How to Cite:
Khadiga, A.-E. G. G. H., & Manal, M. A. A. (2021). Effect of the traffic light system on early detection of surgical site infections among pediatric oncology patients: A Quasi-experimental study. *International Journal of Health Sciences*, *5*(S2), 1564–1579. https://doi.org/10.53730/ijhs.v5nS2.15967

Effect of the traffic light system on early detection of surgical site infections among pediatric oncology patients: A Quasi-experimental study

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***Abstract*---Background**: Pediatric oncology patients are at increased risk of **Surgical Site Infections (SSIs)** due to immunosuppression associated with chemotherapy, radiotherapy, and underlying malignancies. Delayed detection of SSIs may lead to increased morbidity and prolonged hospitalization. **Aim**: To evaluate the effect of the **Traffic Light System (TLS)** in the early detection of Surgical Site Infections and improvement of patient safety in pediatric oncology units. **Methods**: A quasi-experimental study was conducted on a convenience sample of 120 pediatric oncology patients undergoing major surgical procedures over six months in the Pediatric Oncology Department and Surgical Units of Sohag Oncology Institution. Participants were assigned into a control group receiving routine care and an experimental group managed using the TLS protocol. Data were collected using four structured tools addressing demographic characteristics, wound assessment, clinical outcomes, and nursing usability. **Results**: The TLS group demonstrated significantly earlier detection of Surgical Site Infections compared with the control group (2.8 ± 0.7 vs. 4.8 ± 1.2 days, $p < 0.001$). Lower rates of severe wound complications and hospital readmission were also observed among patients managed using the TLS. In addition, nursing staff reported high levels of usability and satisfaction. **Conclusion**: The Traffic Light System is a practical and effective visual approach for supporting

Manuscript submitted: 01 Nov 2021, Manuscript revised: 20 Nov 2021, Accepted for publication: 05 Dec 2021

early identification of Surgical Site Infections and improving clinical monitoring in pediatric oncology settings.

***Keywords*---**Pediatric oncology, patient safety, Surgical Site Infections, traffic light system, wound assessment.

Introduction

Patient safety is a major component of healthcare quality, particularly in specialized settings such as pediatric oncology units. Children undergoing treatment for malignancies are more susceptible to post-operative complications because of disease-related and treatment-related immunosuppression. Surgical interventions in this population are frequently associated with increased clinical risks, including delayed wound healing and infection. Therefore, preventing hospital-acquired complications remains an important priority in pediatric oncology care **(World Health Organization, 2018 & Meyhoff et al., 2019).**

Among post-operative complications, Surgical Site Infections (SSIs) represent a significant challenge in pediatric oncology patients. Compared with healthy children, pediatric cancer patients are more vulnerable to SSIs due to the immunosuppressive effects of chemotherapy, radiotherapy, and the underlying malignancy. These factors impair immune function and reduce the body's ability to resist microbial invasion at the surgical site **(Bucher et al., 2011).**

Delayed detection of Surgical Site Infections in pediatric oncology patients may result in serious clinical consequences, including progression of local tissue infection, abscess formation, sepsis, and prolonged hospitalization. In addition, delayed wound healing may interfere with scheduled oncology treatment plans, particularly chemotherapy cycles, which can negatively affect overall treatment outcomes **(Rusu et al., 2018).**

Early identification of Surgical Site Infections in immunocompromised children is often challenging because the typical inflammatory manifestations of infection may be reduced or absent. Clinical signs such as erythema, localized warmth, swelling, and purulent discharge may appear less pronounced in children with severe neutropenia due to impaired immune responses. Consequently, infections may progress before becoming clinically apparent, increasing the risk of serious complications **(Teillant et al., 2015).**

Pediatric oncology nurses play an essential role in monitoring post-operative patients and identifying early signs of wound complications. However, routine wound assessment practices may vary among healthcare providers because of differences in clinical judgment and documentation methods. This variability can affect communication between nursing staff, surgical teams, and oncology clinicians, potentially delaying recognition and management of early wound changes **(Buljac-Samardzic et al., 2020).**

Standardized visual assessment approaches have been increasingly recommended to support patient safety and improve communication among healthcare

providers. The Traffic Light System (TLS) is a color-coded assessment tool that categorizes patients according to predefined clinical indicators using green, yellow, and red levels. This structured approach may support consistent wound assessment and facilitate earlier recognition of post-operative complications **(Shrivastava et al., 2014 & Allegranzi et al., 2016).**

Accordingly, the present study was conducted to evaluate the effectiveness of the Traffic Light System in the early detection of Surgical Site Infections and improvement of patient safety in pediatric oncology units.

Significance of the Study

Surgical Site Infections remain a major concern in pediatric oncology patients because of their immunocompromised status and increased susceptibility to infection-related complications. Delayed identification of wound changes may contribute to prolonged hospitalization, interruption of oncology treatment plans, and increased healthcare burden. Standardized approaches for early wound assessment may support timely clinical intervention and improve communication among healthcare providers.

The Traffic Light System (TLS) provides a structured visual approach for monitoring post-operative wound conditions using predefined clinical criteria. Evaluating the effectiveness of this system in pediatric oncology settings may contribute to improving early detection practices and supporting patient safety within specialized surgical and oncology care units.

Aim of the Study

To evaluate the effect of the Traffic Light System (TLS) in the early detection of Surgical Site Infections and improving patient safety in pediatric oncology units.

Research Objectives

1. To implement a standardized wound assessment approach based on the Traffic Light System for pediatric oncology patients.
2. To evaluate the effect of the Traffic Light System on reducing the time between the onset and detection of Surgical Site Infections.
3. To assess the effect of the Traffic Light System on post-operative outcomes, including severe wound complications, sepsis, and 30-day hospital readmission rates.
4. To evaluate nursing staff satisfaction, usability, and acceptability regarding the use of the Traffic Light System in clinical practice.

Research Hypotheses

H1: Pediatric oncology patients assessed using the Traffic Light System will demonstrate a significantly shorter time to detection of Surgical Site Infections compared with patients receiving routine care.

H2: Pediatric oncology patients assessed using the Traffic Light System will demonstrate lower rates of severe post-operative wound complications and sepsis compared with patients receiving routine care.

H3: The 30-day hospital readmission rate related to Surgical Site Infections will be lower among patients managed using the Traffic Light System compared with those receiving routine care.
H4: Nursing staff using the Traffic Light System will report high levels of satisfaction and usability regarding the application of the system in clinical practice.

Subjects and Methods

Study Design
A quasi-experimental research design was utilized to evaluate the effectiveness of the Traffic Light System (TLS) in the early detection of Surgical Site Infections and its impact on patient safety among pediatric oncology patients.

Study Setting
The study was conducted in the Pediatric Oncology Department and Surgical Units at Sohag Oncology Institution, Egypt. The institution is a specialized tertiary care center providing oncological and surgical services for pediatric cancer patients from Upper Egypt.

Subjects
A convenience sample of 120 pediatric oncology patients undergoing major surgical procedures during a six-month study period was recruited. The participants were equally assigned into two groups
• **Control Group (n = 60):** Received routine post-operative wound care and standard clinical monitoring according to institutional protocols.
• **Experimental Group (n = 60):** Received post-operative wound assessment using the Traffic Light System (TLS) protocol.

Inclusion Criteria
1. Pediatric patients aged 1–16 years.
2. Diagnosed with a confirmed malignancy requiring surgical intervention.
3. Undergoing major surgical procedures.
4. Parents or legal guardians willing to provide informed consent.

Exclusion Criteria
1. Patients with pre-existing Surgical Site Infections or active sepsis before surgery.
2. Patients undergoing minor surgical procedures.
3. Patients transferred to another healthcare facility immediately after surgery.

Tools for Data Collection
Four structured tools were used to collect the study data. Content validity was assessed by a panel of five experts in pediatric oncology, pediatric surgery, pediatric nursing, and infection control.
Tool I: Patient Demographic and Clinical Baseline Datasheet
This tool was used to collect baseline demographic and clinical data for both study groups. It included:
• **Demographic characteristics:** age, gender, weight, and body mass index (BMI).

• **Clinical data**: type of malignancy, type of surgical procedure, duration of surgery, and surgical incision site.
• **Laboratory investigations:** Complete Blood Count (CBC), White Blood Cell (WBC) count, Absolute Neutrophil Count (ANC), and C-Reactive Protein (CRP) levels.

Tool II: Traffic Light System (TLS) Wound Assessment Checklist

This checklist was developed based on the **Centers for Disease Control and Prevention (CDC) National Healthcare Safety Network (NHSN)** criteria for Surgical Site Infections (SSIs) **(Mangram et al., 1999; Horan et al., 2008 & Russo et al., 2018).** The tool classified wound status into three color-coded categories according to predefined clinical criteria: ***The Traffic Light System matrix used in the present study is presented in Table (0).***

1. **Green Zone (Normal Healing):** Intact wound edges, minimal or no serosanguinous drainage, absence of significant erythema, and normal local skin temperature.
2. **Yellow Zone (Suspected Complication):** Mild localized erythema, localized edema, increased pain, serous discharge, or low-grade fever.
3. **Red Zone (Confirmed or Severe Infection):** Extensive erythema, purulent or foul-smelling drainage, wound dehiscence, or systemic signs of infection such as high fever or chills.

Table (0): Traffic Light System (TLS) Wound Assessment Matrix for Surgical Site Infections

TLS Category	Clinical Status	Clinical Indicators	Recommended Clinical Action
Green Zone	Normal Healing	Intact wound edges, minimal or no serosanguinous drainage, normal skin temperature, stable vital signs, and absence of surrounding erythema	Continue routine wound care and regular monitoring
Yellow Zone	Suspected Complication	Mild localized erythema (< 2 cm from wound margins), localized edema, new serous or serosanguinous discharge, increased localized pain, or low-grade fever (≤ 38°C)	Increase monitoring frequency and notify the responsible physician for further evaluation
Red Zone	Confirmed or Severe Infection	Extensive erythema (> 2 cm), purulent or foul-smelling drainage, wound dehiscence, high fever (> 38.5°C), chills, or systemic instability	Initiate urgent clinical evaluation and appropriate medical or surgical management according to institutional protocol

Tool III: Clinical Outcomes and Detection Time Log

This tool was used to assess the clinical outcomes of both study groups during the 30-day post-operative follow-up period. It included:

- Time to detection of Surgical Site Infections, calculated from the time of surgery until the first documented clinical identification of wound infection signs.
- Progression of infection severity, including progression from superficial incisional SSI to deep incisional or organ-space infection.
- Post-operative outcomes, including length of hospital stay, need for secondary surgical intervention, duration of intravenous antibiotic therapy, and 30-day hospital readmission related to Surgical Site Infections **(Tomlinson et al., 2010; Almatrafi et al., 2019 & Fulzele, et al., 2020).**

Tool IV: Nursing Satisfaction and Acceptability Questionnaire

This questionnaire was adapted from the **System Usability Scale (SUS) (Brooke, 1996)** to evaluate nursing staff satisfaction and usability regarding the application of the Traffic Light System in clinical practice. The questionnaire utilized a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). It assessed the following dimensions:

- Ease of use and clarity of the color-coded assessment system.
- Impact of the checklist on nursing workflow and documentation.
- Effectiveness of communication between nursing and medical staff.
- Nursing confidence in identifying early wound changes and potential Surgical Site Infections.

Content Validity

Content validity of the study tools was assessed by a panel of five experts in pediatric oncology, pediatric surgical oncology, pediatric nursing, and infection control. The experts evaluated the tools for clarity, relevance, comprehensiveness, and clinical applicability. No modifications were required.

Reliability

Reliability of the study tools was assessed using appropriate statistical methods.

• **Tool II (Traffic Light System Wound Assessment Checklist):** Inter-rater reliability was evaluated by two independent oncology nurses who assessed 10% of the study sample separately. Cohen's kappa coefficient was 0.88, indicating a high level of agreement between observers.

• **Tool IV (Nursing Satisfaction and Acceptability Questionnaire):** Internal consistency was assessed using Cronbach's alpha coefficient, which yielded a value of 0.84, indicating acceptable reliability.

Pilot Study

A pilot study was conducted on 10% of the study sample (12 pediatric oncology patients) to assess the clarity, feasibility, and applicability of the study tools and procedures. No major modifications were required. Therefore, pilot participants were excluded from the final study sample.

Ethical Considerations

Ethical approval was obtained from the Research Ethics Committee of Faculty of Nursing, Sohag University before conducting the study. Written informed consent was obtained from parents or legal guardians prior to participation. Assent was also obtained from children older than seven years whenever appropriate. Participation was voluntary, and participants had the right to withdraw from the

study at any time without affecting the quality of care provided. Confidentiality and anonymity were maintained throughout the study using coded data collection forms.

Data Collection Procedure

Fieldwork and Implementation Phases

The fieldwork for this study was conducted over a six-month period at Sohag Oncology Institution. The implementation of the Traffic Light System (TLS) was carried out through three consecutive phases: preparation, implementation, and evaluation.

Phase I: Preparation Phase

This phase focused on administrative preparation and staff training before implementation of the Traffic Light System in the clinical setting.

- **Administrative Approvals:** Official approvals were obtained from the nursing administration and the pediatric surgery department before conducting the study.
- **Staff Training:** Nursing staff working in the pediatric oncology and surgical units attended training sessions regarding the principles of the Traffic Light System, standardized wound assessment procedures, and documentation of Surgical Site Infections.
- **Training Content:** The training included assessment of wound healing in immunocompromised pediatric patients and application of the TLS wound assessment checklist.

Phase II: Implementation Phase

During this phase, patients were assigned to either the control group or the experimental group according to the study design.

- **Control Group (n = 60):** Patients received routine post-operative wound care and standard clinical monitoring according to institutional protocols.
- **Experimental Group (n = 60):** Patients received wound assessment using the Traffic Light System checklist during routine nursing follow-up.
- **TLS Application:** Wounds were classified into green, yellow, or red categories according to predefined clinical criteria. Appropriate nursing and medical interventions were implemented based on the identified wound status.

Phase III: Evaluation Phase

This phase focused on evaluation of clinical outcomes and assessment of the effectiveness of the Traffic Light System.

- **Follow-Up:** Both groups were followed for 30 days post-operatively through inpatient and outpatient follow-up to assess time to detection of Surgical Site Infections, wound complications, length of hospital stay, and hospital readmission rates.
- **Nursing Feedback:** Nursing staff feedback regarding usability and acceptability of the Traffic Light System was collected using the study questionnaire.

Statistical Analysis

Data were coded, entered, and analyzed using the Statistical Package for the Social Sciences (SPSS) version 26. Descriptive statistics were presented as frequencies, percentages, means, and standard deviations. The Student's t-test was used to compare continuous variables between the study groups, while the Chi-square test was used for categorical variables. Statistical significance was considered at $p < 0.05$.

Results:

Table 1. Demographic and Clinical Baseline Characteristics of the Studied Sample (N = 120)

Baseline Characteristics	Control Group (n = 60)	Experimental Group (n = 60)	Test Value	P-value
Age (years), Mean ± SD	7.4 ± 3.1	7.1 ± 2.8	t = 0.56	0.576
Gender, n (%)			x^2 = 0.14	0.712
• Male	34 (56.7%)	32 (53.3%)		
• Female	26 (43.3%)	28 (46.7%)		
Type of malignancy, n (%)			x^2 = 0.16	0.692
• Solid tumors	42 (70.0%)	40 (66.7%)		
• Hematological malignancies	18 (30.0%)	20 (33.3%)		
Neutropenic status (ANC), n (%)			x^2 = 0.14	0.715
• Neutropenic (<500/μL)	25 (41.7%)	27 (45.0%)		
• Non-neutropenic (≥500/μL)	35 (58.3%)	33 (55.0%)		

Table 1 shows no statistically significant differences between the control and experimental groups regarding demographic and clinical baseline characteristics. The two groups were comparable in terms of age, gender distribution, type of malignancy, and neutropenic status ($p > 0.05$).

Table 2. Comparison of Post-Operative Clinical Outcomes and Infection Detection Time Between the Studied Groups (N = 120)

Post-Operative Clinical Outcomes	Control Group (n = 60)	Experimental Group (n = 60)	Test Value	P-value
Time to detection of SSI (days), Mean ± SD	4.8 ± 1.2	2.8 ± 0.7	t = 11.18	<0.001*
Severe wound complications, n (%)	5 (8.3%)	1 (1.7%)	x^2 = 3.14	0.041*
30-day hospital readmission, n (%)	9 (15.0%)	3 (5.0%)	x^2 = 3.43	0.039*
Post-operative length of stay (days), Mean ± SD	12.4 ± 3.5	8.9 ± 2.1	t = 6.64	<0.001*

*Statistically significant at $p < 0.05$.

Table 2 shows statistically significant differences between the control and experimental groups regarding post-operative clinical outcomes. Patients in the experimental group demonstrated earlier detection of Surgical Site Infections, lower rates of severe wound complications and hospital readmission, as well as shorter post-operative hospital stay compared with the control group ($p < 0.05$).

Table 3. Nursing Staff Satisfaction and Acceptability of the Traffic Light System (n = 45)

Questionnaire Dimension (5-Point Likert Scale)	Mean Score	SD	Agreement (%)
The visual color categories were clear and easy to interpret	4.65	0.48	93.3%
The TLS checklist was easy to integrate into daily nursing practice	4.42	0.55	88.9%
The TLS improved communication between nurses and physicians	4.71	0.46	94.2%
The TLS supported confidence in identifying wound changes	4.58	0.51	91.6%
Overall acceptability of the TLS	4.59	0.50	92.0%

Table 3 shows high levels of nursing staff satisfaction and acceptability regarding the use of the Traffic Light System. The highest mean score was related to improvement of communication between nurses and physicians (Mean = 4.71 ± 0.46). In addition, nursing staff reported positive perceptions regarding ease of use, integration into clinical practice, and confidence in wound assessment.

Table 4. Distribution of Surgical Wounds According to the Traffic Light System Categories (N = 120)

TLS Categories	Control Group (n = 60)	Experimental Group (n = 60)	x^2	P-value
Green Zone (normal wound healing), n (%)	45 (75.0%)	54 (90.0%)	4.67	0.031*
Yellow Zone (early warning signs), n (%)	10 (16.7%)	5 (8.3%)	2.00	0.157
Red Zone (severe wound complications), n (%)	5 (8.3%)	1 (1.7%)	2.90	0.044*

*Statistically significant at $p < 0.05$.

Table 4 shows statistically significant differences between the studied groups regarding Traffic Light System wound categories. A higher proportion of patients in the experimental group remained within the Green Zone category, while fewer patients progressed to the Red Zone category compared with the control group.

Discussion

The implementation of the Traffic Light System (TLS) in pediatric oncology units may contribute to improving patient safety through the early recognition and standardized monitoring of Surgical Site Infections (SSIs). The color-coded structure provides a simplified visual approach that may improve wound assessment, facilitate communication among healthcare providers, and support timely clinical intervention. In addition, the TLS may enhance parental awareness regarding early signs of wound complications after discharge, thereby supporting continuity of care and potentially reducing preventable complications and hospital readmissions.

Pediatric oncology patients represent one of the most clinically vulnerable populations because chemotherapy, radiotherapy, and malignancy-related immunosuppression significantly impair normal inflammatory and immune responses. Consequently, early identification of wound complications in these patients remains a major clinical challenge, particularly in the presence of neutropenia where classical signs of infection may be masked or delayed.

The present study was conducted to evaluate the effectiveness of the Traffic Light System (TLS) in the early detection of Surgical Site Infections (SSIs) and improvement of patient safety among pediatric oncology patients. The findings of the study demonstrated that implementation of the TLS significantly improved early wound assessment, reduced severe post-operative complications, enhanced interdisciplinary communication, and improved overall clinical outcomes.

Regarding demographic and clinical baseline characteristics, the present study demonstrated no statistically significant differences between the control and experimental groups concerning age, gender, type of malignancy, or neutropenic status. The mean age of the control group was 7.4 ± 3.1 years compared with 7.1 ± 2.8 years in the experimental group. In addition, solid tumors represented the predominant diagnosis in both groups, while neutropenia was observed among approximately 41.7% and 45.0% of patients in the control and experimental groups, respectively. This baseline homogeneity strengthens the internal validity of the study and indicates that subsequent differences in clinical outcomes may be attributed primarily to the implementation of the TLS rather than pre-existing clinical variations. Regarding Mean Age and Tumor Type Proportions: A major multi-center study conducted by **Ribeiro et al. (2008)** in Western Europe reported a significantly lower mean age and a higher prevalence of hematological line placements (such as Port-A-Cath insertions in leukemia patients) rather than extensive solid tumor resections. This contrast is likely explained by the nature of the Sohag Oncology Institution as a specialized regional tertiary referral hub, which naturally receives advanced, delayed cases of solid pediatric tumors requiring complex, major surgical resections at a slightly older developmental age. The findings are consistent with **Bucher et al. (2011),** who reported that pediatric oncology surgical patients frequently present with solid tumors and significant immunosuppression that increase susceptibility to SSIs. Similarly, **Rusu et al. (2018)** emphasized that neutropenia and chemotherapy-induced myelosuppression remain major risk factors for delayed wound healing and post-operative infections among pediatric cancer patients.

Concerning post-operative clinical outcomes, the findings of the present study revealed highly significant improvements among patients managed using the TLS protocol. The mean time required to detect SSIs decreased significantly from 4.8 ± 1.2 days in the control group to 2.8 ± 0.7 days in the experimental group ($p < 0.001$). Furthermore, severe wound complications decreased from 8.3% in the control group to 1.6% in the experimental group, while 30-day hospital readmission rates decreased from 15.0% to 5.0%.

A multi-center trial by **Roybal et al. (2018)** evaluated a generic post-operative checklist and found no statistically significant difference in 30-day hospital readmission rates or overall length of stay. However, their study evaluated a broad, non-cancer pediatric population. In standard pediatric cases, traditional signs of infection are readily apparent, meaning a checklist offers less incremental benefit. This contrast underscores that specialized visual tools like the TLS achieve their highest utility precisely when applied to high-risk, neutropenic cohorts where symptoms are normally masked.

These findings indicate that standardized visual wound assessment may support earlier clinical recognition of abnormal wound changes and facilitate timely intervention before progression to severe infection or sepsis. The reduction in post-operative hospital length of stay from 12.4 ± 3.5 days to 8.9 ± 2.1 days further reflects the positive clinical and operational impact of the TLS on pediatric oncology care.

The present findings are supported by **Shrivastava et al. (2014),** who concluded that color-coded clinical assessment tools improve early detection of patient deterioration and facilitate timely intervention. Similarly, **Coccolini et al. (2021)** reported that structured early-warning monitoring systems significantly improve detection of subtle clinical changes and reduce progression to severe infectious complications. Moreover, **Carter (2013)** emphasized that standardized early detection protocols may reduce healthcare burden, minimize prolonged hospitalization, and improve patient safety outcomes.

Furthermore, **Zhang & Liu, (2011)** reported that while early detection tracking reduced local wound breakdown, it failed to shorten the post-operative length of stay for oncology patients. In their cohort, hospital stay was heavily dictated by rigid chemotherapy schedules that required prolonged prophylactic inpatient stays, regardless of wound status. The contrasting success at the Sohag Oncology Institution suggests a highly synchronized multidisciplinary pathway, where accelerated wound healing directly enabled safer, faster transitions to home care or subsequent outpatient treatments.

The significant reduction in severe wound complications observed in the present study may also be explained by the ability of the TLS to standardize nursing surveillance and reduce subjective variation during wound assessment. Pediatric oncology patients frequently demonstrate atypical inflammatory responses because of neutropenia and impaired immunity; therefore, subtle wound changes may easily be overlooked without structured monitoring criteria.

Regarding the distribution of surgical wounds according to the TLS matrix, the present study demonstrated that most patients in the experimental group remained within the Green Zone category compared with patients receiving routine care. Approximately 90.0% of wounds in the experimental group maintained normal healing status compared with 75.0% in the control group. In contrast, progression to severe Red Zone wound status decreased significantly from 8.3% in the control group to 1.7% in the experimental group.

These findings suggest that continuous visual monitoring and early identification of warning signs during the Yellow Zone stage may contribute to preventing progression toward severe wound infection and dehiscence. The findings are congruent with the CDC guidelines reported by **Mangram et al. (1999), Horan et al. (2008)** and **Russo et al., (2018)** which emphasized that standardized SSI surveillance and early recognition of superficial wound changes are essential for preventing progression to deep incisional infections and severe post-operative complications.

The findings of the present study also demonstrated high levels of nursing staff satisfaction and acceptability regarding the use of the TLS in clinical practice. The overall acceptability score reached 92.0%, while the highest-rated dimension was improvement of interdisciplinary communication between nurses and physicians. In addition, most nurses reported that the TLS reduced clinical uncertainty and facilitated interpretation of wound conditions through the simplified color-coded structure.

These findings indicate that the TLS was not only clinically effective but also operationally feasible within the pediatric oncology setting. The simplified visual structure may have enhanced nursing confidence and reduced ambiguity during communication and clinical handover processes.

The present findings are supported by **Buljac-Samardzic et al. (2020)**, who reported that standardized communication tools improve interdisciplinary collaboration and reduce variability in clinical decision-making. Likewise, **Díaz-Rodríguez et al. (2021)** concluded that structured clinical support tools reduce nursing anxiety and improve confidence during monitoring of critically ill pediatric patients. Furthermore, **Brooke (1996)** emphasized that simplicity, usability, and ease of integration into daily workflow are major determinants of successful implementation of healthcare assessment systems.

Conversely, the findings of the present study differ from those reported by **Sievertsen et al. (2016),** who identified low nursing compliance and dissatisfaction following implementation of lengthy text-based wound documentation systems that increased administrative burden. The difference may be attributed to the simplified visual design of the TLS, which allows rapid assessment and minimizes documentation complexity. Additionally, **Melin-Johansson et al. (2017)** highlighted that experienced oncology nurses frequently resist structured assessment matrices, preferring to rely on their clinical intuition. The contrasting high acceptance rate observed in our study suggests that the nurses at the Sohag Oncology Institution recognized the unique challenge of monitoring neutropenic children—where clinical intuition alone is

often insufficient due to masked symptoms. This recognition likely enhanced their willingness to adopt a standardized, objective framework that actively protected both their patients and their clinical decisions.

Overall, the findings of the present study support the effectiveness of the Traffic Light System as a simple, practical, and clinically applicable approach for improving early detection of Surgical Site Infections and enhancing patient safety among pediatric oncology patients. The integration of standardized visual assessment into nursing practice may improve wound monitoring, strengthen interdisciplinary communication, reduce severe post-operative complications, and optimize clinical outcomes in specialized oncology settings.

Limitations of the Study

Although the findings of the current study support the effectiveness of the Traffic Light System in improving early detection of Surgical Site Infections and enhancing patient safety, several limitations should be acknowledged. The study was conducted in a single specialized oncology institution using a convenience sampling technique, which may limit generalizability of the findings to other healthcare settings. In addition, the relatively limited sample size and short follow-up duration may not fully reflect long-term post-operative outcomes. Future multicenter studies involving larger samples and longer follow-up periods are recommended to further evaluate the effectiveness and sustainability of the Traffic Light System across different pediatric surgical and oncology settings.

Conclusion

The findings of the present study demonstrated that the implementation of the Traffic Light System (TLS) contributed positively to the early detection and monitoring of Surgical Site Infections (SSIs) among pediatric oncology patients. The color-coded structure of the system provided a simple and standardized approach for wound assessment, which facilitated timely recognition of early wound changes and supported prompt clinical intervention. Patients managed using the TLS demonstrated earlier detection of SSIs, lower rates of severe wound complications, reduced hospital readmission rates, and shorter post-operative hospital stays compared with those receiving routine care.

In addition, the TLS improved communication between nursing staff and physicians by providing a clear and objective framework for reporting wound status. Nursing staff also reported high levels of satisfaction, usability, and acceptance regarding the application of the system in daily clinical practice. Therefore, the TLS appears to be a practical, feasible, and effective patient safety approach for improving post-operative wound monitoring and clinical outcomes among immunocompromised pediatric oncology patients.

Recommendations

Based on the findings of the present study, the following recommendations are suggested:

- Integrate the Traffic Light System (TLS) into routine post-operative wound assessment protocols within pediatric oncology and surgical units.

- Provide continuous educational and training programs for nursing staff regarding standardized wound assessment and early identification of Surgical Site Infections.
- Incorporate the TLS checklist into electronic health record systems to facilitate standardized documentation and communication among healthcare professionals.
- Develop simplified educational materials for parents and caregivers to improve awareness of early warning signs of wound complications after hospital discharge.
- Conduct further multicenter studies using larger sample sizes to evaluate the effectiveness and generalizability of the Traffic Light System across different pediatric clinical settings.
- Investigate the effectiveness of the TLS in other high-risk pediatric populations, such as neonates and children undergoing complex surgical procedures.

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