**The Sabadell score is indepently associated with five-year mortality following critical care discharge: a prospective cohort study**

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**Summary**

Critical care survivors suffer persistent morbidity and increased risk of mortality compared to the general population. However, there are no standardised tools to identify at risk patients. Our aim was to establish whether the Sabadell score, a simple tool applied upon critical care discharge, is independently associated with five-year mortality through a prospective observational cohort study of adults admitted to a general critical care unit in Liverpool, United Kingdom. Sabadell score was applied to all patients from September 2011 to December 2017 and our primary outcome was five-year mortality assessed using a multivariable flexible parametric survival analysis adjusted for demographics, and clinically relevant covariates. There were 5954 included patients with a minimum of 18 months follow-up. Mean (SD) age was 59.5 (34) and 3397 (57.1%) patients were male. We categorised 2287 (38.4%) as Sadabell zero, 2854 (47.9%) as Sadabell one, 629 (10.5%) as Sadabell two and 183 (3.1%) as Sadabell three. Adjusted hazard ratios for mortality were 2.1 (95%CI 1.9–2.4), 4.0 (95%CI 3.4–4.6) and 21.0 (95%CI 17.2–25.7), respectively. A Sabadell score of three was associated with 99.9%, 99.5%, 98.5% and 87.4% mortality at five years for patients aged ≥ 80, 60-79, 40-59 and 16-39 respectively. A Sabadell score of two was associated with 71.0%, 52.7%, 44.8% and 23.7% five-year mortality for these age categories. Sabadell score is independently associated with five-year survival after critical care discharge. These findings could be used to guide provision of increased support for patients after critical care discharge and/or informed discussions with patients and relatives about dying to ascertain their future wishes.

**Introduction**

There is increasing recognition of the need to quantify long-term outcomes for patients who are discharged from critical care areas. Critical care survivors suffer continued and significant healthcare burden, [1-3] and shorter long-term survival compared to the general population [4,5]. Such tools could be used to guide interventions to improve outcomes for at-risk patients [6]. In addition, there is increasing recognition of the need to hold prospective informed discussions with patients and their families to ascertain their wishes and plan for future care [7]. However, there are currently no validated tools to inform provision of resources or the initiation of discussions about death at the point of critical care discharge.

Critical care mortality predicition tools tend to focus on outcomes for the hospital admission episode, rather than long-term survival [2,8-10]. Furthermore, these tools can be complex and labour intensive [5,11], with variable discriminative ability [12]. The Sabadell score was developed and validated as a simplified tool based on the judgement of the treating critical care physician to predict the likelihood of in-hospital mortality after critical care discharge [13,14]. The Sabadell score is prospectively assigned at the point of critical care discharge by the consultant intensivist, based on their experience of treating the patient during their admission (Table 1) [13]. Although it has been validated for shorter term outcomes [13,14], the longer-term discriminative ability of this tool for deaths before and after hospital discharge has not been determined.

The aim of this study was to investigate the utility of the Sabadell score as an independent predictor of long-term outcomes after discharge from a UK critical care unit. If confirmed, this simple scoring system could facilitate improved communication to guide prospective and informed care decisions with patients and their relatives at the point of critical care discharge.

**Methods**

This prospective cohort study was conducted at Liverpool University Hospitals NHS Foundation Trust, Liverpool, after research ethics approval. Consent for inclusion was waivered and anonymyity was maintained throughout data handling. We included adult patients admitted to a 23-bed critical care unit between 1st September 2011 and 31st December 2017. Our unit admits adult medical and surgical patients requiring level two or three care [15] with a maximum patient to nurse ratio of 2:1. The hospital is a regional referral centre for trauma, hepato-biliary, and head and neck surgery. Adult patients (aged ≥ 16) from all specialties are admitted, except for cardiothoracic and plastic surgical patients. The unit is staffed by two consultant intensivists during day-time hours and has resident consultant cover out of hours. Within the hospital, there is a medical emergency team, inclusive of a critical care representative and an outreach service who routinely review patients after critical care discharge. Patients discharged alive from the critical care unit were included in the study. Patients transferred to another critical care unit and those with insufficient data to allow analysis were excluded (Figure 1). For patients with multiple critical care admissions, only the index admission was incorporated into the analysis. Survival data for all patients was last updated in July 2019.

Data were recorded prospectively as part of a UK intensive care national audit project [16]. These included: age; sex; postcode; primary diagnosis; specialty; nature of admission; APACHE II score; and length of ICU stay. For the study, patients were each assigned a Sabadell score by the consultant intensivist at the point of discharge from the critical care unit, based on their experience of treating the patient throughout the admission [13]. The allocated score was not documented in the case notes and the receiving ward team, including those subsequently caring for the patient, were blinded. We differentiated critical care readmission data according to hospital admission status (same or separate admission). Readmission within the same hospital episode was recorded for individual patients, as a potential marker of poor prognosis, within the analysis.

On discharge from the critical care unit, all patients were handed over to the relevant ward team, which included but was not limited to discussion of ongoing issues and specific plans for subsequent management. Ceilings of care were documented in the case notes independently from the allocation of the Sabadell score, if indicated. Hospital electronic records were reviewed in July 2019 to determine the long-term outcomes of the patients. The Hospital Episode Statistics are routinely collected for all admissions to NHS hospitals and contain reliable, comprehensive patient information [17]. Therefore, all patients were subject to a minimum of eighteen-month follow up.

To assess the effect of socioeconomic deprivation on outcome, the Index of Multiple Deprivation (IMD) was used [18]. The Index of Multiple Deprivation (IMD) is based on the home postcode mapped to Lower Super Output Area (LSOA). Lower Super Output Areas are geographic areas designed to report small area statistics (mean population 1500) in England and Wales. The IMD score is derived from weighted scores from seven domains; income; employment and health deprivation; disability; barriers to housing and services; crime; living environment and education; and skill deprivation. These scores are further categorised into deciles with decile one being the most deprived and decile ten the least [19].

We looked for associations between recorded patient characteristics, long-term survival following critical care discharge, and the Sabadell score. Variables were expressed as frequencies and percentages for categorical variables, and median [IQR (range)] for continuous variables. To identify factors independently associated with survival at hospital discharge, we conducted univariable logistical regression analysis with recorded patient characteristics to produce crude odds ratios. These variables were subsequently included within the multivariable logistical regression analysis to produce adjusted odds ratios. The relationship between Sabadell score and five-year survival was initially explored with Cox-regression analysis. However, multiple variables (Sabadell score, elective vs. emergency, medical vs. surgical and APACHE II score) were found to violate proportional hazard assumptions (Table S1). Therefore, a flexible parametric survival model was fitted using the STATA ‘stpm2’ command [20] to produce hazard ratios. The most parsimonious model was identified at six internal splines using the Bayesian information criterion method (Table S2). Statistical significance was accepted at the 5% level. Sensitivity analyses were performed including and excluding in-hospital mortality for univariable (Table S3) and multivariable (Table S4) analysis. Data were analysed using Stata V15.1 (StataCorp, Stata Statistical Software: Release 15, College Station, Texas, USA) and figures produced using R V.3.5.1 (R Development Core Team, Vienna, Austria).

**Results**

During the study period, there were 8374 patients admitted to the critical care unit. Following exclusion of patients who: died during their critical care admission; were discharged to another hospital; were readmitted following discharge; were lost to follow up; or did not have an English postcode, 5954 were included in the final analysis (Fig. 1). Patients with non-English postcodes were more likely to be elective surgical admissions with lower Sabadell scores and improved survival, reflective of the hospital status as a tertiary referral centre (Table S5). Males were responsible for 3397 (57.1%) of admissions and the mean (SD) age was 59.5 (34) years (Table 2). A Sabadell score of: zero was assigned to 2287 (38.4%) patients; one was assigned to 2854 (47.9%) patients; two was assigned to 629 (10.5%) patients; and three was assigned to 183 (3.1%) patients. We observed that age, APACHE II score, the proportion of medical versus surgical admissions, the proportion of emergency admissions and the proportion of hospital mortality were highest in patients assigned a Sabadell score of three (Table 3).

The length of follow up data available was greater than 18 months for all patients. Complete follow up data were available for 5616 (94.3%) patients at two years, 4897 (82.2%) at three years and 3676 (61.8%) at five years. Overall mortality was 289 (4.9%) at 30 days, 481 (8.1%) at 90 days, 978 (17.2%) at one year, 1494 (26.6%) at two years, 1777 (36.3%) at three years and 2115 (57.5%) at five years. For patients with a Sabadell score of two, 50.3% had died at two years (Table 3). In agreement with previous work [13,14], logistic regression analysis demonstrated that the Sabadell score was an independent predictor of hospital mortality in both univariable and multivariable analyses. The adjusted odds ratios for Sabadell scores 1, 2 and 3 were 5.1 (C.I. 2.6 – 9.9), 22.1 (C.I. 11.2 – 43.7) and 278.1 (C.I. 134.3 – 575.6) respectively (Fig. 2 and Table S6).

To explore the relationship between Sabadell score and five-year mortality we used a flexible parametric survival model. We included hospital deaths in this model because, clinically, the Sabadell score was assigned at the point of critical discharge and this is when the opportunity for discussion with patients and/or next of kin could occur. All *a priori* selected variables (Sabadell score, age, sex, elective vs. emergency admission, medical vs. surgical admission, LSOA score, APACHE II score, need for readmission, hospital length of stay and year of admission) were included in both univariable and multivariable analyses. The adjusted hazard ratios for Sabadell scores one, two and three were 2.2 (95%CI 1.9-2.4), 4.2 (95%CI 3.6-4.9) and 23.6 (95%CI 19.2-29.1), respectively (Table S4). Using this model, we predicted five-year survival for Sabadell score and age as the variables with greatest magnitude of effect. Predictions were adjusted for the remaining co-variates within the multivariable model (Fig. 3). The co-variates adjusted for were: sex; medical vs. surgical admission; elective vs. emergency admission; APACHE II score; LSOA score; critical care readmission within the same hospital admission; hospital length of stay; and year of admission [21]. We specifically examined for interactions between type of admission (medical vs. surgical) and nature of admission (emergency vs. elective) as most medical admissions are emergencies. Inclusion of this interaction term had minimal effect on the adjusted hazard ratios (results not presented).

Based on this model, more than half of patients aged ≥ 80 allocated a Sabadell score of three would be expected to die within two months from critical care discharge. This increases to three months for those aged 60-79, five months for those aged 40-59 and 13 months for those aged 16-39. More than half of patients aged ≥ 80 allocated a Sabadell score of two would be expected to die within 26 months from critical care discharge. This increases to 40 months for those aged 60-79. For sensitivity analysis, we removed patients who died during their index hospital admission following critical care discharge and applied the flexible parametric survival model. The most parsimonious model was identified at two internal splines using the Bayesian information criterion method. This demonstrated that the adjusted hazard ratio for mortality for patients who survived their index hospital admission with a Sabadell score of one, two and three was 2.0 (95%CI 1.8-2.3), 3.3 (95%CI 2.7-3.9) and 7.1 (95%CI 5.1-10.0), respectively (Tables S3 and S4). Survival predictions based on this model are displayed in Figure S1.

**Discussion**

Our results suggest that the Sabadell score is independently associated with five-year survival after critical care discharge. Sabadell scores of two and three were associated with in-hospital mortality and mortality following hospital discharge. This tool could potentially be used to guide informed discussions with patients and/or their relatives about dying to ascertain resource planning and future wishes. Further multicentre studies are required to validate our findings for similar and other critical care patient groups.

There is increasing recognition of the need to “ *empower doctors, patients and carers to make shared decisions about care and treatment that balance duration and quality of life*” [7]. In the UK, nearly half of all deaths occur in the hospital setting [22]. Poor communication in the final stages of life is a frequently cited source of complaint. Subsequently, the Royal College of Physicians have proposed a number of recommendations for medical professionals to initiate timely and honest conversations with patients about their future [7]. Episodes of illness that require critical care admission increasingly result from acute exacerbations of chronic disease rather than a single curable event. Patients who survive a critical illness episode frequently suffer significant and persistent morbidity [1,2,23].

The point of discharge from critical to ward-based care represents an opportunity to intervene for high-risk patients and/or guide discussion between professionals and relatives about death. Our study demonstrates that the Sabadell score, a subjective prediction of longer-term patient outcome, has strong potential to guide initiation of these discussions. We observed this effect for both patients who died in hospital after their critical care discharge and for those who survived their index admission. The observed effect for patients allocated a Sabadell score of three was lower for hospital survivors. As Sabadell score three patients are expected to die in hospital, this is an expected finding. Importantly, patients who survived hospital admission, despite allocation of this score, still had a persistently higher risk of death compared to patients allocated Sabadell scores zero, one and two (Table S4).

Our study confirms previous findings that the Sabadell score is strongly predictive of in-hospital mortality [13,14]. This suggests that the tool may be of use in identifying patients at risk of physiological deterioration once discharged to the ward, as described previously [14]. For example, patients with a Sabadell score of two could be managed with an enhanced level of support with an aim to prevent deterioration and in-hospital death, and improve survival in the community. In contrast to the study by Soliman et al, we found that the Sabadell score was strongly predictive of outcomes at one year post critical care discharge [9]. We noted that critical care doctors from our workplace were pessimistic about patient outcomes, with patient survival frequently living beyond their allocated Sabadell score. However, on a population level, the Sabadell score could be a very useful tool to signpost ‘at-risk’ patients to guide rehabilitation interventions post critical care discharge and/or determine if they are willing to engage with end-of-life discussion and begin the process of advanced care planning.

Our study only gathered and analysed data from a single centre. That said, we did accumulate a large patient cohort with comprehensive follow up for at least 18 months following critical care discharge. We have produced long-term data on survival, but could not collect data to assess quality of life, which is an important patient-related outcome measure for critical care survivors [24]. Some might argue the Sabadell score of a patient might affect future clinical decisions and lead to a self fulfilling prophecy. Others might feel the process through which scores are allocated to patients lacks objectivity [25]. In the present study, the ward team were blinded to the Sabadell score, and care received was independent of the score. When a patient was deemed not suitable for further admissions to intensive care, this decision was made before allocating the score. A limitation of this study is that prospective data collection was limited to the prospectively assigned Sabadell score and the ICNARC core outcome dataset. Therefore, we were unable to explore other potentially important prognostic variables such as discharge clinical laboratory parameters, frailty and physiological fitness. In addition, we did not collect sufficient information to assess inter-consultant variability within this cohort. Future studies should collect this data and examine this potentially important factor. We chose to present age and date of admission as categorical variables, and interpretation of results does not alter when these variables are analysed as continuous variables (Table S7).

We found that in-hospital mortality was 5.6% after critical care discharge, in keeping with previously published data [14,26,27]. Mortality one year following critical care discharge was 17.2%, also in keeping with previous studies [3,4,9,23,27]. There appears to be more limited data on mortality at five years, however, the finding of an overall mortality of 64.5% appears to be higher than recent data published by Lone (32%) [23]. Contrary to findings from other studies [28,29], we did not find a relationship between socioeconomic deprivation and longer term outcome. This is potentially explained by the distribution of socioeconomic deprivation in our cohort, as 40.8% of patients were from the lowest income decile (Table S8).

We recommend further multicentre studies to assess the external validity of our findings in critical care patients. Clinicians should also investigate the validity of this tool in patients outside of critical care. This simple tool, based on a clinician’s prior knowledge of how a patient has responded to treatment during a critical care admission, has now been demonstrated to have utility as a predictor of hospital survival in multiple studies. Clinicians may consider using the tool to direct rehabilitation and therapies to prevent subsequent deterioration following ward discharge. Risk stratification for critical care outreach teams to direct care delivery has the potential to improve outcomes and could inform successful delivery of future interventions.

In summary, our findings demonstrate the potential utility of the Sabadell score as a predictor for five-year mortality among critical care patients, with a higher score associated with higher mortality in all age groups. Talking about dying is potentially distressing for patients, carers and care givers. We suggest that with further validation, the Sabadell score could be used to prospectively direct such discussions.

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**Competing interests**

No competing interests declared.

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**Appendices**

*Online supplementary material*

Filename: Online supplementary material.docx

Additional methodological and analytical detail inclusive of tables S1-8.

*Figure S1*

Filename: Figure S1.tiff

Prediction model for sensitivity analysis.

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**Table 1** The Sabadell score was assigned to patients using this table at the point of critical care discharge by the treating intensive care clinician.

|  |  |
| --- | --- |
| **Sabadell score** | **Predicted outcome** |
| **0** | Good prognosis |
| **1** | Poor long-term prognosis (survival > six months) |
| **2** | Poor short-term prognosis (survival < six months) |
| **3** | Death expected during current hospital admission |

**Table 2** Patient characteristics and their association with the Sabadell score. Of 5954 patients who met criteria, 5953 were assigned a Sabadell score**.** Values are mean (SD), number (proportion) or median (IQR [range]).

|  |  |  |  |
| --- | --- | --- | --- |
| Variable | Overall (n = 5954) | Sabadell score | P value |
| **0** **(n =2287)** | **1** **(n = 2854)** | **2** **(n = 629)** | **3** **(n = 183)** |
| Male | 3396 (57.1) | 1316 (57.5) | 1636 (57.3) | 347 (55.1) | 97 (53.0) | 0.481χ |
| Age; years | 59.5 (17.0) | 50.4 (17.7) | 64.5 (13.6) | 67.1 (14.2) | 70.4 (13.6) | <0.001α |
| APACHE II | 15 (5.8) | 12.95 (2.1) | 15.56 (5.2) | 18.0 (6.0) | 20.6 (5.6) | 0.571α |
| Medical admission | 2317 (38.9) | 878 (38.4) | 974 (34.1) | 352 (56.0) | 113 (61.7) | <0.001χ |
| Emergency admission | 4081 (68.5) | 1622 (70.9) | 1735 (60.8) | 545 (86.6) | 179 (97.8) | <0.001χ |
| Readmission in same hospital stay | 227 (3.8) | 65 (2.8) | 126 (4.4) | 35 (5.6) | 1 (0.5) | <0.001χ |
| LSOA IMD score | 37.6 (18.4-57.2)4 - 76 | 39.2 (19.2-57.2 [4-76]) | 35.8 (17.5-57.1 [4-76]) | 39.5 (19.5-57.2 [5-76]) | 40.7 (19.5-56.1 [4-74]) | 0.037β |

LSOA IMD, Lower layer super output area Index of multiple deprivation; χ, Chi squared analysis; α, ANOVA analysis; β, Kruskall-Wallis analysis respectively; SD, standard deviation; IQR, interquartile range.

**Table 3** Patient mortality categorised by Sabadell score: Mortality at intervals following critical care discharge. Of the 5954 patients included in the analysis, 5953 were assigned a Sabadell score**. Values indicate frequency and (percentage).**

|  |  |  |  |
| --- | --- | --- | --- |
| **Time point after critical care admission** | **Patient episodes with complete mortality data** | **Overall mortality n (%)** | **Mortality according to Sabadell score n (%)** |
| **0** | **1** | **2** | **3** |
| Hospital discharge | 5953 | 334 (5.6) | 10 (0.4) | 92 (3.2) | 102 (16.2) | 130 (71.0) |
| 30 Day | 5953 | 289 (4.9) | 5 (0.2) | 65 (2.3) | 87 (13.8) | 132 (72.1) |
| 90 Day | 5953 | 481 (8.1) | 30 (1.3) | 158 (5.5) | 148 (23.5) | 145 (79.2) |
| 1 Year | 5953 | 978 (17.2) | 118 (5.2) | 470 (16.5) | 232 (37.7) | 158 (87.3) |
| 2 Years | 5616 | 1494 (26.6) | 226 (10.6) | 793 (29.5) | 311 (50.3) | 164 (90.6) |
| 3 Years | 4897 | 1777 (36.3) | 303 (17.2) | 955 (40.0) | 350 (60.9) | 169 (94.9) |
| 5 Years | 3676 | 2155 (57.5) | 375 (33.8) | 1170 (62.3) | 398 (77.1) | 172 (98.3) |

**Legends**

**Figure 1**: Patients admitted to the Intensive Care Unit during the study period

**Figure 2:** Adjusted and unadjusted odds ratios for in-hospital mortality after critical care discharge in our patient cohort. Figure displays unadjusted (black) and adjusted (red) odds ratios for our *a priori* selected variables within the analysis. Reference variables are described on the y-axis and assigned an odds ratio of 1. Number of observations for multivariable analysis = 5924, χ2 = 945.06, Pseudo R2 = 0.369

**Figure 3:** Survival predictions for Sabadell score and age category based on a flexible parametric survival model for five-year survival after critical care discharge. Each panel represents predicted survival by Sabadell score according to age category (lines: green=16-39 years; yellow=40-59 years; orange=60-79 years; red=80+ years) after adjustment for sex, APACHE II score, elective vs. emergency admission, medical vs. surgical admission, social deprivation score and need for readmission within the same spell. Coloured shaded areas surrounding lines represent the corresponding 95% confidence intervals. The flexible parametric survival model was fitted with six internal splines and includes 5924 individual patient observations.