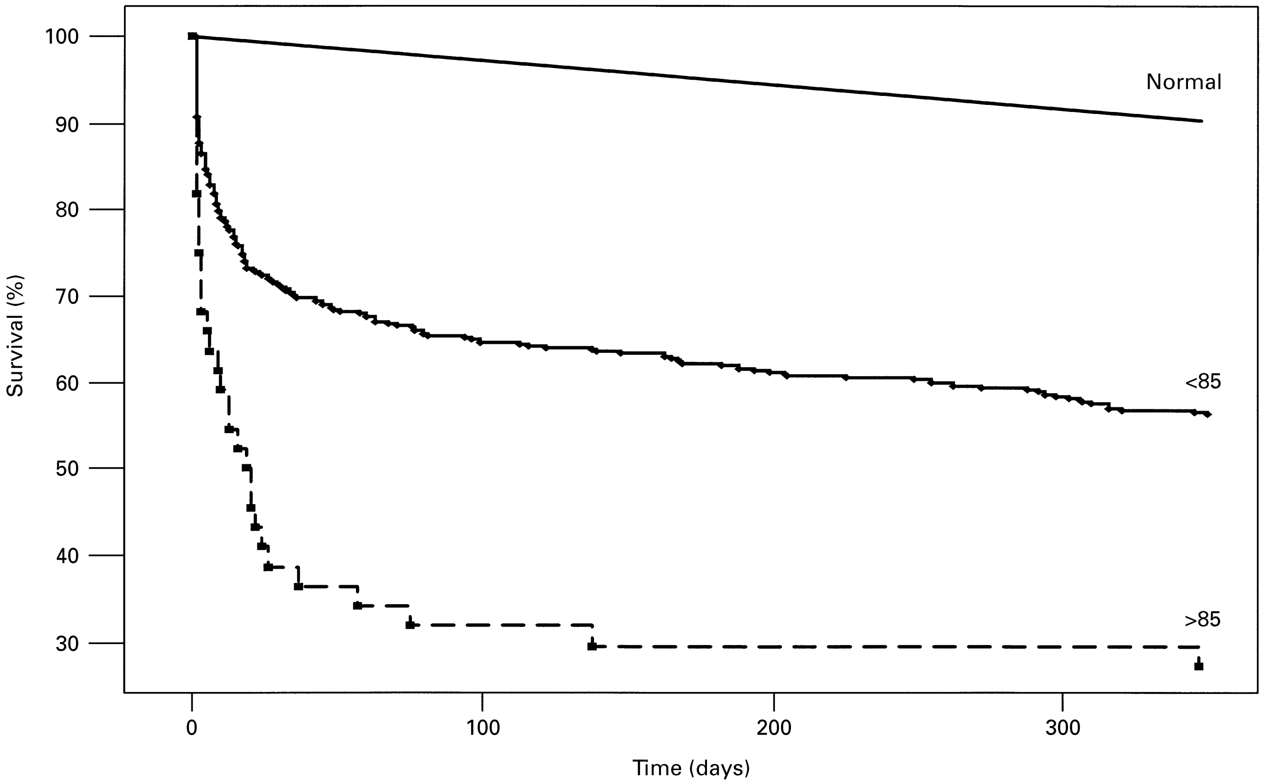

Figure 2 Kaplan–Meier survival curves for a normal population and critically ill patients aged less than and over 85 years.

variables could be used to develop an outcome model with the smallest variance. Best subset regression indicated that being over 85 years old, diagnostic code, an emergency admission, increasing APS score and CHE points would produce a model with minimal variance. However, 5 CHE points and emergency admission are closely correlated as emergency surgery moves the chronic health evaluation from 2 to 5 points. Therefore, the effects of emergency admission, diagnostic code, increasing APS score and age over 85 years were all tested using the multivariate technique of binary logistic regression analysis. This analysis revealed that only age, diagnostic code and APS significantly affected mortality at 1 year ($H = 70.4$, d.f. $= 9$, $p < 0.001$). The probability of 1-year survival is given by the equation:

$$\text{Logit p} = 0.3161 + (\text{APS} \star 0.06572) + (1.5238 \text{ if aged over 85}) - (\text{diagnostic code coefficient}).$$

Emergency admission was found not to have a significant effect in the model. The coefficients are given in Table 5 and worked examples in Appendix A. The goodness of fit of this model appeared reasonable with the observed and expected frequencies of death in the first year following ICU shown in Table 6 (agreement between model and actual mortality 70.7%, disagreement 28.4%, Homer–Lemeshow C statistic $= 6.506$, d.f. $= 8$, $p = 0.591$).

Table 5 Results of the binary regression analysis.

Predictor	Coefficient	SD
Constant	0.3161	0.5686
APS	0.06572	0.01868
≥ 85	1.5238	0.4234
Diagnosis		
Cardiac arrest	0	–
Sepsis	−0.1870	0.6654
Emergency aortic aneurysm	−0.7822	0.5954
Head injuries	−1.0579	0.7049
Gastrointestinal	−1.0212	0.565
Respiratory	−1.2039	0.568
Trauma	−1.3964	0.6404
Elective aortic aneurysm	−2.3857	0.6629

	Decile of risk										
	1	2	3	4	5	6	7	8	9	10	Total
Death											
Observed	5	16	25	19	17	23	24	27	35	24	215
Expected	6.7	15.5	19.1	20.1	20.1	22.5	24.4	27.8	32.7	26.1	
Obs.-Exp.	−1.7	0.5	5.9	−1.1	−3.1	0.5	−0.4	−0.8	2.3	−2.1	
Alive											
Observed	39	33	27	31	28	22	20	17	9	6	232
Expected	37.3	33.5	32.9	29.9	24.9	22.5	19.6	16.2	11.3	3.9	
Obs.-Exp.	1.7	−0.5	−5.9	1.1	3.1	−0.5	0.4	0.8	−2.3	2.1	
Total	44	49	52	50	45	45	44	44	44	30	447

Table 6 Observed and estimated expected frequencies within each decile of risk for mortality using the fitted logistic regression model.

Discussion

Mortality following critical illness is undoubtedly related to age; however, some elderly patients recover remarkably well following intensive care management. Therefore, in general age need not be a barrier to ICU admission. However, the very elderly (≥ 85 years old) do not fare so well. In the present study, the ICU mortality increased with increasing age, from 12% in the 70–74 year age bracket to 34% in the very elderly (≥ 85 years). This agrees with a recent study by Wagner *et al.* [11] in which both the predictive and the actual ICU mortality in elderly patients was much higher than in the younger groups, suggesting an age-related increase in mortality. In France, Nicolas *et al.* [1] reported that the ICU mortality rate in patients over 65 years of age was twice that of patients under 45 years old (36.8% versus 14.8%). However, ICU or hospital mortality, although widely used because it is easy to record, may be a poor measure of intensive care outcome because of the continued mortality after hospital discharge.

In another French study, Le Gall *et al.* [7] reported that patients aged ≥ 70 years had a significantly lower survival rate at 1 year (31%) than those aged 15–49 years (73%) and 50–69 years (45%). An outcome study from Glasgow [12] reported that only 47% of patients aged ≥ 65 years survived to 1 year while 83% of those aged between 18 and 34 years survived the same period. Mahul *et al.* [13] reported similar findings, with a 1-year mortality for those over 80 years old of 74% with 50% dying during the first month after discharge from a French ICU. In the USA, Kass *et al.* [9] reported that the mortality rate for the very elderly group (≥ 85 years) was 64% at 1 year. All of these studies suggest that at the extreme of age, either over 80 or 85 years old, the long-term survival of such patients is poor. The reasons for the continued mortality after discharge may include the presence of severe co-morbidities [2, 3, 14, 15], the higher incidence of malignancy and the punishing effects of critical illness.

The range of diagnostic groups in the present study may be typical of a general adult ICU in the United Kingdom. Most patients were admitted with primarily respiratory and gastrointestinal dysfunction with fewer patients suffering cardiac arrests or sepsis. The present study confirms that some groups of patients, such as those following emergency abdominal aortic aneurysm repair or cardiac arrest, do particularly badly. Survival after cardiac arrest is known to be bleak, rarely exceeding 5% for patients in the ICU and 15% for patients outside the ICU [16–18]. The importance of diagnosis influencing outcome was recently illustrated by Niskanen *et al.* [19] in a study of 12 180 Finnish adult patients. These authors showed that ICU patients attained a life expectancy similar to that of the general population 2 years after admission but that their level of survival was intimately related to their diagnosis. Patients of all ages with cardiac arrest and cancer had a 5-year survival rate of less than 40% compared with patients with trauma and intoxication of whom more than 75% survived 5 years. The survival of elderly patients with similar diagnoses in the present study is much poorer, suggesting that advanced age and diagnosis may act synergistically to reduce survival.

Severity of illness has long been recognised to influence outcome and this is the basis of scoring systems which are now regularly used to stratify and group critically ill patients. Such scoring systems have been developed to predict outcomes for groups of patients and as such are of enormous benefit for audit and research on ICU. Unmodified systems are not sufficiently accurate for the prediction of outcome for individual patients. Chang [20] suggested that dynamic models with high sensitivity and specificity can be developed to identify individual patients with a hopeless outcome. However, Rogers & Fuller [21] could not validate the outcome model proposed by Chang and therefore rejected it. Knaus *et al.* [22] developed and validated a prognostic model that estimated survival over a 180-day period for seriously ill hospitalised adults. The most significant determinants of 6-month survival were physiological measures recorded on day 3 after study entry and the patient's age. Zimmerman *et al.* [23] supplemented their clinical judgement with daily assessment of APS (derived from APACHE III) and the current day's therapy in order to predict the next day's risk for life support. However, Wagner *et al.* [11] concluded that even incorporating the physiological response of the patient to applied therapy into the predictive equation did not reliably predict the outcome.

The aim of the present study was to report the long-term survival of critically ill elderly patients and to identify clinical features that influenced outcome, not to develop a complex tool for prediction of an individual elderly patient's outcome. The results of the univariate analysis confirm what might be intuitively surmised; however, multivariate analysis clearly shows that extreme age, diagnosis and physiological derangement are the most prominent determinants of outcome. These three factors need to be given due prominence when considering the appropriate direction of therapy for some elderly patients. In the present study the logistic regression is simply a mathematical means of quantifying risk factors; however, it is not an absolute and binding estimate of outcome. The equation in the present study is a modest refinement of the APACHE II risk of death calculation with coefficients based on the UK data and an estimate of death extending for 1 year. Although its goodness of fit results are acceptable, it will require further prospective validation.

Follow up after critical illness should be continued until the survival of patients parallels that of a normal population. Basing decisions on outcome before the survival curve has paralleled the normal population may be premature because there is then a risk that the long-lasting effects of critical illness or the course of the underlying pathology or a combination of both may be underestimated. The length of time required for the survivors' curve to parallel that of a normal population is not clear. Zaren & Bergstrom [24] concluded that 1 year after admission to the ICU, surviving patients had regained their previous health status and their further survival almost paralleled that of the general population. Dragsted *et al.* [4], looking at 5-year survival, indicated that patients aged over 70 years had 2.5 times higher mortality than that of an age- and sex-adjusted normal population. In Scotland [25] ICU patients had a significantly higher mortality rate than that of the general population until the start of the fourth year after discharge. In the present study, the mortality rate for ICU patients at 1 year was 1.5 times that of the normal population in the 70–84 year old group and 3.5 times in the very elderly group. Recognising that there are differences in ICU populations and practices in different countries, the results from the UK would suggest that follow up should definitely exceed 1 year and may need to extend as far as 4 years.

In conclusion, the present study suggests that the 1-year survival of the very elderly following critical illness is poor. Long-term survival of patients aged over 70 years is significantly influenced by age over 85 years, diagnosis and acute physiological derangement. We recommend that these features are given prominence when attempting to decide upon the most appropriate course of management for these patients.

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Appendix A

Worked examples of the model:

$$\begin{aligned}\text{Logit p} &= 0.3161 + (\text{APS} \star 0.06572)\\ &\quad + (1.5238 \text{ if aged over } 85)\\ &\quad - (\text{diagnostic code coefficient}).\end{aligned}$$

(a) The probability of mortality for an 87 year old admitted following an emergency aneurysm repair with an APS score of 10 is

$$\begin{aligned}\text{Logit p} &= 0.3161 + (10 \star 0.06572) + (1.5238)\\ &\quad - (0.7822)\end{aligned}$$

$$\text{Logit p} = 1.71$$

$$p = e^{1.71}/(1 + e^{1.71})$$

$$p = 0.85.$$

(b) The probability of mortality for an 87 year old admitted following cardiorespiratory arrest with an APS score of 10 is

$$\text{Logit p} = 0.3161 + (10 \star 0.06572) + (1.5238) - (0.0)$$

$$\text{Logit p} = 2.50$$

$$p = e^{2.50}/(1 + e^{2.50})$$

$$p = 0.92.$$

(c) The probability of mortality for a 77 year old admitted following an elective aneurysm repair with an APS score of 2 is

$$\text{Logit p} = 0.3161 + (2 \star 0.06572) + (0.0) - (2.3857)$$

$$\text{Logit p} = -1.94$$

$$p = e^{-1.94}/(1 + e^{-1.94})$$

$$p = 0.13.$$