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Original Article

## SHARP risk score: A predictor of poor outcomes in adults admitted for emergency general surgery: A prospective cohort study

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### ABSTRACT

**Purpose:** Post-operative complications following emergency abdominal surgery are associated with significant morbidity and mortality. Despite the knowledge of prognostic factors associated with poor surgical outcomes; few have described risks of poor outcomes based on admission information in acute surgical setting. We aimed to derive a simple, point-of-care risk scale that predicts adults with increased risk of poor outcomes.

**Methods:** We used data from an international multi-centre prospective cohort study. The effect of characteristics; age, hypoalbuminaemia, anaemia, renal insufficiency and polypharmacy on 90-day mortality was examined using fully adjusted multivariable models. For our secondary outcome we aimed to test whether these characteristics could be combined to predict poor outcomes in adults undergoing emergency general surgery. Subsequently, the impact of incremental increase in derived SHARP score on outcomes was assessed.

**Results:** The cohort consisted of 419 adult patients between the ages of 16–94 years (median 52; IQR(39) consecutively admitted to five emergency general surgical units across the United Kingdom and one in Ghent, Belgium. In fully adjusted models the aforementioned characteristics; were associated with 90-day mortality. SHARP score was associated with higher odds of mortality in adults who underwent emergency general surgery, with a SHARP score of five also being associated with an increased length of hospital stay.

**Conclusions:** SHARP risk score is a simple prognostic tool, using point-of-care information to predict poor outcomes in patients undergoing emergency general surgery. This information may be used to improve management plans and aid clinicians in delivering more person-centred care. Further validation studies are required to prove its utility.

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## 1. Introduction

### 1.1. Background

Post-operative complications following emergency abdominal surgery can be associated with significant morbidity and mortality.<sup>1</sup> In emergency surgical admissions; Ozdemir et al., identified 30-day

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mortality in 4.2%.<sup>2</sup> Emergency general surgical intervention has also been reported to be associated with a prolonged length of hospital stay (LoS).<sup>3</sup> Prolonged LoS is not only associated with an increased risk of hospital acquired infections<sup>4</sup> but also results in limited capacity to accommodate additional patients.<sup>5</sup> The development of risk scales predicting such poor outcomes in the emergency general surgical setting provides surgeons with the opportunity to devise pre-emptive plans which may reduce the incidence of such adverse events.

A few perioperative scores have been developed to aid in this process, and to facilitate audit and unit performance analysis.<sup>6</sup> These include the Acute Physiology and Chronic Health Evaluation (APACHE)<sup>7</sup> and Physiological and Operative Severity Score for the enumeration of mortality and morbidity (POSSUM).<sup>8</sup> The accuracy of mortality prediction in the latter was enhanced in the Portsmouth-modified (P-POSSUM) score,<sup>9</sup> by adjusting for additional physiological and operative parameters, thereby depicting the potential for enhancing already existing risk scales. However, all of the aforementioned scales fail to allow for a practical, simple and fast approach in dealing with an emergency. To accommodate this, the commonly collected point-of-care patient characteristics of age, hypoalbuminaemia, anaemia, renal insufficiency and polypharmacy were used to assess for the potential associations with poor patient outcomes. Furthermore, since the proportion of adults and more specifically frail adults requiring emergency general surgical interventions is on the rise<sup>10</sup> the need for the development of a more simplified risk scale based upon pre-surgical parameters is pertinent.

## 1.2. Objectives

In this study we had two key objectives. Firstly, we aimed to assess the association between commonly collected point-of-care patient characteristics; age, hypoalbuminaemia, anaemia, renal insufficiency and polypharmacy and our primary outcome; 90-day mortality, in unselected adult patients who received emergency abdominal surgery. Secondly, we aimed to test whether characteristics observed to be statistically significant in our first objective could be combined to produce a risk scale which predicts poor outcomes on admission to the general surgical setting, prior to emergency surgical intervention.

## 2. Materials and methods

### 2.1. Study design

As part of the Older Persons Surgical Collaboration (OPSOC) ([www.opsoc.eu](http://www.opsoc.eu)), this prospective cohort study was conducted across one hospital in Ghent, Belgium, and five hospitals in the United Kingdom (UK) between May to July 2015 and June to August 2016. Data were collected in line with OPSOC methodology; data were collected within the acute General Surgical admission setting for patients aged  $\geq 60$  years admitted to the participating units throughout May–June (two months) of all four years (2013–2016). Since 2015, younger patients (<60 years) were included in OPSOC data collection.<sup>13</sup> Across the six surgical units included, data were collected for all patients consecutively admitted to the Emergency General Surgical units. Emergency General Surgical admissions related to acute General Surgical presentations i.e. appendicitis, cholecystitis, diverticulitis, bowel obstruction/perforation or pancreato-biliary disease, but may have also included conditions such as peri-anal abscesses which required incision and drainage. Patients that presented with surgical conditions not pertaining to the General Surgery; Vascular, Urological, Cardiothoracic, Orthopaedic or Neurosurgical, were admitted under the appropriate specific surgical speciality and thus these patients were thereby excluded from our

study. Within this study, only patients who received an operation were included. No other inclusion or exclusion criteria were used.

This study has been reported in-line with STROCSS criteria.

### 2.2. Outcomes

The primary outcome was 90-day mortality, whilst secondary outcomes were; 30-day mortality, 30-day readmission and greater than median (>5days) length of hospital stay.

### 2.3. Data collection

To characterize co-morbidity, we recorded baseline characteristics, recorded categorically, for the following; anaemia ( $\leq 12.9$  g/dL), hypoalbuminemia (albumin <3.5 g/dL) and polypharmacy ( $\geq 5$  medications), eGFR (<60 ml/min/1.73 m<sup>2</sup>), CRP on admission. All cases were prospectively identified, and baseline data assessed on admission. Follow-up data were obtained via in-hospital electronic records at a later date. A continuous value was recorded, for length of hospital stay (LoS), greater than median (>5days) with days rounded up to the nearest whole day integer. Hospital readmission within 30-days, 30- and 90-day mortality were also collected.

### 2.4. Theory/calculation

Descriptive narrative of the demographics (age, sex, haemoglobin levels, albumin levels, polypharmacy, eGFR, CRP) versus the primary outcome; 90-day all-cause mortality was conducted (Table 1). Descriptive statistics were conducted on patient characteristics using a Chi-squared test. For all variables logistic regression models were constructed to examine the association between each of the demographics and 90-day all-cause mortality as well as the secondary outcomes of 30-day mortality, hospital readmission and increased length of hospital stay.

We stratified the analyses by selected characteristics, based on others and own observation, to assess their relationship with our study outcomes. Variables were specifically chosen due to their routine and ease of collection at the point of care in conjunction with previous reports of their independent association with poor outcomes in surgical patients. Earlier reports showed hypoalbuminemia, anaemia, low eGFR as well as increasing age being independent risk factors associated with mortality.<sup>11,12,14–16</sup>

For our first objective, using our full cohort (N = 419), the following models were constructed; unadjusted (model A), adjusting for undergoing male sex (model B), and adjusting for frailty as well as CRP (model C). Analyses were carried out using the effect of low haemoglobin levels, low albumin levels, polypharmacy and renal disease defined as <60 ml/min/1.73 m<sup>2</sup> eGFR in adults receiving emergency surgical intervention; on outcomes 90-day all-cause mortality, 30-day hospital readmission and increased hospital length of stay (Table 2). Logistic regression models were constructed to examine the association between each variable with sex, CRP (>3mg/L), frailty (1–4 = not frail, 5–7 = frail) and each outcome. All analyses were performed using Statistical Package for Social Science (SPSS version 26). Frailty was determined according to the validated Clinical Frailty Scale (CFS). Frailty is a state of increased vulnerability when faced with physical stressors due to a decreased physiological reserve, coupled with an impaired ability to withstand and recover from physical insult. Each CFS category provides a corresponding set of functional descriptors, allowing the assessor to assign the most appropriate score which most accurately embodies a patient's overall physical functional state, ranging from 1 (very fit) to 9 (terminally ill).

For example, CFS of 1 describes an individual who is 'robust, active and energetic ... among the fittest for their age.' This

**Table 1**  
Patient demographic characteristics by level of frailty on admission to the emergency general surgical setting prior to operation (N = 419).

Patient characteristics	Full cohort N = 419	Alive at 90 days N = 401	Mortality at 90 days N = 18	P
Age (y)				0.001
<65	272 (64.9)	267 (66.6)	5 (27.8)	
≥65	147 (35.1)	134 (33.4)	13 (72.2)	
Sex				0.183
Male	204 (48.7)	198 (49.4)	6 (33.3)	
Female	215 (51.3)	203 (50.6)	12 (66.7)	
Haemoglobin				0.028
≤12.9 g/dL	265 (63.2)	258 (64.3)	7 (38.9)	
>12.9 g/dL	154 (36.8)	143 (35.7)	11 (61.1)	
eGFR				<0.001
≥60	360 (85.9)	350 (87.3)	10 (55.6)	
<60	59 (14.1)	51 (12.7)	8 (44.4)	
CRP				0.220
≤3	31 (7.4)	31 (7.7)	0 (0.0)	
>3	388 (92.6)	370 (92.3)	18 (100.0)	
Albumin				0.004
<3.5 g/dL	230 (54.9)	226 (56.4)	4 (22.2)	
≥3.5 g/dL	189 (45.1)	175 (43.6)	14 (77.8)	
Polypharmacy ≥5				<0.001
Yes	286 (68.3)	282 (70.3)	4 (22.2)	
No	133 (31.7)	119 (29.7)	14 (77.8)	
Frailty				<0.001
1 (Not Frail)	176 (42.0)	175 (43.6)	1 (5.6)	
2	95 (22.7)	93 (23.2)	2 (11.1)	
3	75 (17.9)	69 (17.2)	6 (33.3)	
4	33 (7.9)	29 (7.2)	4 (22.2)	
5	25 (6.0)	23 (5.7)	2 (11.1)	
6	12 (2.9)	10 (2.5)	2 (11.1)	
7	3 (0.7)	2 (0.5)	1 (5.6)	

Values presented are number (%) for categorical data. Chi square test was used for all categorical variables.

**Table 2**  
Results of logistic regression analysis of full cohort (N = 419) examining the impact of anaemia, hypoalbuminemia, sex, age, polypharmacy, renal function, on measured outcomes.

	Model A			Model B			Model C		
	OR	95%CI	P	OR	95%CI	P	OR	95%CI	P
<b>Haemoglobin (≤12.9)</b>									
<b>Outcomes</b>	OR	95%CI	P	OR	95%CI	P	OR	95%CI	P
90-day Mortality	2.84	1.08 to 7.48	0.035	3.98	1.43 to 11.04	0.008	3.33	1.14 to 9.70	0.027
30-day Mortality	3.11	0.90 to 10.79	0.074	4.72	1.29 to 17.26	0.019	3.90	1.00 to 15.18	0.050
30-day Readmission	1.54	0.90 to 2.62	0.112	1.36	0.78 to 2.38	0.278	1.27	0.72 to 2.25	0.410
LOS									
Greater than median length of stay (>5days)	2.10	1.40 to 3.15	<0.001	2.33	1.52 to 3.58	<0.001	1.99	1.28 to 3.10	0.002
<b>Albumin (&lt;3.5)</b>									
<b>Outcomes</b>	OR	95%CI	P	OR	95%CI	P	OR	95%CI	P
90-day Mortality	4.52	1.46 to 13.97	0.009	4.96	1.59 to 15.47	0.006	4.60	1.39 to 15.30	0.013
30-day Mortality	12.79	1.62 to 100.87	0.16	14.53	1.83 to 115.31	0.011	13.94	1.66 to 116.77	0.015
30-day Readmission	1.09	0.65 to 1.85	0.74	1.04	0.61 to 1.77	0.890	0.95	0.54 to 1.69	0.862
Greater than median length of stay (>5days)	3.94	2.62 to 5.93	<0.001	4.06	2.69 to 6.14	<0.001	3.40	2.20 to 5.26	<0.001
<b>Renal Function (eGFR &lt;60)</b>									
<b>Outcomes</b>	OR	95%CI	P	OR	95%CI	P	OR	95%CI	P
90-day Mortality	5.49	2.07 to 14.56	0.001	5.43	2.04 to 14.45	0.001	4.55	1.61 to 12.87	0.004
30-day Mortality	3.67	1.04 to 12.94	0.043	3.59	0.66 to 9.75	0.048	2.79	0.72 to 10.78	0.137
30-day Readmission	1.11	0.53 to 2.32	0.785	1.13	0.54 to 2.37	0.750	0.98	0.45 to 2.13	0.956
Greater than median length of stay (>5days)	6.04	3.04 to 12.02	<0.001	6.03	3.03 to 12.00	<0.001	4.98	2.47 to 10.06	<0.001
<b>Polypharmacy (≥5 medications)</b>									
<b>Outcomes</b>	OR	95%CI	P	OR	95%CI	P	OR	95%CI	P
90-day Mortality	8.29	2.68 to 25.72	<0.001	8.71	2.80 to 27.15	<0.001	7.67	2.33 to 25.23	0.001
30-day Mortality	6.04	1.58 to 23.14	0.009	6.40	1.66 to 24.65	0.007	5.60	1.34 to 23.50	0.019
30-day Readmission	1.09	0.62 to 1.91	0.76	1.07	0.61 to 1.87	0.824	0.871	0.47 to 1.63	0.667
Greater than median length of stay (>5days)	3.75	2.42 to 5.82	<0.001	3.78	2.44 to 5.88	<0.001	3.53	2.20 to 5.68	<0.001
<b>Age (≥65)</b>									
<b>Outcomes</b>	OR	95%CI	P	OR	95%CI	P	OR	95%CI	P
90-day Mortality	5.18	1.81 to 14.84	0.002	5.20	1.81 to 14.92	0.002	4.32	1.42 to 13.11	0.010
30-day Mortality	5.16	1.35 to 19.76	0.017	5.18	1.35 to 19.89	0.017	4.42	1.07 to 18.23	0.040
30-day Readmission	1.45	0.85 to 2.48	0.175	1.46	0.85 to 2.50	0.170	1.29	0.72 to 2.31	0.395
Greater than median length of stay (>5days)	5.23	3.37 to 8.14	<0.001	5.23	3.37 to 8.14	<0.001	5.34	3.32 to 8.59	<0.001

Model A: Unadjusted.

Model B: Adjusted for sex.

Model C: Model B + adjusted for CRP (>3), frailty (CFS 5–7).

contrasts with a patient with a CFS of 6, who require 'help with all outside activities and with housekeeping ... inside they have problems with stairs and need help with bathing'. The frailest of patients correspond with a CFS of 9, where they are 'approaching the end of life ... with a life expectancy of <6 months'.

### 2.5. Risk score development

Finally, we assessed whether the routinely available characteristics on admission identified in Table 2, may be combined to form a predictive risk scale for adults due to undergo emergency surgical intervention which identifies patients at a greater risk of poor outcomes (Table 3). The identifiable characteristics allowed for the formation of a new risk score scale; SHARP, Sixty-five years or over, Hypoalbuminaemia, Anaemia, Renal impairment and Polypharmacy. SHARP variables were drawn from significant multivariate values for our primary outcome, 90-day mortality (Table 2). We assigned one point to each characteristic to make up a 6-point score (minimum 0 to maximum of 5 points), in a similar manner as described earlier.<sup>28</sup> Furthermore, in order to ensure goodness of fit of the proposed scoring system, a Hosmer–Lemeshow test was performed.

Logistic regression models were constructed to examine the association between SHARP score as the predictor variable (with SHARP score of 0 as the reference category) and dichotomized outcomes, using our full cohort (n = 419).

## 3. Results

A total of 2279 patients were enrolled between data collection cycles. Five hundred and seventy-three patients received an emergency operation. Of them, 154 cases were excluded due to incomplete data (see Fig. 1 for exclusion). Thus 419 patients were included in the current study. There were 215 (51.3%) women and 204 (48.7%) men. The 25th Percentile (36), 50th Percentile (55), 75th Percentile (75); IQR(39) of our cohort was 52 (16, 94) years, with 379 (90.5%) patients being not frail (CFS 1–4) and 40 (9.5%) being frail (CFS 5–7) on admission.

The comparison of sample characteristics by 90-day mortality categories are presented in Table 1. In fully adjusted logistic regression models, being sixty-five years or older was associated with 90-day mortality (4.32(1.42–13.11);  $p = 0.010$ ). Hypoalbuminaemia (4.60(1.39–15.30);  $p = 0.013$ ), anaemia (3.33(95%CI

1.148 to 9.70);  $p = 0.027$ ), renal insufficiency (4.55(1.61–12.87);  $p < 0.001$ ) as well as polypharmacy were associated with 90-day mortality (3.53 (2.20–5.68);  $p < 0.001$ ); Table 2. Additionally, in the fully adjusted logistic regression models, having age greater or equal to sixty-five was associated with greater than the median length of hospital stay (5.34(3.32–8.59);  $p < 0.001$ ). Hypoalbuminaemia (3.40(2.20–5.26);  $p < 0.001$ ), anaemia (1.99(1.28–3.10);  $p = 0.002$ ), renal insufficiency (4.98(2.47–10.06);  $p < 0.001$ ) and polypharmacy (3.53 (2.20–5.68);  $p < 0.001$ ); were all associated with greater than the median length of hospital stay.

Based upon these characteristics the SHARP risk score was derived from statistically significant variables identified using our primary outcome; 90-day mortality. Each characteristic scoring one point, with a potential maximum score of five points. Of the 419 patients, 141 (33.7%) had a SHARP score of 0, 76 (18.1%) had a SHARP score of 1, 80 (19.1%) had a SHARP score of 2, 55 (13.1%) had a SHARP score of 3, 51 (12.2%) had a SHARP score of 4 and 16 (3.8%) had a SHARP score of 5. Fig. 2 displays the relationship between increasing SHARP score and the incidence of poor outcomes occurring. For every point increase in SHARP score, there is a corresponding incremental linear increase in the number of patients that died at 90 days and had a greater length of stay than the median (5 days) after the operation. Fig. 2a demonstrates that SHARP score can indeed predict 90-day mortality with scores 4 and 5 being significantly associated.

The application of the SHARP risk score against study outcomes is displayed in Table 3. SHARP scores higher than one, with every point increase were associated with higher odds of mortality, with a SHARP score of 4 and 5 being associated with 90-day mortality (OR(95% CI) = 27.25(3.10–329.81);  $p = 0.003$ ) and (OR(95% CI) = 57.90(4.29–534.36);  $p = 0.002$ ) respectively. Whilst there was an incremental increase in incidence of 30-mortality which correlated with higher SHARP scores, we had an insufficient patient data to complete logistic regression analyses on this outcome. Fig. 2 displays the log<sub>2</sub>(x) of odds ratios with confidence intervals, based on results from Table 3, model A.

## 4. Discussion

### 4.1. Findings

In this paper we propose a more practical risk scale for adults admitted to the emergency general surgical setting, using only five

**Table 3**

Results of logistic regression analysis examining outcomes (OR (95%CI)) compared with an increasing SHARP score (reference category = score 0) (n = 419).

	Model A			Model B			Model C		
	OR	95%CI	P	OR	95%CI	P	OR	95%CI	P
<b>90-day Mortality</b>									
1	3.78	0.34 to 42.42	0.281	4.47	0.40 to 50.51	0.227	4.79	0.42 to 54.68	0.208
2	3.59	0.32 to 40.22	0.300	4.27	0.38 to 48.32	0.241	4.38	0.39 to 49.83	0.234
3	5.28	0.47 to 59.48	0.178	6.51	0.57 to 74.36	0.132	5.85	0.49 to 70.30	0.164
4	22.27	2.67 to 186.02	0.004	27.21	3.20 to 231.32	0.002	27.25	3.10 to 329.81	0.003
5	46.67	4.83 to 551.36	0.001	49.30	0.84 to 6.79	0.001	57.90	4.29 to 534.36	0.002
<b>30-day Readmission</b>									
1	2.82	1.31 to 6.05	0.008	2.63	1.21 to 5.69	0.014	2.59	1.18 to 5.67	0.018
2	1.45	0.62 to 3.36	0.391	1.34	0.57 to 3.14	0.500	1.28	0.54 to 3.02	0.579
3	2.27	0.96 to 5.36	0.062	2.08	0.87 to 4.97	0.100	1.60	0.62 to 4.14	0.334
4	2.79	1.19 to 6.53	0.018	2.59	1.10 to 6.12	0.030	2.17	0.88 to 5.36	0.094
5	0.00	0 to 0	0.998	0.00	0.00 to 0.00	0.998	0.00	0.00 to 0.00	0.998
<b>Greater than Median LOS (&gt;5 days)</b>									
1	3.30	1.79 to 6.06	<0.001	3.69	1.98 to 6.87	<0.001	3.33	1.77 to 6.29	<0.001
2	4.49	2.46 to 8.18	<0.001	5.06	2.73 to 9.39	<0.001	4.82	2.58 to 8.99	<0.001
3	10.30	5.01 to 21.17	<0.001	11.95	5.69 to 25.11	<0.001	11.38	5.19 to 24.96	<0.001
4	11.29	5.33 to 23.91	<0.001	12.92	5.99 to 27.90	<0.001	12.21	5.51 to 27.04	<0.001
5	27.03	5.81 to 125.71	<0.001	1.62	6.06 to 132.93	<0.001	24.91	4.96 to 124.99	<0.001

Model A: Unadjusted. Model B: Adjusted for sex. Model C: Model B + adjusted for CRP (>3), frailty (CFS 5–7).

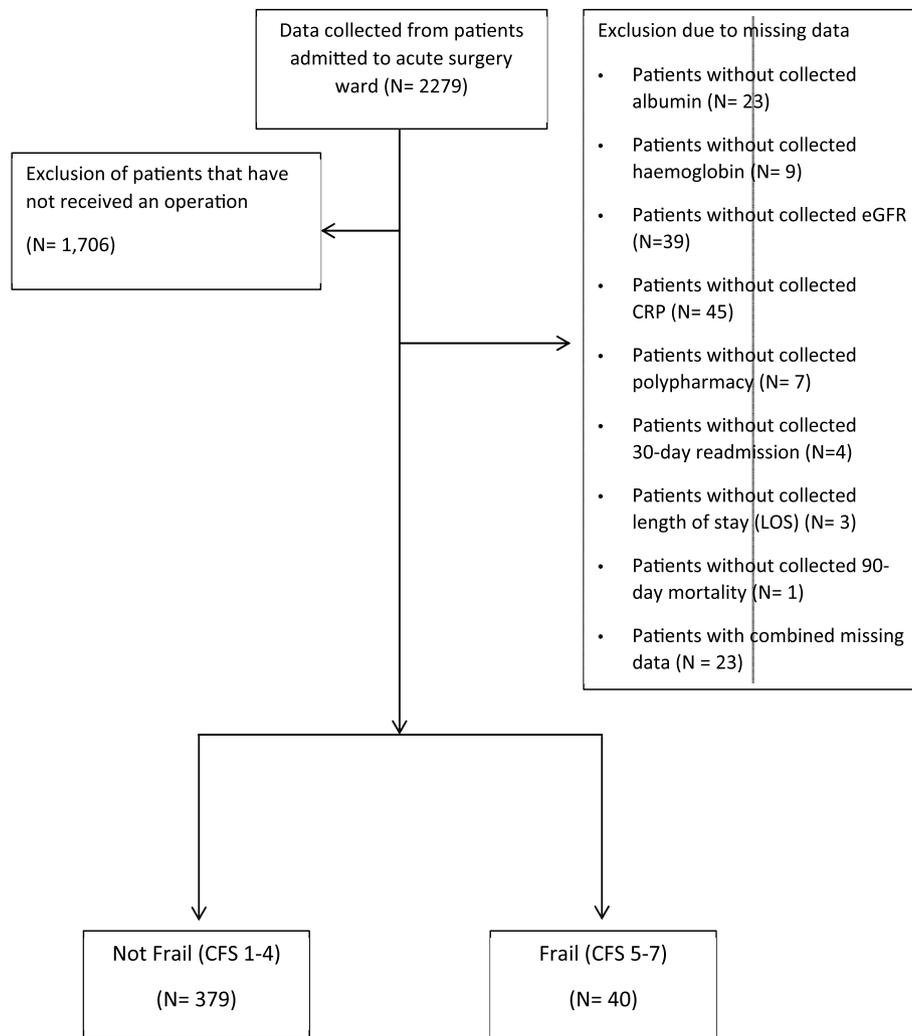


Fig. 1. Table of exclusion.

easily obtainable patient characteristics at the point-of-care, prior to operative treatment. We demonstrated the linear relationship between the incremental increase in SHARP score point and poorer outcomes such as mortality and increased length of hospital stay.

#### 4.2. Impact on research

SHARP scale confirmed earlier reports on hypoalbuminemia and anaemia both being independent risk factors associated with mortality.<sup>11,12,17,18</sup> Whilst we did not record the incidence of these complications, we did record surrogate markers of surgical complications such as increased length of hospital stay and 30-day readmission which are complications of pathological changes discussed below.

In the young, anaemia is most commonly associated with iron deficiency, however, in older populations anaemia can indicate advanced chronic diseases such as chronic kidney disease, liver cirrhosis or malignancy. These irreversible causes of anaemia, akin to frailty, are associated with an impaired physiological reserve baseline, which predisposes these patients not only to prolonged hospital admissions in order to reach suitable stability for safe discharge but also hospital re-admissions, due to their higher risk of deteriorating following discharge.<sup>19,20</sup>

Studies have linked hypoalbuminemia to post-operative

complications such as anastomotic leaks and surgical site infections.<sup>21,22</sup> Hypoalbuminemia is most commonly used as a marker of malnutrition and has been reported as a risk factor for complications such as infections and poor wound healing. Malnutrition is thought to predispose patients to surgical site infection by impairing wound healing and prolonging inflammation via mechanisms such as impaired fibroblast proliferation and impaired collagen synthesis. Additionally, a decreased lymphocyte count is thought to impair the ability of the immune system to eradicate or prevent infection.

When compared to P-Possum score we adjusted SHARP to specific inflammatory markers such as CRP rather than white blood cell count which can indicate various issues such as infection, trauma, allergy and inflammation. The American NS QUIP uses serum potassium and sodium concentration.<sup>18</sup> The National Kidney Disease Education Program recommends calculating glomerular filtration rate from serum creatinine concentration and therefore we used eGFR over other parameters.<sup>23</sup>

A systematic review which investigated the impact of frailty on mortality; identified frailty as a significant predictor of adverse postoperative outcomes.<sup>24,25</sup> Hewitt J et al.,<sup>13</sup> reported that frailty had an influence on a post-operative outcomes and clinical outcome in all adults. This was considered and confirmed through our scale adjustments. SHARP does not contain physiological

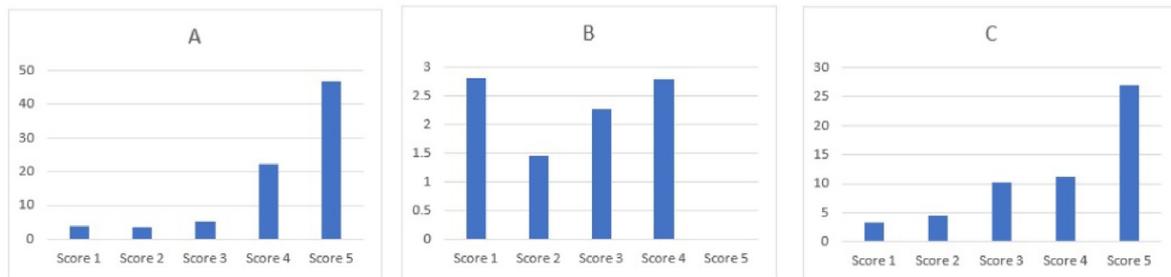


Fig. 2. Comparing SHARP risk score to outcomes (N = 419).

parameters such as cardiac and respiratory function used by both P-Possum and the American NS QUIP, as the aim was to produce a simplified, more generalised risk scale that predicts poor patient outcomes. Furthermore, although the MALE score is useful in the elderly adult population, the scoring system is not generalizable to all adults.<sup>28</sup> The APACHE score was deemed impractical for the clinical setting since it uses thirty-four different individual variables on patients past medical history as well as current condition and severity. Furthermore, it needs to be combined with additional assessments such as a chronic health evaluation in order to calculate a severity score which can then help guide ceiling of care rather than predict poorer outcomes.<sup>26</sup> Even though, in its updated version, APACHEII included a reduction in the number of variables to 12, it still failed to predict mortality in population samples different to the one used in its development.<sup>27</sup> The addition of further variables was considered and disregarded as the most important part of the risk scale was to allow for a fast appraisal which would complement the experienced surgeon's decision. Moreover, the variables used were very carefully selected, in order to be appropriate and significant to the context.

#### 4.3. Strengths and weaknesses

Pre-operative risk assessment allows for appropriate pre-emptive resource allocation which allows for improved patient centred care, reduction of stress as well as expenses. Appropriately assessed patients before major abdominal surgery can have identifiable and modifiable risk factors that can be addressed before surgery.<sup>28</sup>

A potential weakness of this study is the diversity of the different organs affected and the types of surgical intervention available to treat them which is not appropriately reflected by the relatively small number of patients. Ideally a subgroup analysis of the different surgical pathologies of emergency general surgery such as acute cholecystitis and acute appendicitis could be of added value once the risk scale has been validated in a larger cohort of patients.

Despite the inclusion of all unselected adults, our study may suffer from selection bias due to data being collected over May-June in four consecutive years. In order to minimise bias, the data was collected across all sites during the same periods. We acknowledge the limitations of non-randomized study designs. Data was not collected on individual co-morbidities and therefore we cannot be certain that associations were not influenced by specific co-morbidities. Factors such as malignancy and type of surgery may have an impact on mortality. We acknowledge that each operation will be associated with varying degrees of risk which was not accounted for in this study. Nevertheless, the SHARP risk score adjusted for pre-operative variables which predicted poor patient outcomes inspite of this.

## 5. Conclusion

SHARP risk score provides clinicians with an easy method of calculating the risk of poor outcomes based on point-of-care pre-operative information in patients undergoing emergency general surgery. The SHARP risk score will allow clinicians to prioritize patients for comprehensive assessment which has been shown to improve patient outcomes in the surgical setting.

## Declarations

### Statement of ethics

The protocol for this study conforms to the ethical guidelines of the 1964 Declaration of Helsinki and its later amendments. This study was deemed a service evaluation and did not require ethical approval and was registered at each participating site and received approval from individual organisations.

### Conflict of interest statement

No conflict of Interest.

### Funding resources

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### Author contribution

PKM, BC, and JH conceived the study. JH is the PI of OPSOC. PT conducted the literature search, statistical analysis and drafted the manuscript under the supervision of ADA, BC and PKM. BC was the study statistician. PKM, SM, KM, JH, WC and KM are the lead investigators of the participating centres of OPSOC. All authors contributed to the writing of this paper. PKM is the guarantor.

### Guarantor

Professor Phyto K Myint.

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