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# Abdominal wound dehiscence and associated factors among patients undergone midline laparotomy at a comprehensive specialized hospital in Southern Ethiopia: a retrospective cohort study

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## Abstract

**Background** Abdominal wound dehiscence (AWD) is a life-threatening complication of laparotomy, particularly in developing countries. Local data from southern Ethiopia are lacking.

**Objective** To determine the cumulative incidence of AWD and its associated factors following midline laparotomy at Wolaita Sodo University Comprehensive Specialized Hospital (WSUCSH), Southern Ethiopia.

**Methods** A retrospective cohort study included all adult patients who underwent midline laparotomy at WSUCSH between June 1, 2020, and June 30, 2023 ( $n = 450$ ). Because of quasi-complete separation, multivariable analysis used Firth's bias-reduced logistic regression; a sensitivity model excluding postoperative surgical site infection (SSI) was also fitted.

**Results** The cumulative incidence of AWD was 10.4% (47/450; 95% CI: 7.9–13.6%); 45/47 cases followed emergency surgery. SSI (89.4% vs. 10.4%) and preoperative sepsis (66.0% vs. 10.2%) were strongly associated with AWD in crude analysis, but adjusted estimates were unstable. After adjustment, operative duration  $< 3$  h (AOR = 0.02; 95% CI: 0.00–0.50) and gastrointestinal contamination  $< 500$  mL (AOR = 0.03; 95% CI: 0.00–0.57) were associated with lower odds of AWD; postoperative cough/vomiting (AOR = 111.3; 95% CI: 4.9–2534.4) and emergency surgery (AOR = 25.7; 95% CI: 3.4–195.9) showed very imprecise positive associations that attenuated without SSI in the model. AWD was associated with longer stay (median 26 vs. 8 days) and mortality (21.3% vs. 0%).

**Conclusion** One in ten patients developed AWD, mostly after emergency surgery. Preoperative sepsis, SSI, prolonged surgery and heavy contamination were associated with AWD, but adjusted estimates were imprecise and require prospective confirmation.



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**Keywords** Surgical site infection, postoperative complications, Ethiopia, Burst abdomen, Fascial dehiscence, Risk factors, Emergency laparotomy

## 1 Background

Despite continuous advances in understanding the physiology of wound healing, along with improvements in surgical techniques and the application of modern technologies and materials, wound healing complications remain a significant clinical challenge. Immediate postoperative complications, such as wound dehiscence, continue to occur despite the implementation of standard preventive measures [1, 2].

Abdominal wound dehiscence is defined as the partial or complete disruption of a surgically closed abdominal wound, with or without protrusion of abdominal contents [3]. It is considered one of the most serious and life-threatening postoperative complications because of its rapid onset and the potential for irreversible pathological sequelae [4]. In contrast to the improved outcomes observed in developed countries, associated mortality remains high in many developing nations, largely attributable to a higher burden of infectious complications and limited access to adequate healthcare facilities and resources [5].

The magnitude of wound dehiscence varies considerably across hospitals worldwide [4]. In developed countries, incidence typically ranges from 0.4% to 3.5% [5]. In some centers in developing countries, however, incidence may be as high as 10–30%, as reported in India and Pakistan [6], and approximately 12.4% in Egypt [7]. The mortality rate associated with wound dehiscence has been reported to range between 14% and 50% [6, 8].

Numerous studies have attempted to identify the underlying causes of postoperative wound dehiscence. Evidence suggests its occurrence is influenced by a combination of operative variables (type of surgery, suture technique), postoperative conditions (particularly surgical site infection), and patient-related predisposing factors, including anemia, malignancy, obesity, diabetes mellitus, advanced age, hypoalbuminemia, chronic cough or vomiting, malnutrition, and smoking [4, 8–10]. Early identification of modifiable risk factors, along with routine laboratory investigations, may play a critical role in reducing the incidence of wound dehiscence [4]. Existing prediction models, such as the van Ramshorst risk model [10], incorporate several of these predictors, but validated models specific to Sub-Saharan African, resource-limited surgical settings, where the case mix is dominated by emergency, contaminated procedures, remain scarce, representing an important evidence gap that the present study seeks to help address.

Abdominal wound dehiscence typically occurs around one week after surgery and is often preceded by serosanguinous discharge from the wound site. It may progress to evisceration, a surgical emergency requiring immediate intervention. AWD is associated with significant morbidity and mortality, including prolonged hospital stay, a high incidence of incisional hernia, and death [11].

A study conducted in Ethiopia reported that the majority of patients with wound dehiscence (95.2%) underwent relaparotomy for its management; among these, 48.8% were treated using tension sutures during secondary abdominal closure, and 9.7% of patients died following the second operation [4].

Therefore, the current study aimed to determine the cumulative incidence of abdominal wound dehiscence and identify its associated factors at Wolaita Sodo University Comprehensive Specialized Hospital in Southern Ethiopia.

## **2 Materials and methods**

### **2.1 Study design, setting and period**

A retrospective cohort study was conducted among adult patients who underwent midline laparotomy at Wolaita Sodo University Comprehensive Specialized Hospital (WSUCSH) between June 1, 2020, and June 30, 2023. The study was conducted and reported in accordance with the STROBE guideline for observational studies [12]. The design is described as a retrospective cohort rather than a cross-sectional study because a defined group of patients was identified at the time of an index exposure (midline laparotomy), followed through the medical record for a defined postoperative observation period (the index admission), and assessed for an outcome (AWD) that occurred after the exposure; accordingly, the frequency of AWD is reported as a cumulative incidence rather than a prevalence. WSUCSH is located in Wolaita Zone, approximately 329 km from Addis Ababa, Ethiopia. Data collection took place in August 2023.

WSUCSH is a teaching hospital for health science students and residents and provides 24-hour comprehensive healthcare services to a population of over 6 million people from diverse demographic and socioeconomic backgrounds across the southern region of the country. The hospital offers a wide range of specialty services, including general surgery, internal medicine, neurology, orthopedics, neurosurgery, obstetrics and gynecology, pediatrics, radiology, dermatology, pathology, oncology, anesthesiology, and neonatal care.

### **2.2 Source and study population**

The source population comprised all patients who underwent surgical procedures at the hospital. The study population included all patients who underwent midline laparotomy at the hospital between June 1, 2020, and June 30, 2023, and who met the eligibility criteria below.

### **2.3 Eligibility criteria**

All adult patients (aged  $\geq 18$  years) of either sex who underwent midline laparotomy during the study period and had a complete medical record were included. A medical record was considered complete when the admission record, operation note, postoperative progress notes and discharge summary (or death summary) were all available, so that the outcome (presence or absence of AWD during the index admission) and the candidate variables could be ascertained. Patients were excluded if they had a prior history of wound dehiscence, underwent the index laparotomy as a re-operation, underwent laparotomy for a gynecological indication, had an incomplete medical record as defined above, or died on the operating table during the initial surgery.

### **2.4 Sample size and sampling technique**

An a priori minimum sample size was estimated using the single-population-proportion formula ( $Z = 1.96$  for 95% CI;  $p = 0.5$ ;  $d = 0.05$ ), giving  $n = 384$ , inflated to  $n \approx 480$  after adjusting for an assumed 20% non-response rate. This calculation was used only to guide

the minimum length of the retrospective review window required at the proposal stage; a probability sample was not subsequently drawn from a larger sampling frame. Instead, a total enumeration (census) approach was used: every patient who underwent mid-line laparotomy at WSUCSH during the defined three-year period (June 1, 2020 – June 30, 2023) and who met the eligibility criteria above was included. This total enumeration yielded 450 eligible patients with complete records, which constitutes the analytic sample for this study; no eligible patient identified during the review was subsequently excluded from analysis.

Cases were first identified from the operation theatre logbooks and the corresponding medical records were then retrieved. Records that met an exclusion criterion (including incomplete records) were set aside at this stage. The number of logbook entries screened and the number set aside under each exclusion criterion were not tallied at the time of data abstraction; we therefore cannot report exact exclusion counts, and we state this transparently as a limitation rather than presenting an incomplete flow diagram. All 450 patients who met the eligibility criteria were analyzed, and there were no missing values on any analyzed variable.

## 2.5 Study variables

The dependent variable was wound dehiscence (binary: yes/no). Candidate independent variables were age, sex, residence, urgency of surgery, postoperative cough or vomiting, duration of surgery, patient hemodynamic status, presence of preoperative sepsis, gastrointestinal (GI) contamination, surgical site infection, and type of suture material used for fascial closure.

Several additional variables commonly reported as risk factors for AWD in the literature were assessed during data extraction but could not be modelled. We distinguish two situations. First, variables that were not documented at all: body mass index, ASA physical status classification and formal nutritional assessment were not part of the standard admission or operative documentation at this facility during the study period and could not be abstracted; serum albumin was recorded only as a binary indicator of whether it had been requested (documented for 222/450, 49.3%, of patients), not as a measured value. Second, variables for which the medical record recorded no affected patient: diabetes mellitus, hypertension, obesity, pulmonary disease, renal disease, steroid use and smoking were each recorded as absent in all 450 patients, and fascial closure technique was recorded as continuous in all 450 patients. Because these conditions are common in adult surgical populations and comorbidity and smoking history are often recorded incompletely in retrospective charts, we treat 'recorded as absent' as 'not documented' rather than as evidence that the conditions were truly absent, and we do not draw any conclusion about their association with AWD. In either situation the variable carries no usable statistical information in this dataset and was not entered into any model; this is discussed further under Limitations.

## 2.6 Operational definitions

### 2.6.1 Abdominal Wound Dehiscence (AWD)

Full-thickness (fascial) separation of the layers of an abdominal surgical wound before complete healing has occurred, with or without evisceration, occurring during the index admission; isolated superficial (skin/subcutaneous) wound separation without fascial

involvement was not classified as AWD. Diagnosis was based on the operating surgeon's intraoperative or ward documentation of fascial disruption, corroborated by the subsequent management received (relaparotomy with retention sutures or open-abdomen/Bogota bag management in all confirmed cases in this cohort), as recorded in the discharge summary.

### **2.6.2 Midline laparotomy**

A surgical incision made along the midline of the abdomen, extending from the xiphoid process to the symphysis pubis, typically passing around the umbilicus.

### **2.6.3 Sepsis**

A life-threatening organ dysfunction resulting from a dysregulated host response to infection, consistent with the Sepsis-3 concept, as documented and clinically diagnosed by the treating team.

### **2.6.4 Surgical Site Infection (SSI)**

An infection occurring at or near the surgical incision following an invasive surgical procedure, as documented by the treating clinical team in the patient chart; a formal, prospectively-applied CDC surveillance definition was not used, as this was a retrospective chart review, which we note as a limitation.

## **2.7 Data collection tool and procedures**

Data were collected using a pretested, structured data-extraction checklist adapted from relevant literature and tailored to the study variables. Operation theatre and admission records were first reviewed to compile a list of cases that underwent midline laparotomy between June 1, 2020, and June 30, 2023. Detailed data were then extracted from multiple sources, including patient registration records at admission, operating room logs, post-operative evaluation and monitoring sheets, and intensive care unit and discharge records. Data were extracted by trained data collectors who were health professionals with clinical experience in reading surgical records, working under the supervision of designated supervisors and the principal investigator, to ensure consistency and accuracy of extraction.

## **2.8 Data quality management**

A pretested, structured data collection tool, prepared in simple English after reviewing relevant literature, was used to ensure data quality. Data collectors and supervisors received one day of training covering the study objectives, tool contents, identification of relevant records, and appropriate extraction and recording procedures. A pre-test was conducted on 5% of the sample prior to actual data collection, and the tool was refined accordingly. During data collection, supervisors and the principal investigator performed daily completeness and consistency checks, and double data entry was conducted by two independent individuals to minimize transcription error. A formal inter-rater reliability statistic (e.g., kappa) for the extraction of clinical diagnoses (AWD, SSI, sepsis) from the charts was not computed; this is noted as a limitation.

## 2.9 Data processing and statistical analysis

Collected data were checked for completeness and accuracy, coded, and entered into EpiData version 3.1 before being exported to SPSS version 27.0 for analysis. There were no missing values on any analyzed variable across the 450 records (complete-case census). Descriptive statistics (frequencies and percentages for categorical variables; mean with standard deviation or median with interquartile range for continuous variables, as appropriate) were computed and presented in tables and figures. The cumulative incidence of AWD was calculated as the number of patients who developed AWD during the index admission divided by the number of patients who underwent midline laparotomy, with a 95% confidence interval (CI) computed by the Wilson score method. Length of hospital stay and in-hospital mortality were compared between patients with and without AWD using the Mann–Whitney U test and Fisher's exact test, respectively.

For inferential analysis, variables with  $p < 0.25$  in bivariate logistic regression were considered candidates for multivariable logistic regression. During model fitting we identified quasi-complete separation in the data: all 34 patients with both SSI and an operative duration  $\geq 3$  h developed AWD, and all 335 patients with neither SSI nor preoperative sepsis remained free of AWD. Under such conditions, standard maximum-likelihood logistic regression coefficients are known to be biased away from the null with unstable confidence intervals. We therefore fitted the multivariable model using Firth's penalized (bias-reduction) logistic regression, the recommended approach for separated binary outcome data [13]. The final multivariable model (Model 1) contained seven variables: age group ( $\leq 44$  vs.  $> 44$  years), GI contamination ( $< 500$  vs.  $\geq 500$  mL), SSI, postoperative cough and/or vomiting, duration of surgery ( $< 3$  vs.  $\geq 3$  h), urgency of surgery (emergency vs. elective) and preoperative sepsis. Suture material, although associated with AWD in bivariate analysis, was not retained in the final model because of the limited number of events relative to the number of parameters; its effect was examined in a supplementary check in which it was added to Model 1. Multicollinearity among predictors was assessed using variance inflation factors (VIF), and model calibration was assessed with the Hosmer–Lemeshow goodness-of-fit test. Because of the limited number of events (47; approximately 6.7 events per parameter in Model 1), formal interaction terms were not tested. Adjusted odds ratios (AOR) are reported with Wald 95% CIs, and statistical significance was declared at  $p < 0.05$ .

Because SSI is a postoperative event whose timing relative to fascial dehiscence could not be established from the records, and because it is the variable most responsible for the separation, we additionally fitted a pre-specified sensitivity model (Model 2) that excluded SSI but was otherwise identical to Model 1. Model 2 is presented to show how the remaining estimates behave when the postoperative variable most closely linked to the outcome is removed; it is not intended to replace Model 1, and associations are interpreted as associations rather than as causal or independent effects. For SSI and preoperative sepsis, whose point estimates in Model 1 remained unstable even after bias reduction (crossing or approaching the null depending on model specification, most likely reflecting their mutual correlation,  $r = 0.43$ , combined with the separation described above), we report the crude associations and descriptive contrasts rather than a single fixed adjusted odds ratio (see Results and Discussion).

### 3 Results

#### 3.1 Sociodemographic characteristics

A total of 450 patients who underwent midline laparotomy at WSUCSH between June 1, 2020, and June 30, 2023, were included, representing a complete enumeration of eligible patients during the period. Of these, 297 (66.0%) were male and 153 (34.0%) were female, giving a male-to-female ratio of approximately 2:1. The mean ( $\pm$ SD) age was  $44.9 \pm 9.4$  years (median 46 years; range 26–60 years); 303 patients (67.3%) were older than 44 years and 147 (32.7%) were aged 44 years or younger. The majority, 385 (85.6%), resided in rural areas, while 65 (14.4%) were urban residents (Table 1).

#### 3.2 Cumulative incidence of abdominal wound dehiscence

During the index admission, 47 of the 450 patients developed abdominal wound dehiscence, giving a cumulative incidence of 10.4% (95% CI: 7.9–13.6%). The great majority of cases (45/47, 95.7%) occurred after emergency laparotomy: AWD developed in 45 of 352 emergency cases (12.8%) compared with 2 of 98 elective cases (2.0%). Dehiscence was recognized between postoperative days 5 and 10 in 39 patients (83.0%) and before day 5 in 8 patients (17.0%); no case was recorded after day 10.

#### 3.3 Clinical characteristics

Of the 450 patients, 352 (78.2%) underwent emergency midline laparotomy and 98 (21.8%) underwent elective procedures. Preoperative sepsis was documented in 72 patients (16.0%). Anemia was documented in 47 patients (10.4%) and cardiac disease in 3 (0.7%); diabetes mellitus, hypertension, obesity, pulmonary disease and renal disease were not documented for any patient (see Study Variables). Fifty-four patients (12.0%) were hemodynamically unstable at presentation, 59 (13.1%) had documented postoperative cough and/or vomiting, and 84 (18.7%) developed SSI. The duration of surgery was  $\geq 3$  h in 177 patients (39.3%), and estimated blood loss was  $\geq 500$  mL in 18 (4.0%).

Intraoperatively, 74 patients (16.4%) had GI contamination  $\geq 500$  mL, and fascial closure was performed with polyglactin 910 (Vicryl) in 369 patients (82.0%) and with an alternative suture in 81 (18.0%). The mean ( $\pm$ SD) length of hospital stay was  $11.4 \pm 7.8$  days (median 8 days; IQR 8–12), and 385 patients (85.6%) were discharged within 12 days. Overall, in-hospital mortality was 10/450 (2.2%). Among the 47 patients with AWD, relaparotomy with retention sutures was performed in 45 (95.7%) and Bogota bag application in 2 (4.3%) (Table 2).

**Table 1** Sociodemographic characteristics of patients who underwent midline laparotomy at WSUCSH, June 1, 2020 – June 30, 2023 ( $N=450$ )

| Variable    | Category  | n (%)      |
|-------------|-----------|------------|
| Sex         | Male      | 297 (66.0) |
|             | Female    | 153 (34.0) |
| Age (years) | $\leq 44$ | 147 (32.7) |
|             | $> 44$    | 303 (67.3) |
| Residence   | Rural     | 385 (85.6) |
|             | Urban     | 65 (14.4)  |

Percentages may not total 100% due to rounding

**Table 2** Clinical and related characteristics of patients who underwent midline laparotomy at WSU-CSH, June 1, 2020 – June 30, 2023 (N=450)

| Variable                                     | Category                        | n (%)      |
|----------------------------------------------|---------------------------------|------------|
| Urgency of surgery                           | Emergency                       | 352 (78.2) |
|                                              | Elective                        | 98 (21.8)  |
| Preoperative sepsis                          | Yes                             | 72 (16.0)  |
|                                              | No                              | 378 (84.0) |
| Documented comorbidity                       | Cardiac disease                 | 3 (0.7)    |
|                                              | Anemia                          | 47 (10.4)  |
|                                              | None documented                 | 400 (88.9) |
| Duration of surgery (h)                      | < 3                             | 273 (60.7) |
|                                              | ≥ 3                             | 177 (39.3) |
| Hemodynamic status                           | Stable                          | 396 (88.0) |
|                                              | Unstable                        | 54 (12.0)  |
| Estimated blood loss (mL)                    | < 500                           | 432 (96.0) |
|                                              | ≥ 500                           | 18 (4.0)   |
| GI contamination (mL)                        | < 500                           | 376 (83.6) |
|                                              | ≥ 500                           | 74 (16.4)  |
| Suture material for fascial closure          | Polyglactin 910 (Vicryl)        | 369 (82.0) |
|                                              | Alternative suture              | 81 (18.0)  |
| Postoperative cough/vomiting                 | Yes                             | 59 (13.1)  |
|                                              | No                              | 391 (86.9) |
| Surgical site infection                      | Yes                             | 84 (18.7)  |
|                                              | No                              | 366 (81.3) |
| Patient outcome                              | Alive                           | 440 (97.8) |
|                                              | Died                            | 10 (2.2)   |
| Timing of dehiscence (days)                  | < 5                             | 8 (1.8)    |
|                                              | 5–10                            | 39 (8.7)   |
|                                              | No dehiscence                   | 403 (89.6) |
| Length of hospital stay (days)               | ≤ 12                            | 385 (85.6) |
|                                              | > 12                            | 65 (14.4)  |
| Management of dehiscence (n=47) <sup>a</sup> | Relaparotomy + retention suture | 45 (95.7)  |
|                                              | Bogota bag application          | 2 (4.3)    |

GI gastrointestinal

<sup>a</sup>Percentages for management of dehiscence are calculated among the 47 patients who developed AWD; all other percentages use N=450

### 3.4 Indication for first surgery

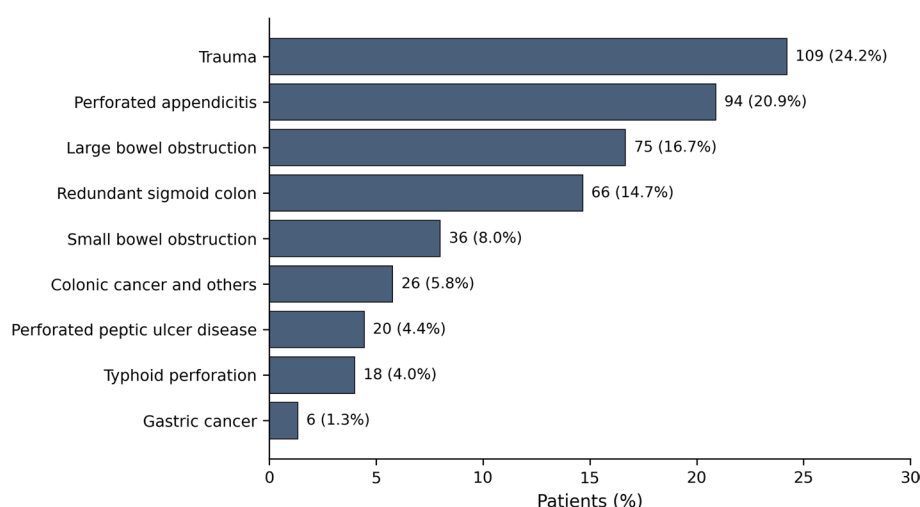
Trauma was the most common indication for surgery in the study setting, 109 (24.2%), followed by perforated appendicitis, 94 (20.9%), large bowel obstruction, 75 (16.7%), redundant sigmoid colon, 66 (14.7%), and small bowel obstruction, 36 (8.0%) (Table 3; Fig. 1).

### 3.5 Dehiscence in relation to indication for surgery

The proportion of patients who developed AWD was highest among those operated for typhoid perforation, 13/18 (72.2%), followed by small bowel obstruction, 25/36 (69.4%), trauma, 7/109 (6.4%), colonic cancer and others, 1/26 (3.8%), and redundant sigmoid colon, 1/66 (1.5%). No case of AWD occurred after surgery for perforated appendicitis (0/94), perforated peptic ulcer disease (0/20), large bowel obstruction (0/75) or gastric cancer (0/6). In absolute terms, small bowel obstruction (25/47, 53.2%) and typhoid perforation (13/47, 27.7%) together accounted for four-fifths of all AWD cases, whereas trauma, the most common indication overall, contributed 7/47 (14.9%) (Table 4).

**Table 3** Clinical indications for surgery among patients who underwent midline laparotomy at WSUCSH (N=450)

| Indication                      | n (%)       |
|---------------------------------|-------------|
| Trauma                          | 109 (24.2)  |
| Perforated appendicitis         | 94 (20.9)   |
| Large bowel obstruction         | 75 (16.7)   |
| Redundant sigmoid colon         | 66 (14.7)   |
| Small bowel obstruction         | 36 (8.0)    |
| Colonic cancer and others       | 26 (5.8)    |
| Perforated peptic ulcer disease | 20 (4.4)    |
| Typhoid perforation             | 18 (4.0)    |
| Gastric cancer                  | 6 (1.3)     |
| Total                           | 450 (100.0) |

**Fig. 1** Indications for surgery among patients who underwent midline laparotomy at WSUCSH, June 1, 2020 – June 30, 2023 (N=450)**Table 4** Abdominal wound dehiscence in relation to indication for surgery (N=450)

| AWD   | Perf. appendicitis | Perf. PUD | Ty-phoid perf. | SBO | LBO | Trauma | Redun-dant sigmoid | Co-lonic ca. | Gas-tric ca. | Total |
|-------|--------------------|-----------|----------------|-----|-----|--------|--------------------|--------------|--------------|-------|
| Yes   | 0                  | 0         | 13             | 25  | 0   | 7      | 1                  | 1            | 0            | 47    |
| No    | 94                 | 20        | 5              | 11  | 75  | 102    | 65                 | 25           | 6            | 403   |
| Total | 94                 | 20        | 18             | 36  | 75  | 109    | 66                 | 26           | 6            | 450   |

AWD abdominal wound dehiscence, PUD peptic ulcer disease, SBO small bowel obstruction, LBO large bowel obstruction, ca. cancer

### 3.6 Factors associated with abdominal wound dehiscence

Bivariate logistic regression was used to identify candidate variables ( $p < 0.25$ ) for the multivariable model. Candidate variables were age, sex, hemodynamic status, preoperative sepsis, residence, GI contamination, surgical site infection, postoperative cough and/or vomiting, duration of surgery, urgency of surgery, and suture material.

As described in the Methods, fitting the multivariable model revealed quasi-complete separation in the data: all 34 patients with both SSI and an operative duration  $\geq 3$  h developed AWD (34/34, 100%), and all 335 patients with neither SSI nor preoperative sepsis remained free of AWD (335/335, 100%). The same pattern is visible in the

cross-tabulation of postoperative cough/vomiting with SSI: all 7 patients with both cough/vomiting and SSI developed AWD (7/7), whereas none of the 314 patients with neither did (0/314). A single precise adjusted point estimate for SSI (and, because of its correlation with SSI,  $r=0.43$ , also for preoperative sepsis) therefore cannot be reliably obtained from this sample. We present the crude (unadjusted) associations for all candidate variables, the bias-reduced (Firth) full multivariable model (Model 1), the sensitivity model excluding SSI (Model 2), and the descriptive contrast for SSI and preoperative sepsis.

Descriptively, 42/47 (89.4%) of patients with AWD had SSI, compared with 42/403 (10.4%) of patients without AWD (crude OR = 72.2; 95% CI: 27.1–192.5;  $p < 0.001$ ); and 31/47 (66.0%) of patients with AWD had preoperative sepsis, compared with 41/403 (10.2%) of patients without AWD (crude OR = 17.1; 95% CI: 8.6–33.9;  $p < 0.001$ ). These are crude associations; because the temporal sequence of SSI and fascial dehiscence could not be established from the records, they should not be read as evidence that SSI is an independent or causal predictor of AWD.

In the full bias-reduced multivariable model (Model 1; Table 5), operative duration  $< 3$  h (AOR = 0.02; 95% CI: 0.00–0.50;  $p = 0.02$ ) and GI contamination  $< 500$  mL (AOR = 0.03; 95% CI: 0.00–0.57;  $p = 0.02$ ) were associated with lower odds of AWD, and postoperative cough and/or vomiting (AOR = 111.3; 95% CI: 4.9–2534.4;  $p = 0.003$ ) and emergency surgery (AOR = 25.7; 95% CI: 3.4–195.9;  $p = 0.002$ ) were associated with higher odds. The confidence intervals for the latter two estimates span more than two orders of magnitude; the point estimates are therefore highly imprecise and indicate the direction, but not the magnitude, of the associations. The adjusted association for age  $\leq 44$  years was not statistically significant (AOR = 0.19; 95% CI: 0.02–2.32;  $p = 0.19$ ). All variance inflation factors in Model 1 were below 2 (range 1.24–1.67), indicating no problematic pairwise multicollinearity, and the Hosmer–Lemeshow goodness-of-fit test indicated adequate calibration ( $\chi^2 = 1.48$ ,  $df = 6$ ,  $p = 0.96$ ). Suture material (polyglactin 910 vs. alternative) was associated with AWD in bivariate analysis (crude OR = 0.27; 95% CI: 0.14–0.51;  $p < 0.001$ ) but was not retained in the final model given the limited events-per-variable ratio; when it was added to Model 1 as a supplementary check it was not associated with AWD after adjustment (AOR = 1.23; 95% CI: 0.05–30.8;  $p = 0.90$ ) and the other estimates were not materially changed.

In the sensitivity model excluding SSI (Model 2; Table 5), the associations of shorter operative duration (AOR = 0.23; 95% CI: 0.09–0.59;  $p = 0.002$ ) and lower GI contamination (AOR = 0.24; 95% CI: 0.09–0.63;  $p = 0.004$ ) with lower odds of AWD persisted and their confidence intervals narrowed considerably; age  $\leq 44$  years was associated with lower odds (AOR = 0.20; 95% CI: 0.07–0.55;  $p = 0.002$ ); and preoperative sepsis, which could not be estimated stably in Model 1, showed a strong and precise association with higher odds of AWD (AOR = 7.46; 95% CI: 3.41–16.30;  $p < 0.001$ ). In contrast, the estimates for postoperative cough/vomiting (AOR = 3.01; 95% CI: 0.99–9.21;  $p = 0.05$ ) and emergency surgery (AOR = 1.39; 95% CI: 0.34–5.76;  $p = 0.65$ ) were markedly attenuated. VIFs in Model 2 ranged from 1.13 to 1.65. The Hosmer–Lemeshow test indicated poorer calibration for Model 2 ( $\chi^2 = 13.75$ ,  $df = 5$ ,  $p = 0.02$ ), as expected once the variable most strongly linked to the outcome is removed. Taken together, the two models indicate that the very large adjusted odds ratios for cough/vomiting and emergency surgery in Model

**Table 5** Factors associated with abdominal wound dehiscence after midline laparotomy: crude and Firth bias-reduced multivariable analyses (N=450)

| Variable                     | Category                           | AWD Yes n (%) | AWD No n (%) | COR (95% CI)         | Model 1 AOR (95% CI) <sup>a</sup> | p     | Model 2 AOR (95% CI) <sup>b</sup> | p      |
|------------------------------|------------------------------------|---------------|--------------|----------------------|-----------------------------------|-------|-----------------------------------|--------|
| Age (years)                  | ≤ 44 (Ref: >44)                    | 8 (17.0)      | 139 (34.5)   | 0.39 (0.18–0.86)     | 0.19 (0.02–2.32)                  | 0.19  | 0.20 (0.07–0.55)                  | 0.002  |
| Preoperative sepsis          | Yes (Ref: No)                      | 31 (66.0)     | 41 (10.2)    | 17.11 (8.63–33.91)   | Not stable <sup>c</sup>           | —     | 7.46 (3.41–16.30)                 | <0.001 |
| GI contamination             | < 500 mL (Ref: ≥500 mL)            | 24 (51.1)     | 352 (87.3)   | 0.15 (0.08–0.29)     | 0.03 (0.00–0.57)                  | 0.02  | 0.24 (0.09–0.63)                  | 0.004  |
| Surgical site infection      | Yes (Ref: No)                      | 42 (89.4)     | 42 (10.4)    | 72.20 (27.08–192.52) | Not stable <sup>c</sup>           | —     | Not included <sup>b</sup>         | —      |
| Postop. cough/vomiting       | Yes (Ref: No)                      | 12 (25.5)     | 47 (11.7)    | 2.60 (1.26–5.35)     | 111.28 (4.89–2534.40)             | 0.003 | 3.01 (0.99–9.21)                  | 0.05   |
| Duration of surgery          | < 3 h (Ref: ≥3 h)                  | 8 (17.0)      | 265 (65.8)   | 0.11 (0.05–0.24)     | 0.02 (0.00–0.50)                  | 0.02  | 0.23 (0.09–0.59)                  | 0.002  |
| Urgency of surgery           | Emergency (Ref: Elective)          | 45 (95.7)     | 307 (76.2)   | 7.04 (1.68–29.54)    | 25.65 (3.36–195.91)               | 0.002 | 1.39 (0.34–5.76)                  | 0.65   |
| Suture material <sup>d</sup> | Polyglactin 910 (Ref: alternative) | 28 (59.6)     | 341 (84.6)   | 0.27 (0.14–0.51)     | Not retained                      | —     | Not retained                      | —      |

AWD abdominal wound dehiscence, COR crude odds ratio, AOR adjusted odds ratio (Firth bias-reduced logistic regression, Wald 95% CI), GI gastrointestinal, Ref reference category, Percentages in the AWD Yes and AWD No columns are column percentages (of 47 and 403, respectively)

<sup>a</sup>Model 1 (full model): age group, GI contamination, surgical site infection, postoperative cough/vomiting, duration of surgery, urgency of surgery and preoperative sepsis; VIF range 1.24–1.67 (all < 2); Hosmer–Lemeshow  $\chi^2 = 1.48$ , df = 6, p = 0.96.

<sup>b</sup>Model 2 (sensitivity model): as Model 1 but excluding surgical site infection; VIF range 1.13–1.65; Hosmer–Lemeshow  $\chi^2 = 13.75$ , df = 5, p = 0.02.

<sup>c</sup>Point estimate not reliably estimable in Model 1 because of quasi-complete separation and correlation between surgical site infection and preoperative sepsis (r = 0.43); crude association reported

<sup>d</sup>Bivariate association only; not retained in either model given the limited events-per-variable ratio (see text for the supplementary check)

1 are conditional on the inclusion of SSI and should not be regarded as stable, precise estimates of effect.

### 3.7 Outcomes of patients with abdominal wound dehiscence

Patients who developed AWD stayed in hospital substantially longer than those who did not (median 26 days, IQR 16–30, vs. median 8 days, IQR 8–12; Mann–Whitney U test  $p < 0.001$ ), and 41/47 (87.2%) of patients with AWD were hospitalized for more than 12 days compared with 24/403 (6.0%) of those without AWD ( $p < 0.001$ ). All 10 in-hospital deaths occurred among patients with AWD: in-hospital mortality was 10/47 (21.3%) among patients with AWD and 0/403 (0%) among those without (Fisher's exact test  $p < 0.001$ ).

## 4 Discussion

Abdominal wound dehiscence is a serious complication of laparotomy whose burden is thought to be highest in resource-limited settings where emergency, contaminated surgery predominates, yet local data from southern Ethiopia were lacking and validated risk models for this case mix are scarce [4, 10]. To address this gap, we conducted a retrospective cohort study of all 450 adult patients who underwent midline laparotomy at WSUCSH over a three-year period, with the objectives of estimating the cumulative incidence of AWD and identifying factors associated with it, using Firth's bias-reduced logistic regression because of separation in the data.

The main finding is that AWD developed in 10.4% of patients (95% CI: 7.9–13.6%), almost exclusively after emergency surgery (12.8% of emergency versus 2.0% of elective laparotomies), and that it carried a heavy burden: patients with AWD stayed in hospital more than three times as long as other patients, and all ten in-hospital deaths in the cohort occurred in this group. The cumulative incidence observed here lies within the 10–30% range described for centres in developing countries [6, 14], is lower than the 22.2% reported from an Indian tertiary centre [15] and the 12.4% reported from Egypt [7], but is substantially higher than the 0.4–3.5% typical of high-income settings [5] and the 0.99% reported from a tertiary hospital in Addis Ababa [4]. The high proportion of emergency, contaminated procedures in our case mix (78.2% emergency; 16.4% with  $\geq 500$  mL GI contamination) and the limited scope for preoperative optimization in such cases are the most plausible explanations for the higher incidence compared with elective-dominated series, while differences in case definition (fascial dehiscence only, in our study) and in the completeness of chart documentation may partly explain differences from other Ethiopian reports.

Wound dehiscence most commonly occurred between postoperative days 5 and 10 (39/47, 83.0%), consistent with reports by Vardhini et al. [11] (65% between days 6–9) and Spiliotis et al. [5] (mean day 9, range days 6–15), and broadly with Soni et al. [16] (days 6–8). This timing coincides with the period in which the tensile strength of the healing fascia is at its lowest and supports the clinical practice of closely inspecting the wound during the second postoperative week.

In this study, 95.7% (45/47) of patients who developed AWD had undergone emergency surgery, slightly higher than reported by Teklewold et al. [4] (90.2%), Spiliotis et al. [5] (60%), and Afzal and Bashir [17] (90%). This may reflect the urgent nature of emergency procedures, with limited time for stabilization and resuscitation and a higher

likelihood of operative site contamination, as well as differences in surgical indications and healthcare settings between studies. Emergency surgery was associated with AWD in crude analysis (COR = 7.04; 95% CI: 1.68–29.54) and in the full adjusted model (Model 1: AOR = 25.65; 95% CI: 3.36–195.91), but the latter estimate is very imprecise and was greatly attenuated when SSI was removed from the model (Model 2: AOR = 1.39; 95% CI: 0.34–5.76). We therefore interpret emergency surgery as a marker of a high-risk clinical context, much of whose association with AWD is carried by co-occurring preoperative sepsis, contamination and postoperative infection, rather than as an independent effect of precisely estimated magnitude.

Surgical site infection showed by far the strongest crude association with AWD in our data: 89.4% of patients with AWD had SSI, versus 10.4% of those without (COR = 72.2). This very large crude odds ratio reflects genuine quasi-complete separation in the data rather than a computational error: all 34 patients who had both SSI and an operative duration  $\geq 3$  h developed AWD, and all 335 patients with neither SSI nor preoperative sepsis remained free of it. When a predictor (or a combination of predictors) almost perfectly determines the outcome in this way, maximum-likelihood logistic regression produces inflated and unstable coefficient estimates. We addressed this using Firth's bias-reduced logistic regression, confirmed that pairwise multicollinearity was not the underlying issue (all VIFs  $< 2$ ), and additionally fitted a model without SSI. Even after bias reduction, the SSI (and correlated preoperative sepsis) estimates in the full model remained too imprecise to report as single fixed values. The direction of the association is consistent with the wide recognition of SSI as a major correlate of wound dehiscence [8] and with reports by Talukdar et al. [18] (>75%), Aksamija et al. [1] (61%), Ahsan et al. [9] (74.1%), Naeem et al. [19] (88.2%), and Ramneesh et al. [15] (90%). A biological mechanism is plausible, involving bacterial collagenase activity that disrupts collagen deposition together with increased matrix metalloproteinase activity and insufficient inhibition, leading to wound breakdown. However, because our data could not establish whether SSI preceded or followed fascial dehiscence in each patient (see Limitations), and because infection and dehiscence may be manifestations of the same underlying process, we interpret SSI strictly as a variable that is strongly associated with AWD, not as an independent or causal predictor. The clinical implication is nonetheless practical: a patient with SSI after midline laparotomy, particularly after a prolonged operation, should be regarded as being at very high risk of fascial dehiscence and monitored accordingly.

Preoperative sepsis was also strongly associated with AWD in crude analysis (66.0% of AWD patients vs. 10.2% of non-AWD patients; COR = 17.1), consistent with several previous studies [9, 18, 20]. Because preoperative sepsis is correlated with SSI in our data ( $r = 0.43$ ) and both sit close to the separated subgroup described above, its adjusted contribution could not be estimated stably in the full model. In the sensitivity model without SSI, however, preoperative sepsis showed a strong and precise association with AWD (AOR = 7.46; 95% CI: 3.41–16.30). Unlike SSI, preoperative sepsis is temporally antecedent to surgery and is identifiable before the incision is made, which makes it a more useful marker for preoperative risk stratification and for decisions about closure technique and postoperative surveillance.

Postoperative cough and/or vomiting was associated with AWD in crude analysis (COR = 2.60; 95% CI: 1.26–5.35) and in the full adjusted model (AOR = 111.3; 95% CI:

4.9–2534.4), plausibly reflecting raised intra-abdominal pressure acting on a healing fascia. The adjusted odds ratio in the full model, however, should not be read as a precise estimate of effect: its confidence interval spans nearly three orders of magnitude, it is driven by the separated subgroup (all 7 patients with both cough/vomiting and SSI developed AWD), and it fell to 3.01 (95% CI: 0.99–9.21) in the sensitivity model. What the data support is that cough or vomiting after laparotomy is associated with higher odds of AWD, of a magnitude that this study cannot quantify precisely. Similar directional findings have been reported by Hegazy and Soliman [7], Jaiswal and Shekhar [21] (52.4% with chest disease), and Pavlidis et al. [22] (36% with cough), and van Ramshorst et al. [10] include coughing in their validated risk model.

Patients with GI contamination < 500 mL had lower odds of AWD in both models (Model 1: AOR = 0.03; 95% CI: 0.00–0.57; Model 2: AOR = 0.24; 95% CI: 0.09–0.63), consistent with other studies [11, 15, 16], plausibly reflecting earlier presentation and reduced severity of intra-abdominal infection. The consistency of direction across models, together with the narrower confidence interval in Model 2, makes this one of the more robust associations in this study.

Age  $\leq 44$  years was associated with lower odds of AWD in crude analysis (COR = 0.39), consistent with other studies [2, 4, 18], but the adjusted association was not statistically significant in the full model (AOR = 0.19; 95% CI: 0.02–2.32;  $p = 0.19$ ). In the sensitivity model the association was statistically significant (AOR = 0.20; 95% CI: 0.07–0.55). Because the result depends on model specification, we do not describe younger age as an independent protective factor; the finding should be re-examined in a larger sample.

Shorter operative time (< 3 h) was associated with lower odds of AWD in both models (Model 1: AOR = 0.02; 95% CI: 0.00–0.50; Model 2: AOR = 0.23; 95% CI: 0.09–0.59), consistent with other studies [6, 19], plausibly reflecting case complexity, surgeon experience, and resource availability, particularly during emergency or night-time procedures.

Sex, residence, hemodynamic instability, and documented comorbidities were not associated with AWD in bivariate analysis, in contrast to some other studies [18, 23, 24]; for comorbidities this null finding must be read in the light of the documentation limitations described below.

Regarding management, relaparotomy with retention sutures was performed in 45 of the 47 patients with AWD (95.7%) and Bogota bag application in 2 (4.3%), similar to the 95.2% relaparotomy rate reported by Teklewold et al. [4]. AWD was associated with a markedly longer hospital stay (median 26 vs. 8 days) and with in-hospital death (21.3% vs. 0%), comparable with other studies [4, 7, 23, 25] and consistent with the recognized contribution of AWD to postoperative morbidity and mortality in low-resource settings. The fact that every in-hospital death in this cohort occurred in a patient with AWD underlines the importance of prevention and early recognition.

#### 4.1 Limitations of the study

This study has several limitations. First, it relied on retrospective document review, which may have resulted in incomplete data, inconsistent recording of SSI and preoperative sepsis against standardized definitions, and residual information or misclassification bias that we could not fully quantify. Diagnoses of AWD, SSI, and sepsis were based on clinical documentation rather than independent, standardized re-adjudication by the study team, and a formal inter-rater reliability statistic for chart-based diagnosis

extraction was not computed. Second, the number of logbook entries screened and excluded under each criterion was not tallied during data abstraction, so exact exclusion counts cannot be reported. Third, the retrospective design precludes establishing the temporal sequence between SSI and AWD; SSI may lie on the causal pathway to dehiscence, or infection and dehiscence may share a common cause, so SSI cannot be interpreted as an independent or causal predictor, and this should be clarified in a prospective, serially assessed cohort. Fourth, several clinically important covariates could not be modelled. Body mass index, ASA physical status class, formal nutritional status and quantitative serum albumin were not documented; diabetes mellitus, hypertension, obesity, pulmonary and renal disease, steroid use and smoking were recorded as absent in every patient, and closure technique was recorded as continuous in every patient. Because absence of documentation does not indicate absence of the condition, these variables are best regarded as not documented, their apparent absence should not be interpreted as a finding, and residual confounding by unmeasured or under-documented factors cannot be excluded; future, ideally prospective, studies should capture these variables systematically. Fifth, with only 47 events and seven predictors (approximately 6.7 events per parameter), the multivariable model is at risk of overfitting; the data showed quasi-complete separation for SSI and preoperative sepsis, so the precise magnitude of these two associations could not be estimated, and the very wide confidence intervals for postoperative cough/vomiting and emergency surgery in the full model, together with their attenuation in the sensitivity model, mean that these adjusted estimates should be regarded as imprecise and model-dependent rather than as precise estimates of effect. Finally, follow-up was limited to the index admission, so cases of dehiscence occurring after discharge, and any deaths after discharge, would not have been captured; the cumulative incidence and mortality reported here may therefore be underestimates.

## 5 Conclusion

In this retrospective cohort, about one in ten patients undergoing midline laparotomy at WSUCSH developed abdominal wound dehiscence, a cumulative incidence higher than that reported from a tertiary hospital in Addis Ababa and within the range reported from other low- and middle-income settings, and AWD occurred almost exclusively after emergency surgery. Shorter operative duration and lower-volume GI contamination were consistently associated with lower odds of AWD in both adjusted models. Preoperative sepsis and SSI showed very strong crude associations with AWD, and preoperative sepsis was strongly associated with AWD in the sensitivity model, but because of separation in the data their adjusted magnitude in the full model could not be estimated; SSI in particular should be regarded as a variable associated with AWD rather than as an independent or causal predictor. The adjusted associations of postoperative cough/vomiting and emergency surgery with AWD were imprecise and model-dependent, and the adjusted association for younger age was not statistically significant in the full model. Patients with AWD had substantially longer hospital stays and accounted for all in-hospital deaths. Prospective studies with systematic documentation of comorbidity, nutritional status and the timing of SSI are needed to quantify these associations precisely; in the meantime, preoperative sepsis, heavy contamination and prolonged surgery identify patients who warrant particular attention to fascial closure and postoperative wound surveillance.

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### Authors' contributions

HT conceived and drafted the research. AD, AAA, MM, SS, MO, and MT contributed to study design, methodology, data analysis, manuscript writing, and critical revision. All authors reviewed and approved the final manuscript for submission.

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### Data availability

All relevant data are included within the manuscript. Additional data can be made available by the authors upon reasonable request.

### Declarations

#### Ethics approval and consent to participate

Ethical clearance was obtained from the Institutional Health Research and Ethics Review Committee (IHRERC) of the College of Health and Medical Sciences, Wolaita Sodo University (Ref. No.: CHSM/ERC/02/15). A written official letter of cooperation was submitted to WSUCSH prior to data collection to obtain administrative permission. Confidentiality of participant information was maintained throughout data collection and dissemination.

The requirement for individual informed consent was waived by the IHRERC of Wolaita Sodo University because the study involved retrospective review of existing medical records without patient contact.

#### Consent for publication

Not applicable, as no identifiable data or images of individual participants are present within the manuscript.

#### Competing interests

The authors declare no competing interests.

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