Putting us to the test: An assessment of the agreement between preoperative investigations ordered and evidence-based guidelines at a tertiary level hospital in the Western Cape Province, South Africa – a retrospective record review study

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Background. Recommendations for preoperative investigations are available worldwide, and are advocated for in an attempt to reduce unnecessary testing, especially in healthy patients undergoing low-risk surgery. However, despite these guidelines, unnecessary preoperative testing still occurs. This is the first South African study comparing preoperative investigations ordered with the recommendations of both the National Institute for Health and Care Excellence (NICE) and local preoperative testing guidelines.

Objectives. Primary objectives were to describe the preoperative investigations ordered in patients undergoing elective surgery, compare these with international and local guidelines, and assess the cost of overtesting. Secondary objectives were to assess the frequency of abnormal laboratory results in tests not indicated by the guidelines, as well as to assess patterns in overtesting.

Methods. This was a retrospective record review study of American Society of Anesthesiologists (ASA) 1 and 2 patients undergoing elective minor and intermediate surgical procedures in Tygerberg Hospital between November and December 2021. The preoperative investigations of 501 patients were studied, including laboratory tests (full blood count (FBC), urea, creatinine and electrolytes panel and international normalised ratio), point-of-care haemoglobin, chest radiographs (CXRs) and electrocardiograms. Tests were compared with guidelines, and the cost of any overtesting was calculated. Patterns in overtesting were evaluated. Data were sourced from electronic medical records. SPSS version 28 was used to analyse data.

Results. A total of 501 patients undergoing elective surgery were included. As many as 89% of the cohort had at least one unnecessary test done (95% confidence interval 85.9 - 91.6). Overall, FBCs and CXRs were the most overtested investigations, being done unnecessarily in one-third of patients. Redundant duplicate testing occurred 177 times. The projected potential cost savings on preoperative investigations if NICE guidelines were followed at Tygerberg Hospital are ZAR857 987 per annum, and ZAR696 515 per annum if the local guidelines are followed. Extra testing as per local guidelines compared with NICE guidelines was mostly unhelpful to reveal additional clinically relevant abnormalities. General surgery patients, patients aged >35 years, ASA 2 patients and females were subject to the highest levels of overtesting ($p<0.001$).

Conclusion. Preoperative testing over and above testing recommended by both international and local guidelines is common, and represents an enormous area for potential cost savings in a resource-limited environment. Additional local studies are required to further expand on overtesting and the factors contributing to it.

Keywords: overtesting, preoperative testing, NICE guidelines, elective surgery, cost

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It is now commonly accepted that a flurry of routine investigations in healthy patients having low-risk surgery is unlikely to be of benefit to the patient.[1-4] The practice advisory of the American Society of Anesthesiologists (ASA) advises targeted testing (for a specific clinical indication or purpose) over routine testing (in the absence of a specific clinical indication or purpose).[3] The test should be likely to both yield an abnormal result and influence management.[4]

The implementation of preoperative testing guidelines reduces costs, regardless of which specific guideline is used.[5,6] Unnecessary tests add to additional man-hours of laboratory staff, prolonged hospitalisations, the cost of follow-up tests and consultations, and possible cancellation or postponement of surgery, while being unlikely to change outcome or predict risk.[5,7,8] One must also factor in the increased risk of occupational exposure to needlestick injuries, and the emotional and social implications of false positive findings.[9]

Numerous guidelines have been formulated using systematic reviews of evidence gathered in developed countries.[3,10-12] The National Institute for Health and Care Excellence (NICE) guidelines, updated in 2016, recommend specific testing based on type and complexity of surgery (categorised as minor, intermediate or major/complex), as well as patient ASA physical status classification.[10] Local guidelines may need to account for a higher prevalence of certain ailments, such as tuberculosis, anaemia, or malnutrition.[13] Both the NICE and the local Tygerberg Hospital guidelines (which were an adaptation of the NICE guidelines) were used as comparators in the present study.

Despite the formulation of guidelines, there is a myriad of evidence that suggests that preoperative investigations are being performed

with poor concordance with the available guidelines, especially in healthy patients undertaking low-risk surgery.[9,13-19] Potential for cost savings is especially valuable in low- and middle-income countries (LMICs).[9]

As there is a relative scarcity of practice data in LMICs, the current study aimed to increase the pool of evidence-based knowledge accessible to healthcare providers in South Africa (SA), and to improve awareness on the issue of preoperative overtesting among healthcare practitioners. The current study was conducted at a tertiary level centre, and the latest pricing of investigations was used in its assessment.

Methodology

Study design and setting

This was a retrospective record review study analysing the adherence to evidence-based guidelines with regard to preoperative investigations ordered in ASA 1 and 2 patients coming to theatre for minor to intermediate elective surgical procedures in November and December 2021 at our institution. Minor surgery was defined as surgery with minimal risk, minimal invasiveness, risk of blood loss <500 mL, minimal potential for fluid shifts and reported cardiac risk generally <1%. Intermediate surgery was defined as surgery with mild to intermediate risk, minimal to moderate invasiveness, risk of blood loss <500 mL, with a reported cardiac risk generally <5%. Tygerberg Hospital (TBH) is a tertiary academic hospital located in Parow, Cape Town. With an annual budget of ZAR2.6 billion, TBH services a drainage area with a population of >3.4 million people, and performs 30 784 operations annually in its 29 operating theatres.[20] The tests that were selected for the current study included blood tests (full blood count (FBC), urea, creatinine and electrolytes (U&E) and international normalised ratio (INR) for clotting status), point-of-care (POC) haemoglobin (Hb), chest radiographs (CXRs) and electrocardiograms (ECGs).

Inclusion criteria were shaped by the NICE guidelines, and included patients aged ≥16 years. Obstetric, cardiothoracic, neurosurgery and burns patients were excluded, as well as those with missing data, those admitted to a high care or intensive care facility, those with previous surgery in the preceding 30 days, those admitted for work-up of a disease and theatre cases where anaesthesia was not involved.

The current study was not limited by a finite population. *A priori* we estimated that at least 50% of preoperative testing performed would be non-guideline based. From this, at least 281 patient records would be required to produce a two-sided 95% confidence interval (CI) with a width equal to 12% (calculated using Power and Sample Size (PASS) 2021 v21.0.2 software (NCSS, USA)).

Following approval from the Human Research Ethics Committee of the National Health Research Ethics Council, SA (ref. no. S22/09/184), a list of patients who had undergone general surgery, or orthopaedic, gynaecology, ophthalmology, ear, nose and throat (ENT), urology, plastic or day case surgery was obtained from the electronic records in the theatre complex. Using systematic sampling in a chronological order of record, working backwards from 31 December 2021, patients were selected until 501 were obtained, to ensure a wide margin above the minimum of 281 patients that was calculated.

Data for each patient were found from online patient files uploaded onto our hospital's record review platform, known as Open Text ECM (enterprise content management). Laboratory investigations were accessed from the National Health Laboratory Service website, and CXRs from the Picture Archiving and Communication System online program. Any reasonable indication for overtesting was recorded.

Preoperative duplicate testing was defined as additional investigations ordered without an indication for duplication, within 30 days of surgery for laboratory tests and within 6 months of surgery for CXRs. International evidence-based guidelines were used to formulate reasonable indications for non-routine testing. Normal laboratory values were defined using our institution's reference ranges, and INR as defined internationally (0.8 - 1.1).[21] The total cost of overinvestigation was calculated using rates fixed by Central Government Health Services.

Statistical analysis

Binary variables were obtained from the study data (i.e. compliant or non-compliant with NICE and local guidelines). From this, frequency of overtesting was assessed. EpiCalc 2000 (Brixton Health, UK) was used to calculate CIs. NICE and local guidelines were then compared. The total number of additional tests per participant was calculated, and the median was compared between departments, age groups, gender, patient comorbidities, ASA grade, type of surgery and type of anaesthetic. Variables with more than two levels were compared using a Kruskal-Wallis test, while those with two levels were assessed using a Mann-Whitney *U*-test. To compare incidence of abnormalities between tests, χ^2 and Fisher's exact tests were used. Frequency tables were used to assess duplicate testing. Projections were made to estimate the total number of patients having surgery over a year, using the number of patients in the database provided, to estimate 26 097 operations per year.

Results

Of the 3 814 patients undergoing surgery at our institution between November and December 2021, 501 met the inclusion criteria. Demographic data of the cohort are shown in Table 1.

For all results, a 95% CI was used. When comparing the NICE with the local guidelines, the percentages of patients (n=501) who had overtesting for specific tests are represented in Fig. 1. No POC Hbs were done superfluously using the local guidelines, as these guidelines recommended every patient for a POC Hb.

For specific tests done, the proportion of overtesting for the NICE and local guidelines, respectively, were as follows: 58.8% of FBCs (n=153) for both guidelines, 78.4% (n=370) and 0% of POC Hbs, 59.6% (n=155) and 36.9% (n=96) of U&Es, 69.2% (n=9) of INRs for both guidelines, 78.5% (n=153) and 74.9% (n=146) of CXRs, and 67.4% (n=89) and 43.9% (n=58) of ECGs. Table 2 illustrates these findings.

Overall, 89% (n=446) of the sample patients had at least one test requested that was not indicated by the guidelines (CI 85.9 - 91.6).

Accepted indications for 'non-indicated' tests

The most frequently occurring rational indications for additional testing were as follows: sepsis for FBC, routine triage Hb for POC Hb, medications affecting renal function or electrolytes for U&E, surgical work-up for INR, malignancy for CXR, and arrhythmias for ECG. Tests with reasonable indications such as these were not included as a non-indicated test.

Factors associated with overtesting

The distribution of overtesting across departments was non-uniform (p<0.001), as illustrated in Fig. 2. General surgery patients were subject to the highest number of superfluous investigations (median=3; interquartile range (IQR) 2 - 4), followed by ENT (median=2; IQR 1 - 5), gynaecology (median=2; IQR 2 - 4), ophthalmology (median=1; IQR 1 - 4), urology (median=1; IQR 1 - 3), orthopaedics (median=1; IQR 1 - 2) and plastic surgery (median=1; IQR 1 - 1). Day case surgery had the lowest incidence of unnecessary testing (p<0.001) (n=86).

Fig. 2 describes overtesting for each department. The number of tests per patient include any FBC, U&E, INR, POC Hb, CXR and ECG done unnecessarily. Duplicate testing was not included. The graph illustrates the range of overtesting: the IQR in the coloured area, and the median by the black horizontal line.

Patients >35 years old were more likely to have unnecessary testing ($p<0.001$). No difference was found between the age groups 36 - 65 years and >65 years old ($p=1$). Females and ASA 2 patients were more likely to be subject to overtesting ($p<0.001$). Table 1 includes p-values for these variables.

Duplicate testing

The most common test duplicated was a POC Hb (17.4%, $n=82$). Furthermore, 237 of the 260 patients who had an FBC also had a POC Hb test. A total of 177 duplicate tests were performed, comprising 88.6% ($n=140$) having one duplicate test done, 10.8% ($n=17$) having two duplicate tests and the remaining 0.6% ($n=1$) having three duplicate tests done, with no evidence to support the need for a repeat test. Out of all unnecessarily repeated investigations, 21.5% ($n=34$) had a test already done at a base hospital.

Indicated v. non-indicated tests when comparing guidelines

Indicated tests usually yielded more abnormalities than non-indicated tests. The exception to this was an FBC, where non-indicated FBCs yielded more abnormalities (72%, $n=66$) than indicated FBCs (43%, $n=77$) ($p<0.001$). To expand upon this finding, Hb values from both FBCs and POC Hb were pooled into clinically relevant groups of <10 g/dL and <8 g/dL. The vast majority (82.3%) had an Hb of >10 g/dL. For Hb <10 g/dL, there was no difference in frequency of abnormalities between indicated and non-indicated tests ($p=1$). This finding remained when using either guideline: for NICE and local guidelines, respectively, indicated tests were abnormal in 19.8% ($n=20$) and 18.3% ($n=44$) of tests, while non-indicated tests were abnormal in 18.3% ($n=32$) and 22.9% ($n=8$) of tests. For Hb <8 g/dL, non-indicated tests conversely yielded more abnormal results: 2.3% ($n=4$) and 8.6% ($n=3$) of non-indicated tests v. 2% ($n=2$) and 1.25%

Table 1. Demographic data

Characteristic	*n* (%)	*p*-value
Gender		< 0.001
Male	326 (65.1)	
Female	175 (34.9)	
Age (years)		< 0.001
16 - 35	234 (46.7)	
36 - 65	236 (47.1)	
>65	31 (6.2)	
Department		< 0.001
Orthopaedics	285 (56.9)	
Ophthalmology	54 (10.8)	
General surgery	46 (9.2)	
Urology	42 (8.4)	
Ear, nose and throat	31 (6.2)	
Plastic surgery	28 (5.6)	
Gynaecology	15 (3)	
ASA grade		< 0.001
ASA 1	148 (29.5)	
ASA 2	353 (70.5)	
Level of surgery		0.19
Minor	240 (47.9)	
Intermediate	261 (52.1)	
Type of anaesthesia		0.91
Regional	121 (24.2)	
General	320 (63.9)	
Regional and general	59 (11.8)	
Sedation	1 (0.1)	
Day surgery		< 0.001
Yes	86 (17.2)	
No	415 (82.8)	

ASA = American Society of Anesthesiologists.

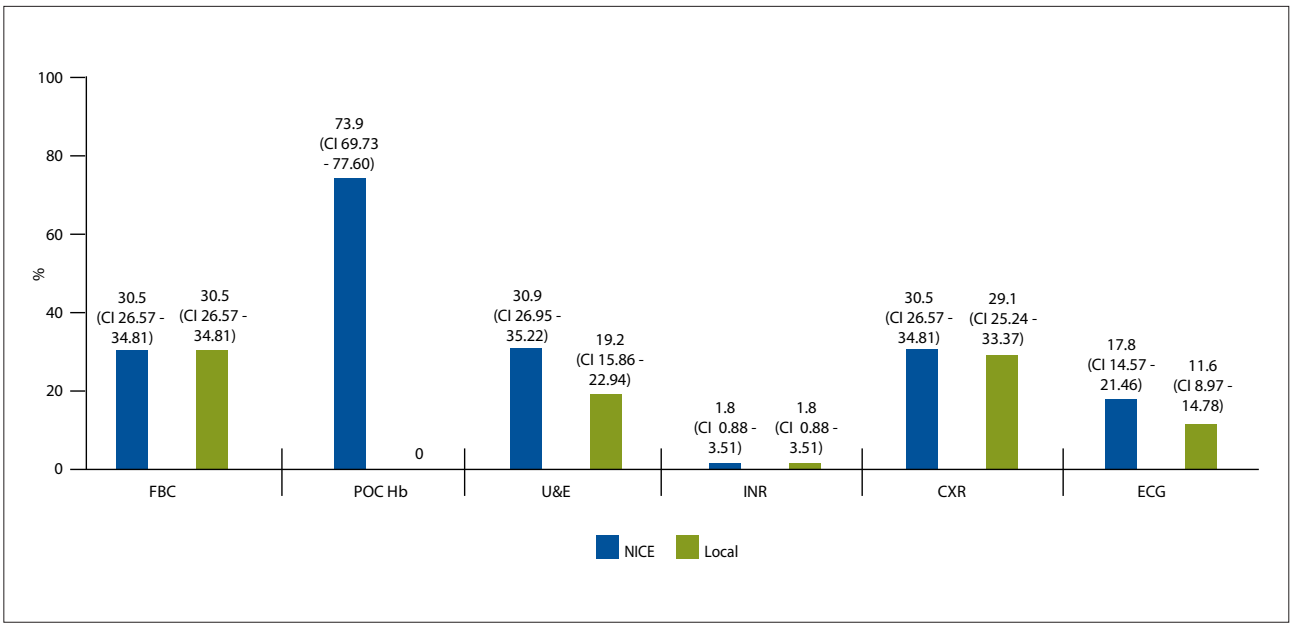

Fig. 1. Percentage of non-indicated testing for the study cohort (N=501). (FBC = full blood count; POC Hb = point-of-care haemoglobin; U&E = urea, creatinine and electrolytes; INR = international normalised ratio; CXR = chest radiograph; ECG = electrocardiogram; CI = 95% confidence interval; NICE = National Institute for Health and Care Excellence.)

Table 2. Percentage of non-indicated testing for all tests ordered

Test	Total number of specific tests, *n*	Non-indicated tests: NICE guidelines, *n* (%)	Non-indicated tests: local guidelines, *n* (%)
FBC	260	153 (58.8)	153 (58.8)
Hb	472	370 (78.4)	0 (0)
U&E	260	155 (59.6)	96 (36.9)
INR	13	9 (69.2)	9 (69.2)
CXR	195	153 (78.5)	146 (74.9)
ECG	132	89 (67.4)	58 (43.9)

NICE = National Institute for Health and Care Excellence; FBC = full blood count; Hb = haemoglobin; U&E = urea, creatinine and electrolytes; INR = international normalised ratio; CXR = chest radiograph; ECG = electrocardiogram.

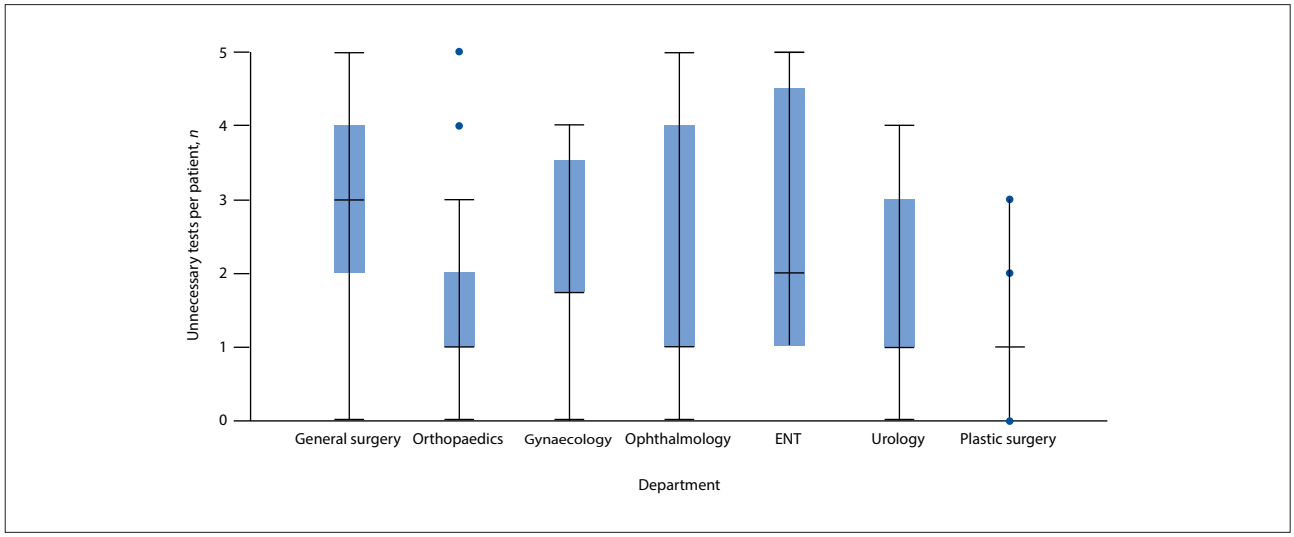

Fig. 2. Overtesting by department. (ENT = ear, nose and throat.)

(*n*=3) of indicated tests were abnormal in NICE and local guidelines, respectively. Thus, one additional patient with an Hb of <8 g/dL would have been detected if utilising the local guidelines instead of the NICE guidelines.

There were no INRs >1.4 in the sample, and no platelets <100 × 10^9/L. In indicated U&E testing done for NICE and local guidelines, 10% (*n*=2) and 9.1% (*n*=2) had urea >10 mmol/L, and 6.5% (*n*=2) and 4.3% (*n*=2) had creatinine >135 µmol/L, respectively. Abnormalities in these ranges for urea and creatinine did not occur in the non-indicated tests done for both guidelines. For less significant abnormalities, using the local guidelines over the NICE guidelines would have detected an additional 2 patients with elevated urea <10 mmol/L, and 16 patients with elevated creatinine <135 µmol/L in the sample (*n*=501). Table 3 summarises the local institutional preoperative testing guidelines.

Cost savings

The projected potential cost savings on preoperative investigations if the NICE guidelines are followed is ZAR857 987 per annum, and ZAR696 515 per annum if the local guidelines are followed.

Discussion

Our results show a significant amount of deviation from the preoperative testing guidelines in our institution, where 89% of patients had at least one unnecessary test performed. Interestingly, a similar finding occurred in a high-income setting,[14] which found that 90% of women undergoing gynaecological surgery underwent at least one non-indicated preoperative test. The study included two additional investigations (liver function tests and urinalysis) that were not included in the current study. Our results were more conservative than those of a prior SA study by Buley *et al.*[9] Buley *et al.* conducted their study in a regional hospital, and found that 61.3% of FBCs, 66.4% of U&Es and 92.5% of INRs were inappropriate, compared with the current study performed in a tertiary centre, which found a lower overtesting prevalence of 58.8%, 36.9% and 69.2%, respectively. A conceivable contributor to this is the examination of patient files that was undertaken in the current study to exclude other possible reasons for a test being conducted. In addition, Buley *et al.* included non-elective operations, which were excluded in the current study, and utilised only their local guidelines in their analysis. Non-laboratory tests were not assessed in their study (such as CXRs and ECGs).

The distribution of overtesting across departments in the current study was non-uniform, with general surgery patients being subject to the highest number of superfluous investigations. Day surgery improved compliance with guidelines overall. Older age and comorbidities (ASA 2) were associated with overtesting, which may be attributed to concerns regarding surgical delays, and a lack of awareness of guidelines.[22] Interestingly, no difference was found between the age groups of 36 - 65 years and >65 years of age. This should be interpreted with caution, due to the low frequency of patients >65 years in the data sample. Females were more likely to experience overtesting, the reasons for which are beyond the scope of this study.

Duplicate testing was common, and patients had up to three unnecessary duplicate tests done. The most common test duplicated was a POC Hb. This is likely due to the idea that the HemoCue Hb test is relatively easy to perform and inexpensive, but whether it is

Table 3. Tygerberg Hospital preoperative testing guidelines (preoperative routine special investigations)

	Minor and low-risk surgery		Intermediate/high- and major-risk surgery	
Test	**ASA 1 and 2**	**ASA 3 and 4**	**ASA 1 and 2**	**ASA 3 and 4**
FBC	Ward Hb only	Yes	Yes	Yes
U&E	ASA 1: not usually needed ASA 2: once every 3 years	Yes	Yes	Yes
ECG	Only if >65 years or cardiovascular risk factor regardless of age (ischaemic heart disease, hypertension, valve lesion, diabetes, cerebrovascular accident, renal dysfunction)			Yes
Clotting	Not usually needed unless on anticoagulants or liver disease			
CXR	Not usually needed unless respiratory disease (chronic obstructive pulmonary disease/asthma/obstructive sleep apnoea) or new and unstable cardiopulmonary disease			

ASA = American Society of Anesthesiologists; FBC = full blood count; Hb = haemoglobin; U&E = urea, creatinine and electrolytes; ECG = electrocardiogram; CXR = chest radiograph.

also indicated should be taken into consideration.[23] In many cases, tests are inadvertently repeated for the sake of expedience.[1] Tests done at base hospitals, which also draw from the provincial pool of resources, should be traced and utilised.

For the most part, indicated tests yielded more abnormalities than non-indicated tests, as would be expected. The exception to this was an FBC, specifically the Hb component. Although the majority of abnormal Hbs were >10 g/dL, the frequency of Hb 8 - 10 g/dL was similar for indicated v. non-indicated tests, illustrating that for the study cohort, guidelines were not helpful in predicting Hb <10 g/dL. Interestingly, an Hb <8 g/dL was more common in non-indicated tests. However, there were only six Hb tests (whether formal or POC) <8 g/dL in the entire sample. Future research with larger cohorts is needed to further investigate this finding. The local guidelines are more liberal in their advocacy of POC Hb and U&E panel. While the incidence of anaemia is more common in LMICs,[24] an advantage of additional Hb testing for preoperative use as per local guidelines was not reflected in this study. However, screening of patients to assist with the medical management of anaemia may be of benefit, and was not addressed in this study. While indicated testing using local as opposed to NICE guidelines yielded more abnormal U&Es, significant abnormalities were detected by both guidelines: for the U&Es classified as superfluous according to NICE guidelines, none had a urea >10 mmol/L nor a creatinine >135 µmol/L. Thus, while SA's population experiences a higher risk of renal disease,[25,26] additional value from the more liberal advocation of U&E testing by the local guidelines is questionable. It should also be noted that in general, abnormal results are not further investigated in a majority of cases, and only influence management in <3% of situations.[2,7,15,16,27,28] In fact, identifying surgical risk on history is a far better predictor of perioperative events than abnormal test results.[29,30]

The potential cost saving of between ZAR696 515 and ZAR857 987 per annum is possibly a gross underestimation for the following reasons: it is likely that elective surgeries were limited during the study period due to the presence of COVID-19; overtesting for major surgery and ASA 3 - 4 patients was excluded; and numerous other investigations, such as glucose tests and echocardiography, were excluded.

It is not fully understood why routine testing is so widespread. In a qualitative study by Brown and Brown[22] looking at the factors influencing the ordering of these tests, some major themes emerged. These included practice tradition and lack of awareness of evidence and guidelines; some ordered tests thinking other physicians would want them, had concerns about surgical delays, or had medicolegal concerns. Ironically, overtesting may predispose to medicolegal issues because routine preoperative screening tests are often not recorded in the notes.[2,5] In addition to training physicians on the use of the guidelines, administrative solutions may be considered, such as implementing gatekeeping, modification of laboratory request forms, time interval restraints to prevent repeat testing, and limiting some tests to consultant-only authorisation.[9] Future studies should aim to assess the impact of such interventions.

Study limitations

This was a retrospective single-centre study and thus has built-in limitations. Grade of surgical invasiveness, ASA grading and indications for investigations are subject to inter-practitioner disagreement. COVID-19 may have affected the study results.

Conclusion

Non-compliant preoperative testing is highly prevalent, and unlikely to yield additional clinically relevant information. The cost implications are enormous, and prudent testing could assist in redistribution of funds in a resource-limited setting. Using the NICE guidelines as opposed to the local guidelines provides similar information to clinicians, with lower cost implications. Additional studies are required to further elucidate the prevalence of overtesting in the SA setting and the factors contributing to it, as well as whether this population might benefit from modifications to the current guidelines.

Data availability. The data used for this study are available on request, subject to ethical and institutional review approval.

Declaration. This study was conducted by SW as a requirement for the MMed Anaesthesiology degree at Stellenbosch University, under the supervision of SV.

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