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1 **Anaemia in patients undergoing major bowel surgery - prevalence and current**
2 **practice: a public and private institution experience**

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20 Keywords: iron, anaemia, blood management, blood transfusion, preoperative period

21

22 **Abstract**

23 **Aim** The study aimed to compare the frequency and alignment of preoperative anaemia screening and
24 treatment with Australian guidelines in elective bowel surgery and determine the impact on clinical
25 outcomes.

26 **Methods** We performed a retrospective observational study, with an audit of 559 adult patients who
27 underwent major elective bowel surgery in an Australian metropolitan hospital, January 2016 to
28 December 2018. Outcome measures included rate of anaemia, guideline compliance, hospital length
29 of stay and transfusion rate.

30 **Results** Preoperative anaemia assessment occurred in 82.6% of patients. However, only 5.2% received
31 recommended biochemical tests at least one week before surgery. Only 25.2% of anaemic patients
32 received preoperative treatment; they experienced a longer hospital length of stay (LOS) (9.93 days vs
33 7.88 days, $p < 0.001$) and an increased rate of transfusion (OR: 3.186, $p < 0.05$).

34 **Conclusion** The gaps between current preoperative anaemia screening, management, and national
35 guidelines, may place patients at higher risk of poor surgical outcome.

36 **Background:**

37 Preoperative anaemia is common in patients undergoing bowel surgery and is a predictor of poor
38 surgical outcomes, including increased hospital LOS, morbidity and health expenditure (Michailidou
39 & Nfonsam 2018, Shander et al 2012). These adverse outcomes may be avoided if anaemia is
40 addressed in the preoperative setting. This highlights the need for timely anaemia assessment and
41 prompt treatment in the preoperative setting.

42

43 Patient Blood Management (PBM) is an approach designed to optimise factors associated with blood
44 loss in the perioperative setting, potentially reducing the incidence of unnecessary transfusion and
45 improving patient outcomes (Society for the Advancement of Blood Management (SABM) 2019).
46 The current PBM model consists of three pillars: optimising red blood cell mass, minimising blood
47 loss, and managing anaemia (SABM 2019). Healthcare facilities that endorse this strategy have
48 reported significant improvement in surgical outcomes and reduced hospital costs (Leahy et al 2017).
49 For these reasons, the National Safety and Quality in Health Care Standards (NSQHC) mandate that
50 hospitals embed PBM in their provision of clinical care; and healthcare providers are encouraged to
51 form multidisciplinary teams to determine how PBM can be effectively incorporated into local
52 practices (Australian Commission on Safety and Quality in Health Care 2017, Delaforce et al 2018).

53

54 Since anaemia management is part of PBM, treatment should be commenced on diagnosis, and
55 consideration given to delaying the surgery, if feasible, to minimise the risk of poor surgical outcomes
56 (National Blood Authority (NBA) 2012). Traditionally, oral iron supplementation is indicated if iron
57 deficiency, with or without anaemia, is confirmed. However, its use is limited by patient complaints
58 of gastrointestinal side effects and the poor bioavailability of iron salts, especially in those with bowel
59 conditions (Leal-Noval et al 2013, Madrazo-González et al 2011, Weiss & Goodnough 2005).
60 Intravenous (IV) iron has been proposed as a superior alternative since it bypasses the gastrointestinal
61 tract, ensuring a 100% bioavailability and a better side effect profile (Baird-Gunning & Bromley

62 2016, Girelli et al 2018). However, the increasing use of iron infusion has led to reports of rare, but
63 severe hypophosphataemia and permanent skin discolouration, associated with either iron's
64 pharmacology or the process of administration (Chen et al 2019, Harris et al 2018).

65

66 To maintain high-quality patient care, healthcare facilities need to examine the level of alignment
67 between their hospital performance and the national PBM guidelines. Work is currently being
68 undertaken at our health facility, in order to identify alignment gaps and develop a robust
69 improvement plan. Other facilities have applied auditing methods to assist in revealing gaps in
70 practice, including a 2015 Australian study involving hospitals in most states which indicated the
71 quality of anaemia screening and treatment remains suboptimal (Department of Health and Human
72 Services Victoria (DHHSV), Blood Matters (BM) 2016). The study revealed only 32% of patients are
73 receiving timely preoperative anaemia assessment that is needed to differentiate the anaemia type, and
74 facilitate appropriate management before surgery. Patients should have at least a full blood count
75 (FBC), ferritin test, and C-Reactive Protein (CRP) at least one week before surgery (DHHSV, BM
76 2016). Limited Australian data have been published since the 2015 study in the bowel surgery
77 population (Hong et al 2018). As there is a lack of clinical data on the effect of perioperative anaemia
78 in bowel surgery patients and uncertainty around the implementation of PBM in the local setting,
79 close monitoring of current practice is vital to guide PBM implementation and identify areas for
80 improvement. Our study aimed to investigate the compliance of anaemia assessment and treatment in
81 accordance with PBM guidelines at a major metropolitan tertiary care hospital, specifically in patients
82 undergoing bowel surgery, and to find if there was an association between anaemia; length of stay and
83 risk of transfusion.

84

85 **Methods:**

86 We conducted an observational, retrospective chart audit at a large Australian metropolitan teaching
87 healthcare facility, with ethical review exemption received from the hospital Human Research Ethics

88 Committee (52917-EXMT/MML/52917 (V1)). This pragmatic approach was chosen as it enabled our
89 team to address a clinical question, through cost-effective longitudinal data access in a large
90 population of interest. As health service data were routinely collected without specific *a priori*
91 research goals, we conducted and reported this research in accordance with the reporting of studies
92 Conducted using Observational Routinely-collected health Data (RECORD) guideline (Benchimol et
93 al 2015).

94

95 Inclusion and exclusion criteria: We included both private and public patients aged 18 or older at
96 admission who underwent major elective bowel surgery between January 2016 and December 2018.
97 We used diagnosis-related group (DRG) codes for major bowel surgery: G01A/B/C and G02A/B/C to
98 assist in patient selection. A team of a surgeon, registered nurse, and pharmacist was formed to assess
99 whether the surgical procedure met the inclusion criteria and minimise any potential DRG coding
100 errors. We excluded patients admitted for emergency surgery or those patients without evidence of
101 preoperative screening. Patients who underwent minor surgery were also excluded as minimal blood
102 loss is anticipated in their surgery, and thus, are less likely to be affected by preoperative anaemia.

103

104 An electronic audit tool was developed by the research team, using evidence-based criteria, sourced
105 from both local policy and the PBM Guidelines: Module 2 – Perioperative, published by the NBA
106 (2012). Measures were categorised and collected across the patient’s surgical journey (Box 1).
107 Categories measured were deemed integral to appropriate surgical care and blood management. All
108 patient data were de-identified to preserve privacy.

109

110 The audit tool was initially piloted for utility, using the electronic medical records of ten patients, to
111 collect demographics, measures and outcomes described in Box1. Two team members independently
112 extracted and recorded the data, with any discrepancies or clarifications resolved, and the tool
113 adjusted prior to data collection.

114 The primary study outcome was to determine the proportion of patients who were screened as
115 anaemic, requiring preoperative iron therapy, and did receive it. The questions were developed to
116 assess the level of compliance with PBM Guidelines (2012); and cases were classified using patient
117 haemoglobin (Hb) levels as a primary denominator in anaemia screening. Hb levels <130g/L for men
118 and <120 g/L for women were considered anaemic. Further testing results, including ferritin and CRP
119 levels, were used to differentiate the type of anaemia. We also compared our laboratory screening
120 audit results with a 2015 Australian multisite audit which was previously benchmarked against the
121 NBA PBM guidelines (DHHSV & BM 2016).

122

123 Data and statistical analysis:

124 Data collected were summarised and reported as means for continuous variables, and as proportions
125 for categorical variables. Proportion, log-rank, and unpaired t-tests were used as appropriate. Logistic
126 regression analysis was performed to determine the odds ratio of the testing subjects. Statistical
127 significance was set as a two-tailed p-value < 0.05. All statistical analysis was performed with R
128 (version 3.6.1).

129

130 Results:

131 Within the 3-year period, 863 patient records were retrieved from the hospital electronic medical
132 record system. After applying the exclusion criteria, 559 patients were included for audit. Patient
133 characteristics are reported in Table 1. The majority admitted for bowel surgery were cancer patients
134 (62.6%), followed by inflammatory or infective bowel disease, including Crohn's disease and
135 ulcerative colitis (23.1%), bowel disease (10.2%), and ileostomy or colostomy procedure for non-
136 malignant disease (4.1%).

137

138 Of these 559 patients, 462 (82.6%) received some preoperative blood testing for anaemia. Of those
139 who were assessed, 310 patients (67.1%) were screened less than one week before their surgery. One
140 hundred and thirty-four (29.0%) patients were assessed 1 week up to 6 weeks and 18 (3.9%) greater
141 than 6 weeks prior to surgery.

142

143 Of the patients who were screened for preoperative anaemia, FBC results were retrieved for 459
144 (99.4%). However, other tests that assist in differentiating the type of anaemia were less commonly
145 conducted alongside the FBC; only 51 (11.0%) patients were assessed for ferritin levels and 92
146 (19.9%) had their CRP levels tested. In total, 167 (36.1%) patients were found to be anaemic in the
147 preoperative setting. However, the majority (n=147, 88.0%) were classified to have undifferentiated
148 anaemia, as further results were needed to determine anaemia type. Table 2 shows the screening tests
149 performed and other screening results. When we compared our audit results of screening laboratory
150 parameters with those from the 2015 multi-state audit (Figure 1), the bar graph indicates our
151 healthcare facility was performing comparably in relation to the proportion of FBCs undertaken in the
152 preoperative setting and even better for conduct of renal function tests. However, performance in
153 determining patient anaemia status for the healthcare facility studied, especially ferritin test results
154 (11.0% versus 31.2% multi-state audit), was subpar.

155

156 Overall, only 42 (25.2%) patients from the anaemic group received treatment preoperatively, 27
157 received IV iron, seven took oral iron supplementation and eight had a preoperative transfusion. A
158 small proportion of the non-anaemic patients also received treatment in the preoperative phase, with
159 four receiving IV iron (Table 3).

160

161 When comparing the anaemic group with the non-anaemic group, the former had a significantly
162 higher mean hospital LOS (9.93 days vs 7.88 days, $p < 0.001$, Figure 2). They also had a higher
163 perioperative transfusion rate than the non-anaemic group (OR: 3.186, $p = 0.049$). In addition, anaemic

164 patients required more units of blood than the non-anaemic group (2.43 units vs 1.40 units) (Table 4).
165 All of these factors are likely to be associated with higher admission-related costs.

166

167 Discussion:

168 This longitudinal retrospective audit indicated that preoperative anaemia is commonly assessed in
169 patients undergoing surgery. However, the majority of these assessments did not comply with the
170 NBA PBM guidelines, with only 5.7% of all patients having the recommended blood tests (at least an
171 FBC, ferritin test and CRP) within the recommended timeframe (at least 1 week before surgery). As
172 preoperative anaemia is a powerful predictor of perioperative transfusion, failure to provide quality
173 anaemia assessment means patients are potentially at risk of preventable suboptimal surgical
174 outcomes, including an increased mortality rate and in-hospital morbidity, which can be further
175 translated into an increased health expenditure (Khanna et al 2003, Goel et al 2018). Anaemic patients
176 should also be screened for anaemia post-surgery, and iron (oral or IV) prescribed if appropriate, with
177 the use of postoperative transfusion limited to patients who reach the restrictive transfusion threshold
178 (Muñoz et al 2018).

179

180 Most patients (67.1%) received anaemia assessment less than 1 week before the surgery: these
181 patients were potentially at a higher risk of poor postoperative outcomes, as the timeframe was
182 insufficient for anaemia to be investigated and treated without delaying surgery. Suboptimal
183 laboratory anaemia evaluations, defined as not having all of the preoperative blood tests
184 recommended by the NBA PBM Guidelines (2012), can also affect diagnosis of anaemia type and
185 related treatment. This can adversely impact on the appropriate use of iron supplementation, which
186 should be avoided in patients with anaemia of chronic illness or inflammation without treatment of the
187 underlying disease (Weiss et al 2019). Treatment may not be effective and may even cause harm in
188 iron overload disorder or renal impairment (Rostoker 2019).

189

190 The occurrence of preoperative anaemia in our study cohort (36.1%) falls within the reported range of
191 preoperative anaemia from other bowel or colorectal studies, between 22-76% (Shander et al 2004,
192 Wilson et al 2017). Our results also confirm that patients undergoing bowel surgery with preoperative
193 anaemia are subject to poor surgical outcomes, including increased transfusion rates and hospital
194 LOS, which once again emphasises the importance of adherence to the PBM guidelines.

195

196 Of those who were anaemic and received preoperative treatment, 81% received iron (but only 16.7%
197 oral iron) and 19.0% a transfusion. Anaemic patients required more units of blood than the non-
198 anaemic group (2.43 units vs 1.40 units). This mirrors the current evidence base, including a
199 retrospective study in colorectal cancer surgical patients, where anaemia treated with oral iron
200 supplementation reduced the need for perioperative transfusion from 27.4% to 9.4% ($p < 0.05$),
201 compared to those who did not receive any preoperative treatment (Okuyama et al 2005). In our audit,
202 four patients without anaemia received preoperative IV iron. This is clinically inappropriate and puts
203 patients at risk of iatrogenic injury. Unnecessary use of parenteral iron in the non-anaemic population
204 should be discouraged, and this risk can be minimised by appropriate application of PBM principles.

205

206 The patient group not screened for preoperative anaemia generally had a shorter LOS than those who
207 were screened (8.62 vs. 5.32, $p < 0.001$). While this may seem counterintuitive, it is probable that
208 clinicians know which groups of patients tend to be anaemic, and therefore, more likely to order blood
209 tests in this cohort. However, as the quality of these anaemia assessments was suboptimal, it is
210 unlikely for the anaemia to be resolved prior to surgery, which might explain the increased hospital
211 LOS. The comparison of laboratory parameter screening between our hospital and the 2015 multi-
212 state audit suggests potential benefit from improved communication, by surgical leadership teams, to
213 disseminate the importance of differentiating anaemia types, and how appropriate identification and
214 management can improve patient outcomes (DHHSV & BM 2016).

215

216 In Australia, PBM implementation remains at an early stage. However, a retrospective multisite audit
217 of over 600,000 Western Australian elective surgery patients confirmed that a jurisdiction-wide PBM
218 program can have a positive impact on patient outcomes (reduction of in-hospital mortality odds ratio
219 0.72), reduced blood product utilisation (41% reduction in units per admission ($p < 0.001$), and
220 product-related costs (\$18,507,023 AUD saved over six years) (Leahy et al 2017). As timely anaemia
221 treatment, particularly preoperative iron supplementation, remains a crucial component of PBM,
222 emphasis should be placed on building a multidisciplinary model to prevent and manage preoperative
223 anaemia. PBM, along with the application of relevant PBM education, audit and feedback
224 interventions, combine to play a crucial role in ensuring patient and medication safety. Restrictive
225 transfusion has also been used by some hospitals, resulting in a dramatic decrease in the proportion of
226 patients transfused without affecting clinical outcomes (Carson et al 2012).

227

228 The major limitation of our study is that it took place at a single centre, so the results may not reflect
229 current practice at other healthcare facilities. However, as our patients were drawn from both our
230 public and private hospitals over a three-year period, it increases the generalisability of our findings.
231 As bowel surgery is not the only surgery with high bleeding risk and PBM guidelines apply, we
232 intend to expand our approach to audit a broader range of major surgical procedures. This will allow
233 surgical specialities to review and compare their local performance, increasing ownership of audit
234 findings and encouraging development of tailored strategies to overcome identified practice gaps.
235 Future local audits are essential to maintain quality of practice and guide hospital feedback activities.
236 At our institution, a newly formed multidisciplinary program of quality improvement will act as a
237 resource for future activities. Our study failed to demonstrate preoperative iron treatment (oral or IV)
238 was associated with reduced hospital LOS or units of blood transfused. However, the treated groups
239 appeared to have a lower rate of transfusion (OR:0.226, $p=0.002$).

240

241 In conclusion, our PBM bowel surgery audit contributes to contemporary Australian evidence on the
242 clinical impact of preoperative anaemia screening and treatment. It highlights that patients undergoing
243 bowel surgery are at moderate risk of being anaemic, risk transfusion and an extended hospital LOS.
244 Moreover, the current practice around preoperative anaemia screening and subsequent treatment
245 remains suboptimal. It appears there is still a sizeable gap between the recommended Australian PBM
246 guidelines and current practice.

247

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251

252 Author contribution

253 EP, AD, DP & TM contributed to the study design. EP, AD & LA reviewed the patient selection
254 criteria. EP conducted the audits. EP, AD, DP & TM contributed to analysis and interpretation of
255 results. All authors contributed to review of results and the final manuscripts.

256

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260

261 Declaration of Conflicting Interests

262 The Authors declare that there is no conflict of interest.

263

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352

353 **Table 1. Patient demographics**

	All patients (n=559)	Anaemic Patients (n=167)	Non- anaemic Patients (n=295)	Patients without evidence of preoperative screening (n=97)	Public patients (n=183)	Private patients (n=376)
Male:Female (n:n)	258:301	79:88	135:160	44:53	74:109	184:192
Age (mean)	59.86	63.17	59.3	55.84	57.33	61.09
Principal diagnosis (n,%)						
Bowel disease	57 (10.2%)	11 (6.6%)	30 (10.2%)	16 (16.5%)	23 (12.6%)	34 (9.1%)
Bowel neoplasm	350 (62.6%)	114 (68.2%)	183 (62.0%)	53 (54.6%)	125 (68.3%)	225 (59.8%)
Inflammatory/infective bowel disease	129 (23.1%)	37 (22.2%)	72 (24.4%)	20 (20.6%)	32 (17.5%)	97 (25.8%)
Ileostomy & colostomy for non-malignant disease	23 (4.1%)	5 (3.0%)	10 (3.4%)	8 (8.3%)	3 (1.6%)	20 (5.3%)

354

355

356 **Table 2. Screening outcomes**

		Total patient (n=559)
Total number of patients screened		462 (82.6%)
Time of assessment prior to surgery		Of those assessed (n=462)
	0-1 day	186 (40.3%)
	2-6 days	124 (26.8%)
	1 week up to 6 weeks	134 (29.0%)
	6 weeks and greater	18 (3.9%)
Blood test performed		Of those assessed (n=462)
	FBC	459 (99.4%)
	Ferritin	51 (11.0%)
	Folate	16 (3.5%)
	B12	16 (3.5%)
	CRP	92 (19.9%)
	Renal function	439 (95.0%)
Screening results		Of those assessed (n=462)
	Anaemic	167 (36.1%)
	Non-anaemic	295 (63.9%)
Anaemia classification		Of those anaemic (n=167)
	Undifferentiated anaemia	147 (88.0%)
	Iron deficiency anaemia	8 (4.8%)
	Iron deficiency	2 (1.2%)
	Anaemia of inflammation/chronic disease	10 (6.0%)

357

358

359 **Table 3. Summary of preoperative treatment**

	Anaemic patients (n=167)	Non-anaemic patients (n=295)	All patients (n=559)
Received treatment	42 (25.2%)	7 (2.4%)	51 (9.1%)*
Types of treatment received			
Oral iron	7 (16.7%)	3 (42.9%)	12 (23.5%)
Intravenous iron	27 (64.3%)	4 (57.1%)	31 (60.8%)
Preoperative transfusion	8 (19.0%)	0 (0%)	8 (15.7%)

360 * 2 patients received treatment without preoperative testings

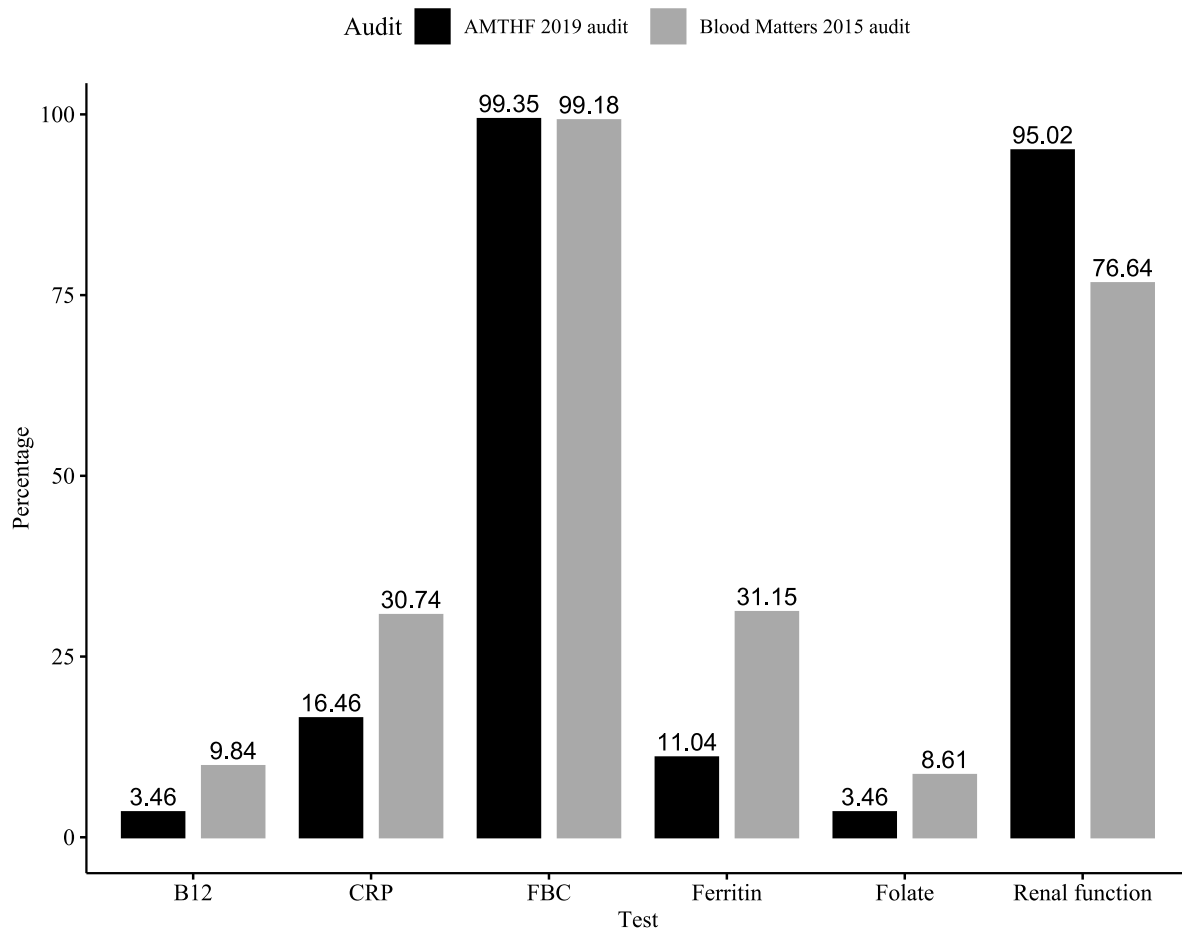
361

362 **Table 4. Postoperative outcomes comparing different groups**

	Anaemic patients (n=167)	Non-anaemic patients (n=295)	p-value
Mean hospital LOS (days)	9.93	7.88	p<0.001
Number of patients transfused perioperatively	42 (25.1%)	5 (1.7%)	OR: 3.186, p=0.049
Mean unit of blood transfused	2.43	1.40	p=0.36

363

364

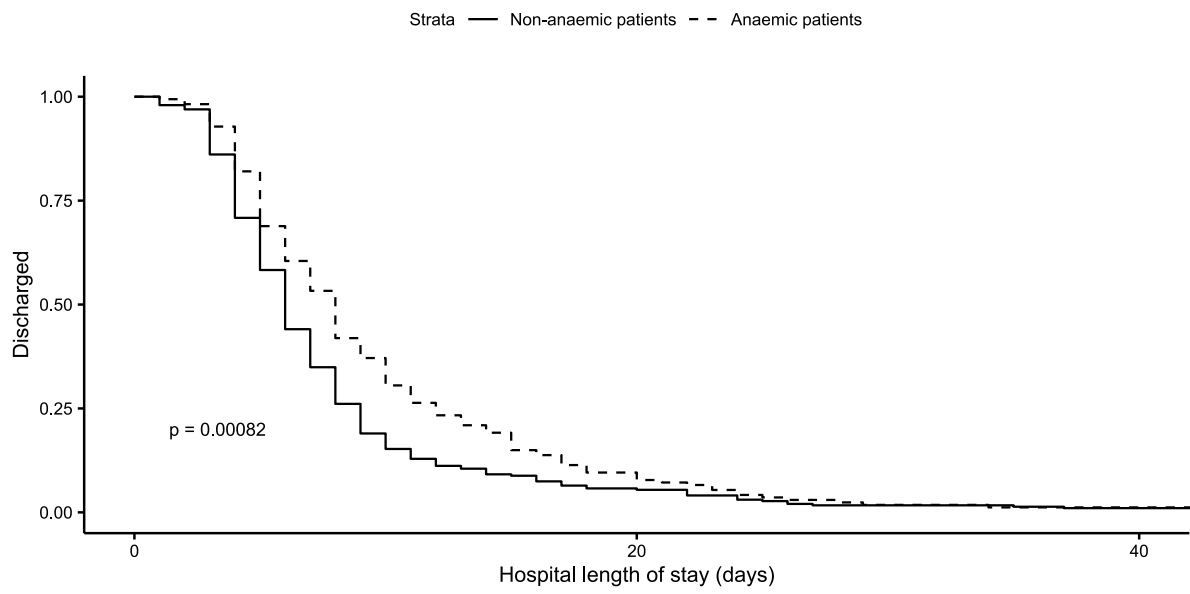


365

366 **Figure 1. Bar graph comparing screening laboratory parameters for two audits: Australian**
 367 **metropolitan teaching healthcare facility (AMTHF) and Australian ‘Blood Matters’ 2015 audits**
 368 **(DHHSV & BM 2016). *Blood Matters audit data used with permission**

369

Impact of anaemia status on hospital length of stay



370

371 **Figure 2. Impact of anaemia status on hospital length of stay**

372 *Key: 0.5=50% of the patients remain admitted.*

373

374 **Box 1. Categories of audit questions**

Patient details	<ul style="list-style-type: none"> • Patient record number • Age, Gender • Principal diagnosis • Comorbidities relevant to anaemia or increased bleeding or clotting risk e.g. inflammatory bowel disease, heart failure, ischaemic heart disease, chronic renal failure, haematological malignancy, haemoglobinopathy that requires regular transfusion
Pre-surgical assessment for anaemia or bleeding risk	<p>Was the patient assessed? If yes:</p> <ul style="list-style-type: none"> • Time of assessment prior to surgery • Which blood tests results were available, specifically: vitamin B₁₂, C-reactive protein (CRP), folate, full blood count (FBC), iron studies including ferritin and renal function • Screening results (anaemic vs non-anaemic) and anaemia classification • Whether the available blood test results indicated that treatment was required • Based on haematological values, whether treatment was required <p><i>Was assessment in accordance with the PBM Guidelines?</i></p>
Surgical details	<ul style="list-style-type: none"> • Surgical diagnosis related group (DRG) • Surgical team • Surgery conducted in a public or private hospital
Hospital length of stay (LOS)	<ul style="list-style-type: none"> • Number of days
Pre-operative treatment	<p>Was treatment provided? If yes specify:</p> <ul style="list-style-type: none"> • Oral iron (dose, frequency of administration) • Intravenous iron (dose, rate, frequency of administration)

	<ul style="list-style-type: none"> • Transfusion <p><i>Was treatment in accordance with PBM Guidelines?</i></p>
Contraindications to intravenous iron?	<ul style="list-style-type: none"> • Known hypersensitivity, atopic allergies, fluid overload, acute renal dysfunction, hepatic impairment, infection, iron overload, sodium restriction, uncontrolled hyperparathyroidism
Reassessment after treatment and before surgery (blood tests)?	<ul style="list-style-type: none"> • Was the patient reassessed? If yes: • Was the patient optimised according to the PBM guidelines i.e. Hb >130g/L (male) or Hb > 120 g/L (female)
Comparison of post-operative outcomes in anaemic vs non-anaemic groups	<ul style="list-style-type: none"> • Mean LOS • Number of patients transfused perioperatively • Mean unit(s) of blood transfused
Postoperative treatment	<p>Was postoperative treatment provided? If yes:</p> <ul style="list-style-type: none"> • Transfusion and number of units • Was the transfusion clinically appropriate • Discharged on oral iron