

Implementation of the WHO Surgical Safety Checklist and Its Role in the Perioperative Care Process and Postoperative Outcomes: A Prospective Longitudinal Study from a Tertiary Care Institute in Manipur, India

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ABSTRACT

Background: The WHO Surgical Safety Checklist (SSC) reduces perioperative morbidity and mortality, but its benefit depends on implementation quality. Northeast Indian data are scarce. **Aim:** To study WHO SSC implementation and its role in the perioperative care process and postoperative outcomes in a tertiary care institute in Manipur. **Methods:** This prospective longitudinal study included 224 patients undergoing elective or emergency general surgery at JNIMS, Imphal, from March 2024 to February 2026. Implementation was graded as complete (all three phases) or partial. Patients were followed until postoperative day 30; complications were graded by Clavien-Dindo classification. **Results:** Mean age was 40.0 ± 21.2 years; 60.3% were male; 59.8% of procedures were elective. All three checklist phases were completed in 14.3%, two phases in 17.4% and one phase in 68.3%. Antibiotic prophylaxis and normothermia were universal; site marking was performed in 44.6%. Complications occurred in 20.1%, surgical site infection in 14.3%, 30-day readmission in 9.4% and mortality in 1.8%. Compared with single-phase use, complete implementation was associated with shorter hospital stay (6.2 ± 2.4 vs 10.4 ± 10.5 days, $p < 0.001$), fewer ICU admissions (6.3% vs 20.3%, $p = 0.003$), fewer complications (9.4% vs 23.5%, $p = 0.001$) and fewer readmissions (3.1% vs 11.8%, $p = 0.024$), with no deaths. Complete implementation was lower in emergency than elective surgery (4.4% vs 20.9%, $p < 0.001$) and rose from 7.1% to 21.4% during the study ($p < 0.001$). **Conclusion:** Complete SSC implementation was infrequent but was associated with graded reductions in adverse postoperative outcomes, supporting efforts to achieve full adherence, particularly in emergency surgery.

Keywords: Checklist; Patient safety; Postoperative complications; Surgical wound infection; Emergency surgery; Quality improvement; World Health Organization

INTRODUCTION

Surgery is an indispensable component of modern health care. Conditions such as trauma, malignancy, obstetric emergencies, congenital anomalies and complicated infections cannot be managed without timely operative intervention, and the volume of surgery performed across the world continues to rise. Weiser and colleagues estimated that 234.2 million major surgical procedures were undertaken worldwide each year, a volume large enough to place surgical

safety firmly within the scope of global public health policy [1]. The Lancet Commission on Global Surgery subsequently estimated that approximately 313 million procedures are performed every year and emphasised that the unmet need for safe, affordable surgical and anaesthesia care is greatest in low-income and middle-income countries [2]. As access to surgery expands in these settings, the safety and reliability of each individual operation become as important as the availability of surgery itself.

Despite advances in operative technique, anaesthesia and perioperative medicine, adverse events remain common among hospitalised surgical patients. In a systematic review of eight studies including 74,485 patient records, de Vries and colleagues reported a median incidence of in-hospital adverse events of 9.2%, of which a median of 43.5% were judged preventable; operation-related events formed the largest single category, accounting for 39.6% of all adverse events [3]. These events carry a heavy human and economic cost. They prolong hospitalisation, increase the need for intensive care and reoperation, generate additional expenditure for patients and institutions, and in the most severe cases lead to permanent disability or death. Because a substantial proportion of such harm is preventable, systematic safety measures in the operating room offer a realistic opportunity to improve outcomes.

Patient safety in surgery spans the entire perioperative pathway. The preoperative phase involves correct patient identification, informed consent, assessment of comorbidity and anaesthetic risk, and marking of the operative site. The intraoperative phase requires a functioning anaesthesia machine, appropriate monitoring, timely antibiotic prophylaxis, maintenance of normothermia, anticipation of blood loss and clear communication among surgeons, anaesthetists and nurses. The postoperative phase depends on accurate instrument and swab counts, correct specimen labelling and a clear handover of key concerns for recovery. Failures at any of these points, whether wrong-site surgery, retained foreign bodies, omitted antibiotic prophylaxis, unrecognised airway difficulty or miscommunication within the team, can result in serious harm. Many of these failures arise not from a lack of knowledge but from lapses in routine, time pressure and fragmented communication in a complex, high-pressure environment.

Recognising the global magnitude of this problem, the World Health Organization launched the "Safe Surgery Saves Lives" programme in 2008 as its second Global Patient Safety Challenge. The central product of this initiative was the WHO Surgical Safety Checklist (SSC), a concise 19-item tool designed to reinforce accepted safety practices and to foster better communication and teamwork within the operating team [4]. The checklist is organised into three phases. The "Sign In" is performed before induction of anaesthesia and confirms patient identity, the procedure, the site and consent, the marking of the site, the anaesthesia safety check, pulse oximetry, known allergies, airway risk and the risk of major blood loss. The "Time Out" is performed before skin incision and requires introduction of team members, confirmation of patient, site and procedure, review of anticipated critical events and confirmation that antibiotic prophylaxis has been given within the preceding 60 minutes. The "Sign Out" is performed before the patient leaves the operating room and covers the name

of the procedure, instrument, sponge and needle counts, specimen labelling, equipment problems and key concerns for postoperative care. The brevity of the tool was intended to make it feasible in any hospital, from well-resourced academic centres to district hospitals with limited infrastructure.

The first evidence of benefit came from the WHO pilot study conducted in eight hospitals in eight cities, including New Delhi, which represented a wide range of economic circumstances. Among 3733 patients enrolled before and 3955 patients enrolled after introduction of the checklist, the rate of death fell from 1.5% to 0.8% ($p=0.003$) and inpatient complications fell from 11.0% to 7.0% ($p<0.001$) [4]. A concern raised at the time was whether the checklist would be practical during urgent operations, when time is short and patients are more unstable. A subsequent analysis of 1750 patients undergoing urgent surgery in the same hospitals showed that complications declined from 18.4% to 11.7% and deaths from 3.7% to 1.4% after introduction of the checklist, while adherence to six measured safety steps improved from 18.6% to 50.7% [5]. These findings established that the checklist could be applied to emergency surgery and that the patients at greatest risk might benefit the most.

Subsequent studies from high-income settings broadly supported these observations. In the Netherlands, a comprehensive surgical safety system spanning the whole surgical pathway reduced the proportion of patients with one or more complications from 15.4% to 10.6% and in-hospital mortality from 1.5% to 0.8% [6]. A stepped wedge cluster randomised trial from Norway reported a fall in complication rates from 19.9% to 11.5% and a reduction in mean length of stay of 0.8 days after introduction of the WHO checklist [7]. A large Dutch cohort of 25,513 patients demonstrated that the mortality benefit depended crucially on compliance; full completion of the checklist was associated with an odds ratio for death of 0.44, whereas partial completion or non-compliance conferred no benefit [8]. A meta-analysis of seven studies found pooled risk ratios of 0.59 for any complication, 0.77 for mortality and 0.57 for surgical site infection after checklist implementation, although the authors noted marked methodological heterogeneity among the included studies [9].

The evidence is not uniformly positive. When checklists were adopted across 101 acute care hospitals in Ontario, Canada, following a provincial policy, no significant reduction in operative mortality or surgical complications was observed in more than 200,000 procedures [10]. The International Surgical Outcomes Study of 44,814 patients found that checklist exposure was associated with lower in-hospital mortality (odds ratio 0.49) but not with lower complication rates (odds ratio 1.02), and its authors cautioned that the observed benefit might partly reflect the wider quality of care in hospitals where checklist use is routine [11]. These contrasting results have shifted attention away from

whether a checklist is present towards how well it is actually used.

The quality of implementation appears to be the decisive factor. In a longitudinal study from five hospitals in the United Kingdom, at least one of the three phases was completed in 96.7% of operations, yet the entire checklist was completed in only 62.1%; the reduction in complications was concentrated in cases in which all three phases had been completed, with an odds ratio of 0.57 [12]. Direct observation in English operating rooms showed that, on average, only two-thirds of checklist items were actually checked, team members were frequently absent or failed to pause, and the Sign Out was not completed in 39% of cases [13]. Such findings suggest that the checklist can easily degenerate into a paper exercise in which boxes are ticked without the intended communication taking place, and that measuring the completeness of all three phases is a more meaningful indicator than simple adoption.

Data from India and other resource-limited settings reveal similar gaps. At a high-volume tertiary cancer centre in Mumbai, compliance was 100% for the Sign In but fell to 78% for the Time Out and 76.5% for the Sign Out, and genuine interaction among the surgeon, anaesthetist and nurse occurred in only 52% of cases [14]. In a tertiary hospital in Ethiopia the checklist was used in 93.5% of operations but was fully completed in only 17.3%, with the Time Out being the least completed phase [15]. Emergency surgery, high patient volumes, staff shortages, hierarchical team structures and the perception that the checklist is time-consuming have all been proposed as barriers in such settings. Whether incomplete use in these circumstances translates into worse patient outcomes has not been well characterised, particularly in the northeastern region of India.

Manipur is a hilly, geographically isolated state in northeast India, where tertiary surgical services are concentrated in a small number of institutions in and around Imphal. Jawaharlal Nehru Institute of Medical Sciences (JNIMS) is a government teaching hospital that receives a large volume of both elective and emergency general surgical cases, many of whom are referred late from peripheral areas with advanced disease. In such a setting the operating team must balance heavy workloads, unpredictable emergency lists and limited resources, conditions under which structured safety tools are most vulnerable to incomplete use. At the same time, the potential gains from reliable checklist use are considerable. Local evidence describing how completely the WHO SSC is implemented, which perioperative processes are consistently achieved and whether the depth of implementation is linked to patient outcomes is needed to guide institutional quality improvement.

We therefore undertook a prospective longitudinal study in the Department of General Surgery at JNIMS to evaluate the quality of WHO SSC implementation,

to examine its role in key perioperative care processes such as antibiotic prophylaxis, surgical site marking and maintenance of normothermia, and to assess the association between the completeness of checklist implementation and postoperative outcomes, including length of hospital stay, intensive care unit admission, complications graded by severity, 30-day readmission and mortality. We further compared implementation and outcomes between elective and emergency surgery and examined changes in implementation over the study period.

Aims and Objectives

Aim: To study the implementation of the WHO Surgical Safety Checklist and its role in the perioperative care process and postoperative outcomes in a tertiary care institute in Manipur.

Objectives: (1) To assess the implementation of the WHO Surgical Safety Checklist, including the proportion of procedures in which all three phases (Sign In, Time Out and Sign Out) were completed. (2) To determine the role of the checklist in the perioperative care process, with particular reference to surgical antibiotic prophylaxis, preoperative site marking and maintenance of normothermia, and to compare implementation between elective and emergency surgery. (3) To study the association between the quality of checklist implementation and postoperative outcomes, namely length of hospital stay, intensive care unit admission, postoperative complications and their severity, 30-day readmission, mortality and final clinical outcome.

MATERIALS AND METHODS

Study Design

A prospective longitudinal observational study was conducted to evaluate the implementation of the WHO Surgical Safety Checklist and its association with perioperative care processes and postoperative outcomes.

Study Setting and Duration

The study was carried out in the Department of General Surgery, Jawaharlal Nehru Institute of Medical Sciences (JNIMS), Porompat, Imphal, Manipur, a government tertiary care teaching hospital. Data were collected over a period of two years, from March 2024 to February 2026.

Ethical Considerations

Approval was obtained from the Institutional Ethics Committee of JNIMS before commencement of the study. Written informed consent was obtained from all adult participants, and from parents or legal guardians of patients younger than 18 years. The checklist was applied as part of the institutional operating room protocol, and participation in the study did not alter clinical management.

Sample size

The sample size was calculated using the formula for estimating a proportion, $n = Z^2 \times p \times q / l^2$, where Z is the standard normal deviate for a 95% confidence level (1.96), p is the expected proportion, $q = 1 - p$ and l is the allowable error. Based on a previous similar study, the expected proportion of complete WHO SSC implementation was taken as 85% ($p = 0.85$, $q = 0.15$) with an allowable error of 5.5%. The calculation gave $n = (1.96 \times 1.96 \times 0.85 \times 0.15) / (0.055 \times 0.055) = 0.490 / 0.003025 \approx 162$ as the minimum required sample. A total of 224 patients were enrolled during the study period.

Sampling Technique

Patients were recruited by convenience sampling. All eligible patients admitted under the Department of General Surgery who met the inclusion criteria and provided informed consent were enrolled consecutively until the end of the study period.

Inclusion Criteria

Patients of all age groups and of both sexes who underwent elective or emergency surgical procedures under the Department of General Surgery during the study period were included.

Exclusion Criteria

Patients who refused to participate in the study or did not provide informed consent were excluded.

Checklist Implementation and Assessment

The WHO Surgical Safety Checklist, comprising the Sign In before induction of anaesthesia, the Time Out before skin incision and the Sign Out before the patient left the operating room, was applied for every enrolled patient. For each procedure, completion of each of the three phases was documented. The quality of implementation was categorised as complete when all three phases were completed, partial when one or two phases were completed, and not implemented when no phase was completed. Specific process measures, namely preoperative surgical site marking, administration of surgical antibiotic prophylaxis and maintenance of normothermia, were recorded as achieved or not achieved. Any deviation from protocol or non-compliance was noted along with the reason.

Data Collection

Data were recorded on a standardised case record form that incorporated the WHO SSC along with additional study variables. In the preoperative phase, demographic details (age, sex, hospital and study identification numbers), primary diagnosis, planned procedure, pre-anaesthetic evaluation findings, comorbidities, risk factors and American Society of Anesthesiologists (ASA) physical status were recorded, together with the type of surgery (elective or emergency). In the intraoperative phase, completion of each checklist phase and the process measures

described above were documented. In the postoperative phase, patients were followed systematically from the immediate postoperative period until discharge, and again on postoperative day 7 and postoperative day 30.

Outcome Measures

The outcomes recorded were total length of hospital stay, requirement for blood transfusion, intensive care unit (ICU) admission, postoperative complications, readmission within 30 days, mortality and final clinical outcome (recovered, died or still under treatment at study completion). The complications specifically sought included wrong-site surgery, difficult intubation, acute renal failure, deep vein thrombosis, pulmonary embolism, stroke, myocardial infarction, cardiac arrest, pneumonia, unplanned intubation, requirement for ventilatory support, major wound disruption, surgical site infection (SSI), systemic inflammatory response syndrome, sepsis, unplanned return to the operating theatre, coma and death, as well as procedure-specific complications. Complications were graded according to the Clavien-Dindo classification, which ranks complications by the therapy required to manage them, from Grade I (deviation from the normal postoperative course without need for specific treatment) to Grade V (death) [16,17]. Grades III to V were considered higher-grade complications.

Statistical Analysis

Data were entered in Microsoft Excel and analysed using the Statistical Package for the Social Sciences (SPSS) version 22.0. Normality of continuous variables was assessed using the Kolmogorov-Smirnov test. Continuous variables were expressed as mean $\pm$ standard deviation or median and range, and categorical variables as frequencies and percentages. Distributions of single categorical variables were assessed using the chi-square goodness-of-fit test. Categorical variables were compared between groups using the chi-square test, the chi-square test for trend or Fisher's exact test, as appropriate. Continuous variables were compared between two groups using the Mann-Whitney U test and among three groups using the Kruskal-Wallis test, with post hoc pairwise Mann-Whitney U tests. Change in the rate of complete implementation over the study period was assessed using the Cochran-Armitage test for trend. A p-value below 0.05 was considered statistically significant.

RESULTS

A total of 224 patients were included in the analysis. The baseline characteristics of the study population are presented in Table 1. The mean age was 40.0 ± 21.2 years (median 42.0 years; range 4 to 90 years; 95% CI for the mean 37.2 to 42.8 years). The most common age group was 18 to 40 years (39.7%), followed by 41 to 60 years (28.6%); children younger than 18 years

formed 17.0% and patients older than 60 years formed 14.7% of the cohort. Males constituted 60.3% of patients, giving a male to female ratio of 1.52:1

($p=0.003$). Elective procedures accounted for 59.8% and emergency procedures for 40.2% of cases ($p<0.001$).

Table 1. Baseline characteristics of the study population (n = 224)

Characteristic	Value	p-value
Age (years), mean $\pm$ SD	40.0 $\pm$ 21.2	
Age (years), median	42.0	
Age (years), range	4 to 90	
95% CI for mean age	37.2 to 42.8	
Age group, n (%)		
<18 years	38 (17.0)	
18 to 40 years	89 (39.7)	
41 to 60 years	64 (28.6)	
>60 years	33 (14.7)	
Sex, n (%)		0.003*
Male	135 (60.3)	
Female	89 (39.7)	
Type of surgery, n (%)		<0.001*
Elective	134 (59.8)	
Emergency	90 (40.2)	

SD, standard deviation; CI, confidence interval. *Chi-square goodness-of-fit test.

The quality of checklist implementation and the individual perioperative process measures are shown in Table 2. No procedure was performed without any part of the checklist. All three phases were completed in 32 procedures (14.3%), two phases in 39 procedures (17.4%) and only one phase in 153 procedures (68.3%) ($p<0.001$). Surgical antibiotic prophylaxis was administered and normothermia was maintained in all 224 patients (100%). Preoperative surgical site marking, in contrast, was performed in only 100 patients (44.6%; $p=0.089$). The quality of implementation differed significantly by type of surgery ($p<0.001$). Complete implementation was achieved in 20.9% of elective procedures but in only 4.4% of emergency procedures, a nearly five-fold difference, whereas single-phase implementation was more frequent in emergency surgery (82.2%) than in elective surgery (59.0%) ($p<0.001$).

Table 2. Quality of WHO Surgical Safety Checklist implementation and perioperative process measures

Parameter	Overall (n = 224)	Elective (n = 134)	Emergency (n = 90)	p-value
Implementation level, n (%)				<0.001†
All three phases completed	32 (14.3)	28 (20.9)	4 (4.4)	
Two phases completed	39 (17.4)	27 (20.1)	12 (13.3)	
One phase completed	153 (68.3)	79 (59.0)	74 (82.2)	
None completed	0 (0.0)	0 (0.0)	0 (0.0)	
Process measure, n (%) achieved				
Preoperative site marking	100 (44.6)			0.089*
Surgical antibiotic prophylaxis	224 (100.0)			<0.001*
Normothermia maintained	224 (100.0)			<0.001*

†Chi-square test comparing elective and emergency surgery; the overall distribution of implementation levels was also significant ($p < 0.001$, chi-square goodness-of-fit test). *Chi-square goodness-of-fit test for the overall cohort.

Postoperative outcomes for the whole cohort are summarised in Table 3. The mean hospital stay was 9.10 ± 9.11 days (median 7.0 days; range 3 to 100 days; 95% CI 7.9 to 10.3 days), and 66.1% of patients were discharged within 3 to 7 days, while 1.8% stayed longer than 30 days. ICU admission was required in 17.0% and blood transfusion in 8.5% of patients. Postoperative complications occurred in 45 patients (20.1%) and 21 patients (9.4%) were readmitted within 30 days. Surgical site infection was the most frequent specific complication (14.3%), followed by sepsis (4.9%), major wound disruption (2.7%) and unplanned return to the operating theatre (0.9%). Four patients died, giving a mortality of 1.8%; 219 patients (97.8%) recovered and one patient (0.4%) remained under treatment at study completion. On Clavien-Dindo grading, Grade II was the most frequent category (75.0%), followed by Grade IIIa (16.5%) and Grade I (5.4%); Grades IIIb, IVa and V accounted for 0.9%, 0.4% and 1.8%, respectively ($p < 0.001$).

Table 3. Postoperative outcomes in the study population (n = 224)

Outcome	n (%) or value	p-value
Hospital stay (days), mean $\pm$ SD	9.10 ± 9.11	
Hospital stay (days), median (range)	7.0 (3 to 100)	
3 to 7 days	148 (66.1)	
8 to 14 days	56 (25.0)	
15 to 30 days	16 (7.1)	
>30 days	4 (1.8)	
ICU admission	38 (17.0)	<0.001*
Blood transfusion required	19 (8.5)	<0.001*
Postoperative complications	45 (20.1)	<0.001*
Readmission within 30 days	21 (9.4)	<0.001*
Surgical site infection	32 (14.3)	<0.001*
Sepsis	11 (4.9)	<0.001*
Major wound disruption	6 (2.7)	<0.001*
Unplanned return to operating theatre	2 (0.9)	<0.001*
Clavien-Dindo grade		<0.001†
Grade I	12 (5.4)	
Grade II	168 (75.0)	
Grade IIIa	37 (16.5)	
Grade IIIb	2 (0.9)	
Grade IVa	1 (0.4)	
Grade V (death)	4 (1.8)	
Final outcome		<0.001*
Recovered	219 (97.8)	
Died	4 (1.8)	
Under treatment at study completion	1 (0.4)	

SD, standard deviation; ICU, intensive care unit. *Chi-square goodness-of-fit test. †Chi-square test for distribution.

The association between the quality of checklist implementation and postoperative outcomes is shown in Table 4. Hospital stay decreased progressively as implementation became more complete, from 10.4 ± 10.5 days with single-phase implementation to 8.1 ± 4.8 days with two-phase implementation and 6.2 ± 2.4 days with complete implementation ($p < 0.001$). Post hoc comparisons were significant for complete versus two-phase implementation

($p=0.038$), complete versus single-phase implementation ($p<0.001$) and two-phase versus single-phase implementation ($p=0.012$), representing an approximately 40% shorter mean stay with complete compared with minimal implementation. ICU admission was required in 6.3%, 12.8% and 20.3% of patients with complete, two-phase and single-phase implementation, respectively ($p=0.003$ for trend). The complication rate showed a similar gradient, being 9.4% with complete implementation, 15.4% with two-phase implementation and 23.5% with single-phase implementation ($p=0.001$ for trend), with a significant difference between complete and single-phase implementation ($p=0.048$). Readmission within 30 days occurred in 3.1%, 5.1% and 11.8% of the three groups, respectively ($p=0.024$ for trend), although the individual pairwise comparisons were not statistically significant. No deaths occurred among patients with complete implementation, compared with 2.6% in the two-phase group and 2.0% in the single-phase group ($p=0.041$). All patients in the complete implementation group recovered fully, compared with 97.4% in each of the other two groups ($p=0.038$), and the only patient still under treatment at study completion belonged to the single-phase group.

Table 4. Association between quality of WHO Surgical Safety Checklist implementation and postoperative outcomes

Outcome	All three phases (n = 32)	Two phases (n = 39)	One phase (n = 153)	p-value
Hospital stay (days), mean $\pm$ SD	6.2 $\pm$ 2.4	8.1 $\pm$ 4.8	10.4 $\pm$ 10.5	<0.001a
Hospital stay (days), median (range)	6.0 (3 to 13)	7.0 (3 to 25)	8.0 (3 to 100)	
ICU admission, n (%)	2 (6.3)	5 (12.8)	31 (20.3)	0.003b
Postoperative complications, n (%)	3 (9.4)	6 (15.4)	36 (23.5)	0.001b
Readmission within 30 days, n (%)	1 (3.1)	2 (5.1)	18 (11.8)	0.024b
Mortality, n (%)	0 (0.0)	1 (2.6)	3 (2.0)	0.041c
Recovered, n (%)	32 (100.0)	38 (97.4)	149 (97.4)	0.038c
Under treatment at study completion, n (%)	0 (0.0)	0 (0.0)	1 (0.7)	

SD, standard deviation; ICU, intensive care unit. aKruskal-Wallis test; post hoc Mann-Whitney U test: all three vs two phases $p=0.038$, all three vs one phase $p<0.001$, two vs one phase $p=0.012$. bChi-square test for trend; for complications, all three vs one phase $p=0.048$ (Fisher's exact test). cFisher's exact test.

The distribution of complication severity according to implementation quality is presented in Table 5. Implementation quality significantly influenced the Clavien-Dindo grade distribution ($p=0.008$). Higher-grade complications (Grades III to V) were recorded in 1 of 32 patients (3.1%) with complete implementation, 5 of 39 patients (12.8%) with two-phase implementation and 38 of 153 patients (24.8%) with single-phase implementation ($p<0.001$ for trend). All four deaths (Grade V) occurred in patients with incomplete implementation, one in the two-phase group and three in the single-phase group.

Table 5. Severity of complications (Clavien-Dindo grade) according to quality of WHO Surgical Safety Checklist implementation

Clavien-Dindo grade	All three phases (n = 32)	Two phases (n = 39)	One phase (n = 153)	Total (n = 224)
Grade I, n (%)	3 (9.4)	2 (5.1)	7 (4.6)	12 (5.4)
Grade II, n (%)	28 (87.5)	32 (82.1)	108 (70.6)	168 (75.0)
Grade IIIa, n (%)	1 (3.1)	4 (10.3)	32 (20.9)	37 (16.5)
Grade IIIb, n (%)	0 (0.0)	0 (0.0)	2 (1.3)	2 (0.9)
Grade IVa, n (%)	0 (0.0)	0 (0.0)	1 (0.7)	1 (0.4)
Grade V, n (%)	0 (0.0)	1 (2.6)	3 (2.0)	4 (1.8)

Clavien-Dindo grade	All three phases (n = 32)	Two phases (n = 39)	One phase (n = 153)	Total (n = 224)
Higher grade (III to V), n (%)	1 (3.1)	5 (12.8)	38 (24.8)	44 (19.6)

Overall distribution $p=0.008$ (chi-square test). Higher-grade complications $p<0.001$ (chi-square test for trend).

Outcomes of elective and emergency surgery are compared in Table 6. Emergency procedures were associated with a longer mean hospital stay (11.1 ± 12.1 vs 7.8 ± 6.2 days, $p=0.006$), a higher rate of ICU admission (25.6% vs 11.2%, $p=0.005$), a higher complication rate (27.8% vs 14.9%, $p=0.018$), more frequent readmission (14.4% vs 6.0%, $p=0.034$), a higher SSI rate (20.0% vs 10.4%, $p=0.043$) and more higher-grade complications (28.9% vs 13.4%, $p=0.004$). Mortality was higher after emergency surgery (3.3% vs 0.7%), but the difference was not statistically significant ($p=0.144$).

Table 6. Comparison of outcomes between elective and emergency surgery

Outcome	Elective (n = 134)	Emergency (n = 90)	p-value
Hospital stay (days), mean $\pm$ SD	7.8 ± 6.2	11.1 ± 12.1	0.006
ICU admission, n (%)	15 (11.2)	23 (25.6)	0.005
Postoperative complications, n (%)	20 (14.9)	25 (27.8)	0.018
Readmission within 30 days, n (%)	8 (6.0)	13 (14.4)	0.034
Mortality, n (%)	1 (0.7)	3 (3.3)	0.144
Surgical site infection, n (%)	14 (10.4)	18 (20.0)	0.043
Higher-grade complications (III to V), n (%)	18 (13.4)	26 (28.9)	0.004

SD, standard deviation; ICU, intensive care unit. Chi-square test for categorical variables; Mann-Whitney U test for hospital stay.

The temporal pattern of complete checklist implementation is shown in Table 7. The proportion of procedures in which all three phases were completed rose from 7.1% in the first quarter to 12.5% in the second, 16.1% in the third and 21.4% in the fourth and fifth quarters, a threefold increase that was statistically significant ($p<0.001$, Cochran-Armitage test for trend). Even at its highest, however, complete implementation was achieved in only about one in five procedures.

Table 7. Complete WHO Surgical Safety Checklist implementation over the study period

Period	Surgeries (n)	All three phases completed (n)	Complete implementation rate (%)
Q1 (March to May 2024)	56	4	7.1
Q2 (June to August 2024)	56	7	12.5
Q3 (September to November 2024)	56	9	16.1
Q4 (December 2024 to February 2025)	28	6	21.4
Q5 (March to May 2025)	28	6	21.4
Overall	224	32	14.3

$p<0.001$ (Cochran-Armitage test for trend).

DISCUSSION

This prospective study from a tertiary care teaching hospital in Manipur yielded three principal findings. First, although some part of the WHO Surgical Safety

Checklist was applied in every operation, all three phases were completed in only 14.3% of procedures, and emergency operations were particularly affected. Second, process measures that are embedded in routine operating room practice, such as antibiotic prophylaxis

and temperature management, were achieved universally, whereas preoperative site marking was performed in fewer than half of the patients. Third, there was a consistent, graded association between the completeness of checklist implementation and postoperative outcomes; patients in whom the full checklist was completed had shorter hospital stays, fewer ICU admissions, fewer and less severe complications, fewer readmissions and no deaths.

The rate of complete implementation in our study is considerably lower than that reported from high-income settings. In the United Kingdom Surgical Checklist Implementation Project, at least one component was completed in 96.7% of operations and the entire checklist in 62.1% [12]. Our finding closely resembles the experience from Jimma University Medical Center in Ethiopia, where the checklist was used in 93.5% of procedures but fully completed in only 17.3% [15]. In both settings the checklist was nominally present in almost every case but seldom used in its entirety. Direct observational data from England have shown that even where documentation appears complete, only about two-thirds of items are actually checked and the Sign Out is omitted in 39% of cases [13]. At the Tata Memorial Centre in Mumbai, Ambulkar and colleagues found that compliance fell from 100% for the Sign In to 78% for the Time Out and 76.5% for the Sign Out, with meaningful interaction among all three professional groups in only 52% of cases [14]. Together with our results, these observations suggest that the Sign In, which coincides with the anaesthetic preparation of the patient, is readily adopted, while the later phases that require the whole team to pause are the most vulnerable to omission.

The universal compliance with antibiotic prophylaxis and normothermia in our cohort is encouraging. It mirrors the experience of Shankar at a teaching hospital in Bangalore, where 100% of patients received prophylactic antibiotics during the study period and the checklist identified and corrected a deficit in 27 patients [18]. These process measures are likely to be supported by established departmental routines and anaesthetic protocols, which may explain their reliability even when the formal checklist is incomplete. By contrast, preoperative site marking was performed in only 44.6% of our patients. Joselyn and colleagues at Christian Medical College, Vellore, reported a baseline site marking rate of 74% that rose to 95% after a phased surgical safety bundle with repeated audits and education [21]. Site marking in general surgery is often perceived as unnecessary for midline or single-organ procedures, but it forms an integral part of the Sign In and of wrong-site prevention in lateralised procedures such as hernia repair, breast surgery and limb operations. Our finding identifies site marking as a specific, easily measurable target for improvement.

The overall complication rate of 20.1% in our study falls within the range reported in comparable populations. The baseline complication rate in the WHO pilot study was 11.0%, and among urgent operations in the same hospitals it was 18.4% before checklist introduction [4,5]. In the Norwegian stepped wedge trial, complications occurred in 19.9% of patients in the control phase [7], and in the African Surgical Outcomes Study, which included 57% urgent or emergency procedures, postoperative complications occurred in 18.2% of patients [20]. The International Surgical Outcomes Study, restricted to elective surgery, reported at least one complication in 16.8% of patients [11]. Our cohort included 40.2% emergency procedures and a wide age range, which may partly account for the complication rate observed.

Surgical site infection was the most common specific complication in our study, affecting 14.3% of patients. In the GlobalSurg cohort of 12,539 patients undergoing gastrointestinal surgery in 66 countries, SSI occurred in 12.3% overall, with rates of 9.4%, 14.0% and 23.2% in high, middle and low Human Development Index countries, respectively [19]. Our rate is therefore close to that reported for middle-income countries. Infection was also the most common complication in the African Surgical Outcomes Study, affecting 10.2% of patients [20], and in the Bangalore study SSIs accounted for 44 of 73 complications [18]. The SSI rate in emergency surgery in our study (20.0%) was almost twice that in elective surgery (10.4%, $p=0.043$), consistent with the higher proportion of contaminated and dirty procedures in emergency general surgery. Since antibiotic prophylaxis was universal in our cohort, further reduction in SSI is likely to require attention to other elements such as wound care, glycaemic control and the timing of prophylaxis.

The postoperative mortality of 1.8% observed in our study is comparable with the baseline mortality of 1.5% in the WHO pilot study [4] and lower than the 2.1% reported in the African Surgical Outcomes Study [20]. Among urgent operations in the WHO dataset, mortality fell from 3.7% to 1.4% after checklist introduction [5], and the mortality after emergency surgery in our study was 3.3%. The small number of deaths in our study limits the precision of mortality comparisons, but the absence of any death among patients with complete implementation is noteworthy. The most important finding of this study is the graded relationship between the completeness of implementation and outcome. Complete implementation was associated with a complication rate of 9.4% compared with 23.5% for single-phase implementation ($p=0.001$ for trend), and with a lower proportion of higher-grade complications (3.1% vs 24.8%). This pattern closely parallels the observations of van Klei and colleagues in 25,513 patients, in whom full checklist completion was associated with an odds ratio for mortality of 0.44 (95% CI 0.28 to 0.70),

whereas partial completion (odds ratio 1.09) and non-compliance (odds ratio 1.16) conferred no benefit [8]. Similarly, Mayer and colleagues found that the reduction in complications from 16.9% to 11.2% was largely confined to cases in which all three components had been completed (odds ratio 0.57, 95% CI 0.37 to 0.87) [12]. The meta-analysis by Bergs and colleagues also reported a strong correlation between reductions in complications and adherence to the care processes embedded in the checklist [9]. The consistency of these findings across different health systems supports the view that it is the completeness of the checklist, rather than its mere presence, that determines its impact.

The reduction in hospital stay associated with complete implementation in our study (6.2 vs 10.4 days) was substantially larger than the 0.8-day reduction reported in the Norwegian stepped wedge trial [7]. The greater difference may reflect the higher baseline complication rate and the larger proportion of emergency cases in our setting, in which each avoided complication has a proportionally greater effect on length of stay. The lower rates of ICU admission (6.3% vs 20.3%) and 30-day readmission (3.1% vs 11.8%) with complete implementation have important implications for resource use in a public hospital where critical care beds are limited, since avoidance of these events translates directly into savings for both patients and the institution.

Emergency surgery emerged as the principal weakness in checklist implementation. Complete implementation was achieved in only 4.4% of emergency procedures compared with 20.9% of elective procedures. Time pressure, out-of-hours operating, unstable patients and rapidly assembled teams are plausible explanations. Yet emergency patients are those who stand to benefit most; in the WHO urgent surgery cohort, complications fell from 18.4% to 11.7% after checklist introduction, and adherence to safety steps rose from 18.6% to 50.7%, demonstrating that the checklist is feasible even in urgent situations [5]. The literature on this point is not uniform. Girma and colleagues in Ethiopia found that checklist completeness was actually lower in elective surgery than in emergency procedures (adjusted odds ratio 0.367) [15], and Russ and colleagues found no difference in checklist performance between elective and emergency procedures in English hospitals [13]. These contrasting findings indicate that the relationship between urgency and checklist use is shaped by local workflow and team culture rather than by urgency alone, reinforcing the need for context-specific interventions.

The progressive rise in complete implementation from 7.1% to 21.4% over the study period suggests that familiarity, repeated exposure and ongoing reinforcement can improve adherence. Joselyn and colleagues similarly reported that checklist usage at their institution increased from 65% in 2010 to 97% in 2019 through a slow, phased programme of audits, re-

audits and repeated education [21]. Awareness alone is insufficient; in a national survey of 513 Indian orthopaedic surgeons, 90.3% were aware of the checklist but only 55.8% used it routinely, and 17% considered it time-consuming [22]. These data suggest that sustained improvement in our institution will require regular audit and feedback, designated checklist leaders for each operating list, simulation-based team training and adaptation of the workflow for emergency theatres.

Our findings must also be interpreted in light of studies that did not demonstrate benefit. The Ontario experience showed that mandating checklist adoption across a province was not followed by significant reductions in mortality (odds ratio 0.91) or complications (odds ratio 0.97) [10], and the International Surgical Outcomes Study found no association between checklist exposure and complications (odds ratio 1.02) [11]. Abbott and colleagues suggested that the apparent benefit of checklists might partly reflect the overall quality of care in hospitals that use them consistently [11]. In the same way, within a single institution, teams that complete the entire checklist may also be those that are more attentive to other aspects of care, and patients with complete implementation were more often undergoing elective surgery, which was itself associated with better outcomes in our study. The association between complete implementation and better outcomes should therefore be regarded as consistent with, rather than proof of, a causal effect.

STRENGTHS OF THE STUDY

This study has several strengths, Data were collected prospectively over two years in a real-world tertiary setting that included both elective and emergency cases and patients of all ages. Patients were followed up to postoperative day 30, and complications were graded using the standardised Clavien-Dindo classification, which has been validated across many surgical fields [16,17]. To our knowledge, this is among the first reports from northeast India to link the depth of WHO SSC implementation with postoperative outcomes.

LIMITATIONS

There are also limitations, The study was conducted at a single centre with convenience sampling, which may limit generalisability. The observational design cannot exclude confounding by case mix, urgency, ASA grade or operative complexity, and the analyses presented did not adjust for these factors. The number of patients with complete implementation was modest and the number of deaths was small, so the mortality comparisons should be interpreted with caution. Clavien-Dindo grading was applied across the whole cohort as recorded in the case record form. Checklist completion was assessed from documentation and observation by the study team, and the awareness of

being studied may itself have influenced team behaviour. Finally, the reasons for incomplete implementation were not analysed in detail. Multicentre studies with risk-adjusted analyses and direct observation of checklist quality would help to confirm these findings.

CONCLUSIONS

In this prospective study from a tertiary care institute in Manipur, the WHO Surgical Safety Checklist was applied in some form to every operation, but all three phases were completed in only 14.3% of procedures, and complete implementation was particularly uncommon in emergency surgery (4.4%). Antibiotic prophylaxis and normothermia were achieved universally, whereas preoperative site marking was performed in fewer than half of the patients.

The completeness of checklist implementation showed a consistent, graded association with postoperative outcomes. Patients in whom all three phases were completed had a shorter hospital stay, fewer ICU admissions, fewer complications, a lower proportion of higher-grade complications, fewer readmissions and no mortality, compared with those in whom only one or two phases were completed. Emergency surgery was associated with both lower checklist completion and poorer outcomes across several parameters. The steady rise in complete implementation during the study period shows that adherence can be improved within the existing system.

These findings indicate that the benefit of the WHO SSC depends on its complete and meaningful use rather than on its mere presence in the operating room. Institutional strategies should focus on achieving full completion of the Time Out and Sign Out, improving preoperative site marking and adapting the checklist workflow to the realities of emergency theatres, supported by regular audit, feedback and team training. Larger, multicentre studies with risk-adjusted analyses are recommended to confirm the association between complete checklist implementation and improved surgical outcomes.

Declarations

Ethical Approval

The study was approved by the Institutional Ethics Committee of Jawaharlal Nehru Institute of Medical Sciences (JNIMS), Porompat, Imphal, Manipur, India, before commencement of the study.

Consent to Participate

Written informed consent was obtained from all adult participants. For participants younger than 18 years, informed consent was obtained from their parents or legal guardians.

Consent for Publication

Not applicable. No individually identifiable personal information or identifiable patient images are presented in this manuscript.

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The authors received no specific funding or financial support for this study.

Conflict of Interest

The authors declare that they have no conflict of interest.

Availability of Data and Materials

The data generated and/or analysed during the present study are available from the corresponding author on reasonable request, subject to institutional and ethical restrictions.

Author Contributions

All authors contributed to the conception and design of the study, data collection, analysis and interpretation of the results, manuscript preparation and critical revision. All authors approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

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Use of Artificial Intelligence

The authors declare that no generative artificial intelligence tool was used to generate or interpret the scientific data, perform statistical analysis, or draw scientific conclusions presented in this manuscript.

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