SAGE Open Medicine
Volume 11: 1–8

DOI: 10.1177/20503121231181648
journals.sagepub.com/home/smo
Sage

# Prevalence and associated factors of infection after intramedullary nailing of long bone fractures among patients attending St. Paul's Hospital Millennium Medical College, AaBET Hospital, Addis Ababa, Ethiopia

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## Abstract

**Objectives:** The intramedullary nailing of long bone fractures is a major challenge for orthopedic surgeons, with increased risk of infection in third-world countries. Research gaps remain in Ethiopia, determining the magnitude of the problem. This study aimed to determine the prevalence and associated factors of infection after intramedullary nailing of long bone fractures in Ethiopia.

**Methods:** This was a descriptive, cross-sectional, retrospective design study with a total census of 227 cases of long bone fractures treated with intramedullary Surgical Implant Generation Network nails at Addis Ababa Burn Emergency and Trauma Hospital from August 2015 to April 2017. Data were collected from 227 patients and descriptive analyses were done to summarize the study variables. Binary and multivariable logistic regression analyses were performed at a *p* value of 0.05 with a 95% confidence interval and adjusted odds ratio.

**Results:** The mean age of patients was 32.9 years, with a male-to-female ratio of 3.5:1. Only 22 (9.3%) of the 227 patients with long bone fractures treated with intramedullary nails developed a surgical site infection, and 8 (3.4%) were developed deep (implant) infections requiring debridement. Road traffic injuries were the leading cause of trauma (60.9%), followed by falls from a height (22.7%). Debridement was done within 24 h for 52 (61.9%) and within 72 h for 69 (82.1%) patients with open fractures. Only 19 (22.4%) and 55 (64.7%) patients with open fractures and tibial long bone fractures received antibiotics within 3 h. Open fractures and tibial fractures had higher percentages of infection, 18.6% and 12.1%, respectively. Previous use of an external fixator (44.4%) and prolonged surgery (12.5%) were associated with higher proportions of infection.

**Conclusion:** This study found that the prevalence of infections after intramedullary nailing of long bone fractures in Ethiopia was 44.4% after external fixation, compared to 6.4% after intramedullary nail was inserted directly. Proper control measures are needed to reduce morbidity and complications related to long fracture treatment, such as open fractures, tibial fractures, the use of an external fixator, delayed debridement and skin closure, and prolonged surgery developed surgical site infection rate.

## Keywords

surgical site infection, intramedullary nail infection, sign nail, long bone fractures

Date received: 16 October 2022; accepted: 26 May 2023

## Introduction

Trauma is the leading cause of fracture in the general population, resulting in significant morbidity and mortality.[1,2] Open fractures are mostly treated through debridement, immediate bony stabilization, and soft tissue coverage to enable early mobility and restoration of optimum function.[3] Surgical Implant Generation Network (SIGN) Fracture Care International provides free intramedullary nails, which are one of the most commonly used nails in low-and

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middle-income countries. It is preferred over other nails because the procedure does not require fluoroscopy or a fracture table.[4,5]

An intramedullary nail is a metal rod that is inserted into the medullary cavity of a bone. These nails have been used for a long time to treat long bone fractures.[2] In general, intramedullary nailing is associated with high success rates and low complication rates.[6] However, implant infection remains one of the most challenging complications that an orthopedic surgeon faces.[3,6]

Intramedullary implants are intended to be used in situations where strict aseptic protocols and a proper operation setup are possible. Given the limited resources available to provide a proper surgical setup, this does not appear feasible.[4] Implant-associated infections are typically caused by microorganisms growing in biofilms.[7,8] Depletion of metabolic substances and/or waste product accumulation in a biofilm causes microbes to enter a slow or non-growing state.[8,9] Surgical site infection (SSI) is disastrous in orthopedic practice as it is difficult to rid the bone and joint of the infection.[10] Many preventable causes of SSI have been identified; if proper measures are implemented, the incidence could be reduced. Patients, surgeons, nurses, and the operating room's atmosphere and equipment are all major sources of concern. The aim of this study was to determine the prevalence and associated factors of infection after an operation to remove nails from under the fingernails and to identify factors associated with infection after such an operation.

## Methods

### *Study duration and place*

The study was conducted at Saint Paul's Hospital Millennium Medical College (Addis Ababa Burn Emergency and Trauma Hospital), which is found in Addis Ababa (the capital city of Ethiopia), from August 2015 to April 2017. Ethiopia's first trauma center was established by the Federal Ministry of Health in collaboration with Saint Paul's Hospital. The hospital has a wide catchment area, providing service for around 100 patients per day, with 30%–50% of those being orthopedics. On average, the orthopedics and traumatology department provides service to 710 patients per month at regular outpatient department (OPD) and 460 patients per month at emergency OPD.

### *Nature of the study, sample size, and data collection*

This was a descriptive, cross-sectional, retrospective design study with a total census of 227 cases of long bone fractures treated with intramedullary SIGN nails at Addis Ababa Burn Emergency and Trauma Hospital from August 2015 to April 2017. Data were extracted using pretested 5% of total census[11] and validated questionnaire to collect data[11,12] by trained orthopedic residents. The collected data were analyzed using SPSS version 23 (IBM SPSS Statistics 23). Frequency, percentages, cross tabs, and graphs were used to summarize the study variables. Both binary and multiple logistic regressions were conducted to identify factors associated with intramedullary nail infection.

### *Inclusion and exclusion*

Patients treated for acute long bone fractures treated with SIGN nails were included in the study, and fracture cases with less than 1 year of follow- pathologic fractures, and revisions for non-unions were automatically excluded from the study.

### *Definition of terms*

Fracture-related infection is a condition that has at least one of the following criteria: fistula, sinus or wound breakdown, purulent drainage from the wound or presence of pus during surgery, phenotypically indistinguishable pathogens identified by culture from at least two deep tissue/implant specimens taken during an operative intervention, or presence of microorganisms in deep tissue taken during an operative intervention, as confirmed by histopathological examination using specific staining techniques.[13]

All of the fractures were classified as per the Association of Orthopedics fracture classification for fracture anatomy[11] and the Gustilo Anderson classification for open fractures.[12]

Infection was diagnosed if there was pain, swelling, and discharge from the wound site with an elevated erythrocyte sedimentation rate, C-reactive protein, and white blood cell count, or if radiographic features of osteomyelitis were present.

Infection after intramedullary nailing is defined as a confined or diffuse infection of medullary cavity caused by the invasion of pathogens during intramedullary nailing.[14]

The management of infection after intramedullary nailing of the femoral shaft fracture remains a challenge to orthopedic surgeons.[14]

All diaphyseal as well as metaphyseal fractures were included. Both open and closed reduction techniques were used for tibial fractures, and both antegrade and retrograde nailing for femur fractures were implemented. Both open and closed fractures were assessed. All fractures were reamed by hand because flexible reamers were not available. All age groups, including both sexes, were included. All fracture cases were assessed, including trauma, revision or non-union, and pathological conditions.

All patients took antibiotics, even though the duration varied. For open fractures, the time from injury to debridement and the time from injury to skin closure were assessed, with classification based on the duration. The duration of initiation and total antibiotic coverage were also assessed. Intravenous ceftriaxone was used in almost all cases.

**Table 1.** Profile of study population status of patients attending St. Paul's Hospital Millennium Medical College, AaBET Hospital, Addis Ababa, Ethiopia 2021.

| Variables | Categories | Infection status | | Total *f* (%) |
|---|---|---|---|---|
| | | Infected *f* (%) | Non-infected *f* (%) | |
| Age group | <30 | 11 (9.6%) | 104 (90.4%) | 115 (53.%) |
| | ⩾30 | 11 (10.8%) | 101 (89.2%) | 112 (47.0%) |
| | Total | 22 (9.3%) | 205 (95.7%) | 227 (100%) |
| Gender | Male | 17 (9.2%) | 158 (90.3%) | 175 (80.7%) |
| | Female | 5 (9.6%) | 47 (90.4%) | 52 (23.9%) |
| | Total | 22 (9.3%) | 205 (94.5%) | 227 (100%) |

Cloxacillin, metronidazole, Augmentin, ciprofloxacin, gentamicin, and cephalexin were used. The duration of surgery was also considered in the analysis.

### *Statistical analysis*

The collected data were analyzed using SPSS version 23. Frequency, percentages, cross tabs, and graphs were used to summarize the study variables. Both binary and multiple logistic regression analyses were conducted to identify factors associated with intramedullary nail infection at a $p$ value of 0.05 with 95% confidence interval and adjusted odds ratio.

## Results

The mean age of patients at admission was 32.9 (ranging from 14 to 78). The majority of the patients (78.1%) were men; see details in Table 1.

The most common cause of long bone fracture, 227 (100%), was trauma fracture. Of the traumatic causes of long bone fractures, the majority, 139 (61.2%), were due to road traffic accident (RTA) injuries, followed by fall-down accidents (FDA) with 50 (22.0%). Of these, 13 (5.7%) of the infections were superficial, and 8 (3.4%) were developed deep (implant) infections requiring debridement. 33.3% of patients who sustained bullet injuries developed infection, followed by 11.5% of patients who sustained FDA and 7.9% of those who sustained RTA are types of injuries. Tibial fractures had a higher percentage of infection (12.1%) compared to femur fractures (7.5%), and open fractures had a higher percentage of infection (18.6%), while closed fractures only had a 4% infection rate after intramedullary nail (IMN) treatment of long bone fractures (see details in Table 2).

### *Treatment of long bone fractures*

An external fixator and a plate were used in 17 patients and 1 patient before application of the IMN. All of the fractures were reamed manually by hand, and only 6 (2.5%) were closed. Patients who received intramedullary nailing after external fixation had a higher percentage of infection (44.4%) compared to those in whom the intramedullary nail was inserted directly (6.4%).

Debridement was done within 24 h for 52 (61.9% of the total) open fractures and within 72 h for 69 (82.1% of the total) open fractures. Skin was closed within 24 h in 38 (44.2%) open fractures, within 72 h in 52 (60.5%) open fractures, and skin closure was done after 1 week for 27 (31.4%) open fractures. The infection rate was assessed based on time from injury to debridement, and it showed that fractures that are debrided within 24 h have a lower infection rate (11.5%). For femur fractures, retrograde nailing was used in 83 (56.2%) patients and antegrade nailing in 63 (43.2%) patients. There were 91 (38.5%) tibiae treated with intramedullary nailing. In addition, 36% of those who had skin closures done after 1 week were infected.

Of total open fractures, GA II fractures were the most commonly encountered (46%), followed by GA I fractures (34.5%), GA IIIA fractures (10.3%), GA IIIB fractures (5.7%), and GA IIIC fractures (3.4%). Antibiotics were initiated within 3 h in only 19 (22.4%) open fractures and within 24 h in 55 (64.7%) open fractures. Antibiotics were initiated after 24 h in 11 (12.9%) open fractures. The majority of patients (127, or 47%) received antibiotics for more than a week, with only 21 (8.8%) receiving antibiotics for less than 3 days, and 88 (37.3%) patients took antibiotics for 3–7 days.

Only 10.5% of open fractures initiated antibiotics within 3 h, and only 12.9% of those in which antibiotics were initiated within 3–12 h were infected. On average, approximately 28% of patients who received antibiotics after 12 h were infected. Of total patients, 37.5% had received antibiotics for more than 3 weeks became infected, and only less than 10% who had taken antibiotics for less than 3 days were infected, but only in 3.4% of patients who took antibiotics for 3–7 days were infected. The mean duration of surgery was 2 h and 20 min, and only 7 (3%) patients had prolonged surgery, which is more than 4 h (see details in Table 3).

The relationship between the duration of surgery and the proportion of infections revealed that 6.4% of patients who were operated within 2 h developed postoperative infection, while twofold (12.5%) of those who were operated within 2–4 h were infected (see details in Table 3).

**Table 2.** Cause of trauma and types of fractures at St. Paul's Hospital Millennium Medical College, AaBET Hospital, Addis Ababa, Ethiopia 2021.

| Variables | Categories | Infection status | | Total *f* (%) |
|---|---|---|---|---|
| | | Infected *f* (%) | Non-infected *f* (%) | |
| Indication for IMN | Trauma | 18 (7.9%) | 209 (92.1%) | 227 (95.8%) |
| | Total | 22 (9.3%) | 215 (90.7%) | 227 (100%) |
| Cause of trauma | RTA | 11 (7.9%) | 128 (92.1%) | 139 (61.2%) |
| | Fall | 6 (11.5%) | 44 (88.0%) | 50 (22.0%) |
| | Blow/assault | 0 (0.0%) | 22 (100%) | 22 (9.6%) |
| | Crushed by heavy object | 1 (11.1%) | 8 (88.9%) | 9 (3.9%) |
| | Bullet | 1 (33.3%) | 2 (66.7%) | 3 (1.3%) |
| | Other * | 0 (0.0%) | 4 (100%) | 4 (1.7%) |
| | Total | 19 (8.3%) | 210 (91.7%) | 227 (100%) |
| Fractured bone | Femur | 11 (7.5%) | 125 (91.2%) | 136 (60%) |
| | Tibia | 11 (12.1%) | 80 (87.9%) | 91 (40.0%) |
| | Total | 22 (9.3%) | 215 (90.7%) | 227 (100%) |
| Types of fracture | Closed | 6 (4.0%) | 135 (96.0%) | 141 (62.1%) |
| | Open | 16 (18.6%) | 70 (81.4%) | 86 (37.9%) |
| | Total | 22 (9.3%) | 215 (90.7%) | 227 (100%) |
| Gustilo type (*N* = 86) | GA-I | 4 (13.3%) | 26 (86.7%) | 30 (34.5%) |
| | GA-II | 5 (12.5%) | 35 (49.3%) | 40 (46%) |
| | GA-IIIA | 1 (11.1%) | 8 (88.9%) | 9 (10.3%) |
| | GA-IIIB | 5 (31.3%) | 0 (0.0%) | 5 (5.75%) |
| | GA-IIIC | 1 (33.3%) | 2 (66.7%) | 3 (3.4%) |
| | Total | 16 (18.4%) | 70 (81.4%) | 86 (100%) |
| Previous implant use | No | 14 (6.4%) | 195 (93.6%) | 209 (92.0%) |
| | Yes | 8 (44.4%) | 10 (55.6%) | 18 (8.0%) |
| | Total | 22 (9.3%) | 215 (90.7%) | 227 (100%) |

*Other includes stab injuries, stone injuries, etc.
GA, Gustilo Anderson.

The Gustilo Anderson classification divides soft-tissue wounding of open fractures into three grades—I, II, and III (12). Based on this classification, open fracture accounts for 86 (37.9%) of total study respondents.

Figure 1 depicts that open fractures also had a higher percentage of infection (18.6%), whereas closed fractures had only a 4% infection rate.

Rates of infection were stratified according to GA classification, and it shows that GA IIIB fractures have a 31.3% infection rate, followed by GA IIIC (33.3%), GA I (13.3%), GA II (12.5%), and GA IIIA (11.1%). The proportion of infection was very high (44.4%) in the fracture, which was treated with IMN after external fixation. All reduced and closed fractures were not infected; see details in Figure 2.

## Factors associated with infection after intramedullary nailing of long bone fractures

Multiple logistic regression analysis was used to control for confounding variables and identify risk factors that were significantly predictive of infection. Because of small cells, only two variables were candidates for multivariate analysis. These are age-related and fractured bones. After the analysis, both were found to be statistically insignificant. Patients over the age of 30 have a 9% infection rate with a *p* value of 0.752 compared to patients under 30. Tibial fractures had a 12.1% infection rate with a *p* value of 0.244 compared to femur fractures.

## Discussion

The incidence of SSI in this study was 9.3%, which is comparable to the reported worldwide incidence of 2.6%–41.9%.[3,10] The rate of deep implant infection also corresponds reasonably well to those of previously published reports from other large trauma units.[4,5,12,15] The relatively higher follow-up rate (91.5%) in our study may be due to the behavior of our patients. They don't want any metal in their bodies for too long, so they keep coming for removal.[5] Compared to the findings in the paper by Elias et al., the infection rate in this study seems slightly higher. The rate of infection for open fractures in this study was 18.6%, compared to 13.6% in the above study. The rate of infection for closed fractures was comparable with 4% in this study and 3% in the

**Table 3.** Treatment of long bone fractures in St. Paul's Hospital Millennium Medical College, AaBET Hospital, Addis Ababa, Ethiopia 2021.

| Variables | Categories | Infection status | | Total *f* (%) |
|---|---|---|---|---|
| | | Infected *f* (%) | Non-infected *f* (%) | |
| Reduction method | Open | 16 (18.6%) | 70 (81.4%) | 86 (37.9%) |
| | Closed | 6 (4.0%) | 135 (96.0%) | 141 (62.1%) |
| | Total | 22 (9.3%) | 205 (90.3%) | 227 (100%) |
| Time from injury to | <1 day | 6 (11.5%) | 46 (88.5%) | 52 (60.0%) |
| | 1–3 days | 5 (29.4%) | 12 (70.6%) | 17 (20.0%) |
| Debridement | 3–7 days | 2 (25%) | 6 (75%) | 8 (9.3%) |
| | >7 days | 3 (33.3%) | 6 (66.7%) | 9 (10.0%) |
| | Total | 15 (17.9%) | 69 (82.1%) | 86 (100%) |
| Time from injury to skin closure | <1 day | 1 (2.6%) | 37 (97.4%) | 38 (44.2%) |
| | 1–3 days | 4 (28.6%) | 10 (71.4%) | 14 (16.3%) |
| | 3–7 days | 1 (14.3%) | 6 (85.7%) | 7 (8.1%) |
| | 7–14 days | 4 (36.4%) | 7 (63.6%) | 11 (12.8%) |
| | >14 | 6 (37.5%) | 10 (62.5%) | 16 (18.6%) |
| | Total | 16 (18.6%) | 70 (81.4%) | 86 (100%) |
| How early antibiotics was initiated | <3 h | 2 (10.5%) | 17 (89.5%) | 19 (22.4%) |
| | 3–24 h | 11 (20%) | 45 (80%) | 56 (64.7%) |
| | >24 h | 3 (27.3%) | 8 (72.7%) | 11 (12.9%) |
| | Total | 16 (18.8%) | 69 (81.2%) | 86 (100%) |
| Duration of surgery | <2 h | 7 (6.4%) | 98 (93.3%) | 105 (46.3%) |
| | 2–4 h | 15 (12.5%) | 100 (86.9%) | 115 (50.7%) |
| | >4 h | 0 (0.0%) | 7 (100%) | 7 (3%) |
| | Total | 22 (9.3%) | 205 (90.3%) | 227 (100%) |

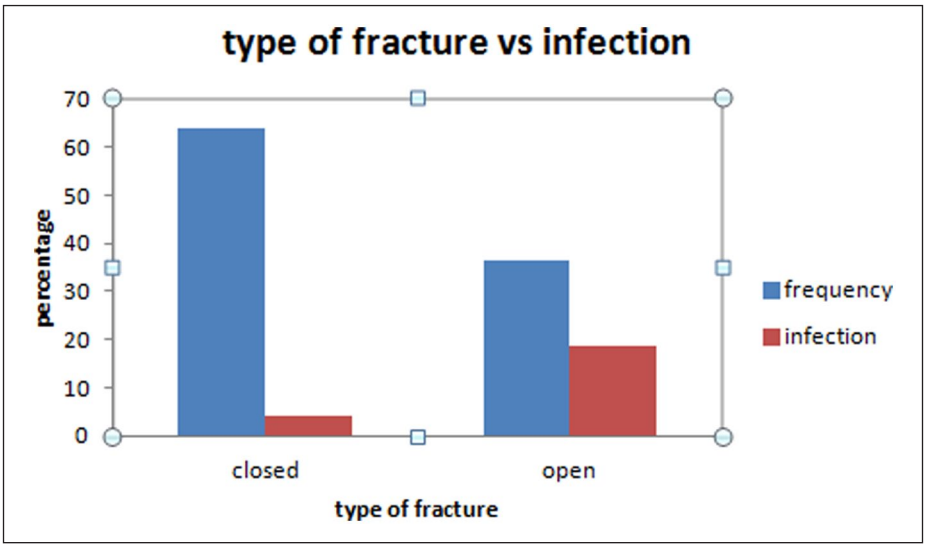


**Figure 1.** Proportion of types of fractures versus infection rate in 2021.

previous study. This may be because we included a large number of open fractures (14%–36%) in this study.[16] The proportion of infection in those patients below the age of 30 and above the age of 30 is comparable and similar to previous studies.[10] Unlike the previous studies, which consistently show a higher infection rate in males, the proportion of infections is slightly higher in females in this study.[15-17]

Similar to previous studies, RTAs are the leading cause of trauma, followed by falls, similar to previous studies. Trauma was the most common indication for intramedullary nailing, and the femur was the most commonly fractured bone, similar to previous studies.[11,12,16]

Tibial fractures had a higher percentage (12.1%) of infection compared to femur fractures (7.5%). This may be due to

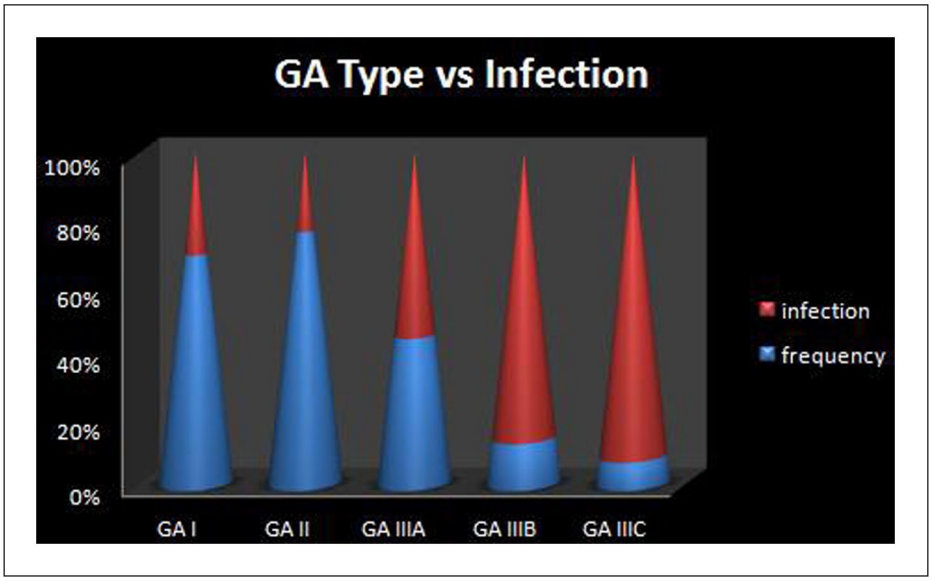


**Figure 2.** Rates of infection were stratified according to GA classification among long bone fractures in Ethiopia.

the subcutaneous localization of the tibia in contrast to the femur, which is surrounded by large, well-perfused muscles. No significant difference in the risk of infection was found between retrograde and antegrade nailing of the femur. The proportion of open fractures in this study was 36.3%. The relatively high percentage of open fractures with soft tissue injuries selected for intramedullary nailing may be one risk factor for the relatively higher rate of infection in this study. Open fractures had a higher percentage (18.6%) of infection than closed fractures (4%).[4,10]

The infection rate for Gustilo Anderson type I fractures[12] was low compared to GA type II and IIIA open fractures. In this study, the infection rate for GA I fractures (13.3%) was slightly higher than that for GA II (12.5%) and GA IIIA (11.1%) open fractures. This may be because of inadequate debridement considering the small size of the wound. Adequate debridement before insertion of any implant is mandatory, even though the size of the wound is very small.[10,18,19]

Changing the external fixator and inserting an intramedullary SIGN nail were associated with a higher percentage of infection (44.4%) compared to fractures that are directly fixed with an intramedullary nail (6.4%). This increment is probably secondary to the lack of use of pin holidays. We do not practice "pin holiday" after removal of the external fixator to apply IMN almost all the time. It should be a trend to wait 7–10 days for the pin sites to be clean before inserting intramedullary nails.[20]

Even though their number is small, reduced and closed fractures were not infected at all. These results suggest that opening the fracture site should be avoided if possible. The presence of an experienced trauma surgeon at the time of operation could help to avoid this in many cases.[17]

Skin closure after 24 h was associated with a higher percentage (28.6%) of infection, especially closure after 7 days (36.4%) compared to closure within 24 h (2.6%). Open fractures, tibial fractures, use of a previous implant, delayed surgery, and delayed debridement are associated with a higher proportion of infection, even though it is not statistically significant because of small cells.

In the authors' opinion, the infection risk after intramedullary nailing in this study is acceptable, and the advantages of intramedullary nailing over skeletal traction far outweigh this risk. We do not think that the risk of infection should be used as an argument against IM nailing of femoral fractures in low-income countries, but efforts must be made to reduce the infection rate where possible through improvements in hospital infrastructure and supply chains and systematic training of surgeons and theater staff.[3]

### *Limitations*

The limitation of this study is sample size was not calculated and applied as a total census of all eligible study participants.

## Conclusion

This study found that the prevalence of infections after intramedullary nailing of long bone fractures in Ethiopia was 44.4% after external fixation, compared to 6.4% after intramedullary nail was inserted directly. Proper control measures are needed to reduce morbidity and complications related to long fracture treatment, such as open fractures, tibial fractures, the use of an external fixator, delayed debridement and skin closure, and prolonged surgery and deep SSI rate.

This study found that intramedullary infection has a great financial burden on patients and hospital resources, and could lead to increased patient morbidity and mortality. To reduce this burden, early skin closure, pin holding, prophylactic antibiotics, and closed reduction techniques should be encouraged.

In addition, researchers should include other variables such as whether the surgery was an emergency or elective, any underlying comorbidity, the number of staff in the OR, and movement during surgery. If using an external fixator is necessary, waiting for the pin to heal is important before changing it to an intramedullary nail. The authors strongly advise avoiding the prolonged prophylactic antibiotic use and sticking to the standard recommendations, even though the resource-limited setting environment is not sterile compared to a western setup.

## Acknowledgements

Our Special gratitude goes to Dr Lewis G. Zerkle for providing us the SIGN nail and instrument and for providing constructive comments throughout the research process. A special gratitude also goes to Dr Kumelachew Abate for his dedication and humble mind to help us throughout the research process. We would like to appreciate all department colleagues who gave us the inspiration and support to do this study. We would like to thank SPHMMC research directorate for providing the grant to conduct this study.

## Authors' contributions

TD, HM, KA, TL, and DBD designed the study, developed the proposal, participated in the data collection, performed the analysis, and drafted the manuscript. TD and KA approved the proposal with revisions, participated in data analysis, and revised subsequent drafts of the manuscript. All authors reviewed the manuscript.

## Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

## Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This study was funded by Saint Paul's Hospital Millennium Medical College. However, the funder had no role in the study design, data collection, analysis, preparation of the manuscript, and decision to publish.

## Ethics approval and consent to participate

Ethical approval was obtained from St. Paul Hospital Millennium Medical College, Ethical Review Board Ref. No. Pm289/678, this requirement was not waived by the Institutional Review Board and confirmed that all experimental protocols were approved by St. Paul's Hospital Millennium Medical College Institutional Ethical Review Board. The authors confirmed that written informed consent was obtained from all subjects aged greater than 18 years, and for minor subjects less than 18 years old prior to study initiation and written inform consent was obtained from their parent or legal guardian(s) or legally authorized representatives before the study. Authors had confirmed that all methods were carried out in accordance with relevant guidelines and regulations. Authors had confirmed that all experimental protocols were approved by St. Paul Hospital Millennium Medical College Institutional Review Board/Ethics Committee (Ref. No. Pm289/678).

## Ethics approval

Ethical approval was obtained from St. Paul Hospital Millennium Medical College Ethical Review Board Ref. No. Pm289/678, this requirement was not waived by the Institutional Review Board and confirmed that all experimental protocols were approved by St. Paul's Hospital Millennium Medical College Institutional Ethical Review Board.

## Informed consent

The authors confirmed that written informed consent was obtained from all subjects aged greater than 18 years, and for minor subjects less than 18 years old prior to study initiation and written inform consent was obtained from their parent or legal guardian(s) or legally authorized representatives before the study. Authors had confirmed that all methods were carried out in accordance with relevant guidelines and regulations. Authors had confirmed that all experimental protocols were approved by St. Paul Hospital Millennium Medical College Institutional Review Board/Ethics Committee (Ref. No. Pm289/678).

## Trial registration

Not applicable.

## Availability of the data and materials

The summary data are available in the main document.

## Supplemental material

Supplemental material for this article is available online.

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