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Developing and implementing an intervention model
for chronic osteomyelitis prevention in rural Rwanda
through early detection of osteomyelitis
at community and primary healthcare levels
and evaluating the impact of the model

Inaugural-Dissertation
zur Erlangung des Doktorgrades der Medizinwissenschaften
dem Fachbereich Medizin der Philipps-Universität Marburg vorgelegt
von

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aus Kibogora, Rwanda
Marburg, 2025

Angenommen vom Fachbereich Medizin der Philipps-Universität Marburg
am: 27. März 2025

Gedruckt mit der Genehmigung des Fachbereichs Medizin

Dekan: Herr Prof. Dr. M. Hertl

Referent: Herr Prof. Dr. P. Schuler

1. Korreferentin: Frau Prof. Dr. C. Eberle

Dedicated to my family with heartfelt gratitude and love.

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LIST OF ABBREVIATIONS

AIDS	Acquired Immunodeficiency Syndrome
CHW	Community Health Worker
CoRSU	Comprehensive Rehabilitation Services in Uganda
CRP	C-Reactive Protein
ESR	Erythrocyte Sedimentation Rate
HC	Health Center
HIV	Human Immunodeficiency Virus
HP	Health Post
IRB	Institutional Review Board
KOMS-Test	Kibogora Osteomyelitis Screening Test
MOH	Ministry of Health
NISR	National Institute of Statistics Rwanda
OM	Osteomyelitis
RNEC	Rwanda National Ethics Committee
WBC	White Blood Cells
WHO	World Health Organization

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A. INTRODUCTION

Osteomyelitis is an inflammatory process of the bone and bone marrow caused by an infectious organism which results in local bone destruction, necrosis, and apposition of new bone (Callistus et al., 2015; Shirwaiker et al., 2015). Osteomyelitis is caused by microbial infections or auto-inflammatory processes (M. Lu et al., 2016). In developed countries, the incidence of osteomyelitis is 8-10 per 100.000 inhabitants; the disease in these countries is usually detected and treated in the early stage. In developing countries, the incidence of osteomyelitis is significantly higher, and the disease is often recognized and treated too late (Jaramillo and Dormans, 2017). Osteomyelitis is a serious problem among children as well as adults (DeRonde et al., 2018; El-Sobky & Mahmoud, 2021). Due to similarity of signs and symptoms of osteomyelitis with other diseases, it is difficult to identify the infection at early stage (Riise et al., 2008).

Half of the world's population has access to adequate primary healthcare, and two-thirds lack access to orthopaedic care (Jones et al., 2011). Most of those affected people live in rural areas of undeveloped countries where the people are poor.

According to Baldan et al., 2014, osteomyelitis typically begins with acute symptoms such as pain, swelling, heat and fever. Early treatment within the first four to six weeks is crucial for a successful cure. Delayed initiation of treatment after this period can lead to the chronic stage, characterized by persistent pain, discharge of pus from the skin with multiple skin lesions, the development of sequestrum and formation of new bone, which is called involucrum (DeRonde et al., 2018). At this advanced stage, bones can become fragile and prone to fracture even without trauma and the fractured bone can penetrate through the skin. In some individual cases, only amputation of the affected limb is possible, with correspondingly dramatic consequences for the patient, his family and for the society (DeRonde et al., 2018).

According to Ogunjumo, 2006, social stigma is one of the most challenging aspects of chronic osteomyelitis, mainly due to the unpleasant odor of the discharge from infected wounds. This stigma can lead to social isolation as patients may be ostracized by their communities. Furthermore, the suggestion of amputation,

which may be a necessary treatment in some cases, is often rejected by patients due to socio-cultural beliefs and the socio-economic impact of losing a limb. The financial burden of treating chronic osteomyelitis is significant. Deo (2018) reported that the prolonged use of expensive antibiotics, longer hospital stays, and the need for multiple surgeries contribute to the high cost of treatment.

The following Figure 1 shows a typical case of osteomyelitis of one patient among many others treated at Kibogora Hospital. The patient was 9 years old and suffered for more than one year from typical chronic osteomyelitis. The first picture reveals pus draining from the skin with multiple lesions, while the radiograph displays extensive bone destruction. The picture on the right side illustrates the intraoperative situation after removing dead bone. Several complex and difficult surgical procedures were necessary to treat the infection and to reconstruct the bone.



Figure 1: Chronic osteomyelitis with multiple skin lesions (left image), x-ray image with necrosis and involucrum (middle image), intraoperative findings (right image)

The images in Figure 2 show another case of osteomyelitis of a 13-year-old boy treated at Kibogora Hospital. He suffered for more than one year from chronic osteomyelitis. The first picture reveals that the dead bone has fractured and already penetrated the skin, while the radiograph displays an extensive bone

destruction. The final picture shows the removed dead bone as the first step of treatment.



Figure 2: Chronic osteomyelitis with bone penetrating the skin (left image), x-ray image with necrosis and involucrum (middle image), necrotic bone fragments (right image)

The cases in figures 1 and 2 demonstrate complex complications resulting from delayed detection and treatment of osteomyelitis.

There is a growing recognition of the importance of implementing community-based interventions to prevent chronic osteomyelitis. Muluaem et al., 2023, and Olivier et al., 2019, recommend establishing a prevention project to increase awareness about signs of osteomyelitis among healthcare providers and to improve the management of the disease.

Many authors recommend a spectrum of actions which include health education and awareness campaigns to improve healthcare infrastructure (Birt et al., 2017; Das et al., 2014; El-Sobky & Mahmoud, 2021; Stanley et al., 2010; Tissingh et al., 2022)

Kim et al., 2016, appeal to politicians to set up national health programs for the rural population. Healthcare providers should be trained and equipped to deliver preventive services effectively, with a focus on reaching underserved populations in remote rural areas.

Especially, in many parts of African Countries chronic osteomyelitis is a public health concern (Callistus et al., 2015). Also, in Rwanda chronic osteomyelitis is present. In the last years, among the patients treated at Kibogora Hospital because of osteomyelitis, about 90% of cases showed already the chronic stage of the disease and needed severe and multiple surgical procedures (Kibogora Level 2 Teaching Hospital, 2020).

The particular challenges for an intervention model to reduce chronic osteomyelitis were:

- The time at which osteomyelitis begins is unknown
- The treatment should start within a maximum of 4-6 weeks after the onset of the disease

Due to the serious problems associated with chronic osteomyelitis, the main question arises:

- Is it possible to reduce the high rate of chronic osteomyelitis with an intervention model? And how could that happen?

The aim of this work was to develop, implement, and evaluate an intervention model for the prevention of chronic osteomyelitis through early detection of osteomyelitis in Nyamasheke District, Rwanda. The intervention was designed as a three-phase project.

In Phase I, the prevalence of osteomyelitis-related operations and profile of osteomyelitis patients operated in Nyamasheke District hospitals in Kibogora and Bushenge were examined.

In Phase II, the intervention model was developed and implemented at all healthcare levels through information, communication, and education to change behavior.

In Phase III, the prevention program was monitored and evaluated.

The following questions were to answer:

- What was the prevalence of operations performed for osteomyelitis in hospitals in Nyamasheke District in Rwanda from 2016 to 2020?
- What was the profile of patient having osteomyelitis treated in Nyamasheke District hospitals of Rwanda before project implementation?
- How could a prevention program to prevent chronic osteomyelitis look like?
- How could this program be implemented?
- Were developed community and primary healthcare-based interventions successful?
- What was the impact of the implemented prevention program in Nyamasheke District of Rwanda?

B. MATERIALS AND METHODS

I. Phase I: Prevalence of osteomyelitis-related operations and profile of patients having osteomyelitis who underwent surgery in Nyamasheke District hospitals in Kibogora and Bushenge.

For Phase I a descriptive, retrospective cross-sectional, mixed-methods approach was used. For quantitative analysis data were collected from medical records of 10,305 operations performed in the period from 2016-2020 in the two district hospitals.

1. Quantitative analysis

The sample size was calculated with Taro Yamane formula (Uakam et al., 2021)

$$no = \frac{N}{1 + N(e^2)}$$

N: Population size (10305 Surgical cases).

no: Sample size to be determined

e: Marginal of error (0.05)

To select medical records for the study, a systematic sampling approach was employed. Eligible medical records of surgical cases within the defined time frame were systematically selected from the available pool of 10,305 cases meeting study criteria.

The data extraction form included comprehensive fields to capture relevant information from medical records. Key variables to be extracted include patient demographics, details of the surgical procedure, transfer-time to hospitals, information on any treatment by traditional healers prior to referral, as well as the distribution of acute and chronic osteomyelitis in patients operated on in hospitals in Nyamasheke District.

2. Qualitative analysis

A descriptive, cross-sectional study was conducted to explore the experiences of individuals involved in osteomyelitis care through in-depth interviews with 12

nurses from health centers and 20 participants (5 patients and 5 parents from both Kibogora and Bushenge Hospitals). Purposive sampling ensured a diverse representation of participants, including nurses directly involved in osteomyelitis treatment and patients diagnosed with the disease, along with their parents.

All participants were required to provide informed consent and demonstrate a willingness to share their experiences. The interviews were designed to cover key topics such as access to healthcare services, timeliness of care, patient satisfaction, clinical improvement, and the challenges encountered during treatment.

Thematic analysis of the interview data was conducted using ATLAS.ti 24 software, following a systematic six-step approach: data familiarization, coding, generating themes, reviewing themes, defining themes, and reporting results. This structured process ensured that the analysis was thorough and that the emergent themes accurately reflected the participants' experiences. The use of semi-structured interviews allowed for in-depth exploration of the topics, while the cross-sectional design provided a snapshot of the current state of osteomyelitis care from multiple perspectives, contributing to a comprehensive understanding of the issues at hand.

II. Phase II: Development and implementation of an intervention model at community and primary healthcare levels

1. Scoping review of the literature about osteomyelitis prevention programs

The scoping review was conducted to investigate the literature on the existence and implementation of any intervention model for preventing chronic osteomyelitis, particularly in low-resource settings.

A systematic search used PubMed, MEDLINE, Embase, Scopus, and CINAHL to identify relevant studies. Keywords used in the search strategy included “osteomyelitis prevention”, “hospital-based intervention”, “community intervention”, “low-resource settings”, and “developing countries”. Included were only studies with publication years ranging from 2005 to 2024 were included, with most studies published in the last decade.

First, titles and abstracts of the identified studies were reviewed for relevance to the review objectives. Full-text articles of potentially relevant studies were then checked for suitability using predefined inclusion and exclusion criteria.

Studies focusing on interventions for preventing chronic osteomyelitis in low-resource settings were included, while those not meeting the criteria or focusing solely on clinical management or treatment of osteomyelitis were excluded. For the scoping review different study designs such as randomized controlled trials, quasi-experimental studies, observational studies and qualitative studies were included. Two reviewers conducted screening and articles with 80% agreement were considered.

2. Implementation site associated conditions

a) Geographical and climate situation

Rwanda, with an area of 26,338 km² and around 13 million inhabitants, is located in eastern Central Africa between 1° and 3° south latitude. It is surrounded by Uganda to the north, Tanzania to the east, Burundi to the south and the Democratic Republic of Congo to the west. Rwanda is politically divided into 5 Provinces, with Kigali as the capital in the middle of the country (National Institute of Statistics of Rwanda (NISR), 2023).

The western part of Rwanda, which includes the Nyamasheke District where the study was conducted, is a heavily dissected highland with an average altitude of 1,500 meters above sea level known as “Land of a Thousand Hills” because of the hilly landscape with very steep hills and swampy valleys.

Nyamasheke District is one of the seven districts belonging to the Western Province. Nyamasheke District has a surface area of 1,174 km² including 225,85 km² as part of Nyungwe Forest National Park and 346,53 km² of water area as part of Lake Kivu. There is only one paved road along Lake Kivu; all other roads in the hilly region are in a poor condition and difficult to drive on even with off-road vehicles.

Due to the altitude, Nyamasheke District has a temperate tropical climate all year round. The temperature ranges from an average of 25 degrees during daytime to around 15 degrees at nights. Nyamasheke District has two dry seasons from June to August and in January and two rainy seasons from February to May and September to December.

The average annual rainfall is 1,364 mm, and can reach up to 2,000 mm. During the rainy seasons, the unpaved, muddy roads and paths are difficult or impossible to drive on for days.

b) Population structure

Nyamasheke District is one of the most populated districts in Rwanda with more than 434,121 thousand residents. Only 1.8% of the population lives in an urban area, while 98.2% of the population lives in rural areas in more than 500 small hamlets and scattered houses on the hills. Only a few hamlets are accessible by car (National Institute of Statistics of Rwanda, 2023).

The population of Nyamasheke District is predominantly female at 53.3%, while 46.7% of the population is male. The majority of the district's residents are young, 62.1% are under 25 years old, 37.9% are older than 25 years. Those over 60 years of age constitute 5.6% of the total population of the district (National Institute of Statistics of Rwanda (NISR, 2012)

The population is poor. The Integrated Household Living Conditions Survey 2013/14 conducted by the National Institute of Statistics of Rwanda (NISR) showed that in Nyamasheke District 62 % are poor and of those 39.2% are extremely poor. Based on the 2022 Rwanda 4th Population and Housing Census findings for Nyamasheke District, Sanitation infrastructure remains predominantly basic, with private pit latrines (89.2%) and shared pit latrines (7.3%) being the primary toilet facilities. Flush toilets/WC systems are rare.

In terms of employment, the district's overall employment-to-population ratio stands at 42.5%, with urban areas having a higher ratio (54.6%) than rural areas. The average household size is 4.5 people (National Institute of Statistics of Rwanda, 2023).

Agriculture plays an important role in the local economy, with 85.1% of households engaged in agricultural activities. Crop farming is prevalent among 78.5% of households, while 64.2% do livestock farming. The mean size of land cultivated in Nyamasheke District per household is 0.49 ha, which is below the rural average 0.6 ha. Around 50% of the rural population lives on production from subsistence farming.

A significant proportion, namely 25.7% of the population aged 3 years and older do not receive formal education. The primary school qualification is most commonly achieved at 60.1%, followed by the secondary school qualification with 9.1% and a small proportion (0.9%) with a university degree (National Institute of Statistics of Rwanda, 2012).

c) Health Care structure in Nyamasheke District

The structure of the health organization in Rwanda is designed to ensure access to health services throughout the country. To support community health and wellness different components such as community health workers, nurses at health posts and health centers and staff at hospitals must work together (Rwanda Ministry of Health, 2018). Also, traditional healers with indigenous knowledge play an important role in the health care structure.

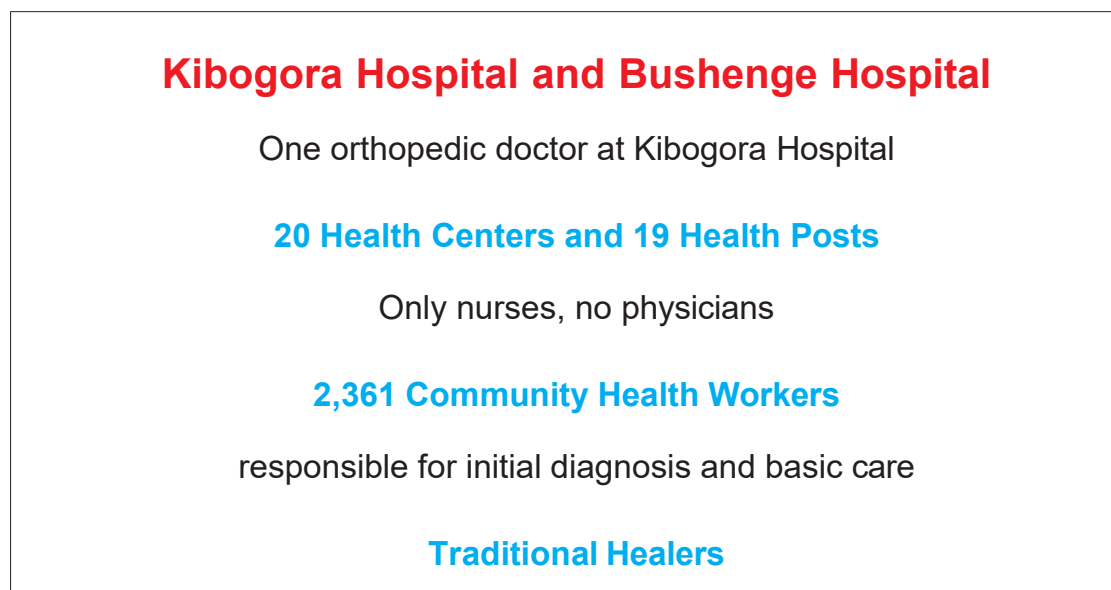


Figure 3: Healthcare structure in Nyamasheke District

District hospitals in Rwanda play a critical role in providing comprehensive health services at the district level and serve as important facilities that address a wide range of health needs in local communities. These hospitals complement the primary health care by providing specialised medical care, surgical procedures, diagnostic services, and emergency care (Rwanda Ministry of Health, 2013).

Nyamasheke District is served by two district hospitals but only one orthopaedic surgeon serves the district with 434,221 people (NISR, 2023).

Health centers in Rwanda serve as primary health care centers in local communities and are staffed by nurses who provide a wide range of basic services, including prevention, family planning and treatment of common diseases (MOH, 2013). With 20 health centers in Nyamasheke District, and about 500 nurses working there, these facilities play a vital role in delivering comprehensive and integrated healthcare services, particularly focusing on maternal and child health, HIV/AIDS care, tuberculosis treatment and malaria control. Experience levels varied, with a notable proportion of nurses having more than 5 years of experience (37.5%), indicating some level of expertise and familiarity with diseases. Health centers not only provide medical care but also conduct health education programs and encourage community participation through community health workers, ensuring culturally appropriate and responsive healthcare delivery to Rwandan communities.

Nyamasheke District is a rural area and from the hamlets scattered throughout the country, patients can only reach the health centers on foot or must be carried. The patients have to walk on average of 1 to 3 hours to reach the health centers and from health centers to the hospital they need an additional time between 1 to 2 hours with an ambulance.

Health posts in Rwanda represent essential primary healthcare facilities at the community level, providing accessible services including basic medical care, maternal and child health services, immunizations, and health education (Rwanda Ministry of Health, 2018).

There are two nurses working in each health post. With 19 health posts in Nyamasheke District these facilities serve as crucial points of contact for individuals

seeking healthcare, offering preventive measures and basic treatments. Health posts are also engaged in outreach and health promotion to effectively address local health needs. Health posts are linked to and supervised by health centres.

Community health workers are integral parts of the health system in Rwanda and play a central role at the community level, driving behavior change and extending health services to rural populations. Community health workers actively participate in awareness campaigns, early diseases detection, and dissemination of prevention information in villages and communities (Rwanda Ministry of Health, 2013).

Traditional healers in Rwanda are also an integral part of the community, with some being openly recognised and playing significant roles as facilitators and counsellors, while others operate discreetly, using herbs, medicinal plants, and community-based techniques to treat various physical and mental ailments. However, the practice of traditional healing can have negative impacts on community health outcomes due to the lack of knowledge, standardisation and regulation. This can lead to issues such as misdiagnosis, delays in accessing modern healthcare, and resistance to scientific medicine. Reliance solely on traditional healing methods may result in ineffective treatments or even harmful practices, particularly for serious health conditions (Rwanda Ministry of Health, 2019).

d) Community based health insurance

Community based health insurance, commonly known as Mutuelle de Santé, ensures that all individuals and families, especially those with low incomes, have access to essential medical services at an affordable cost. The insurance operates on the principle of collective contributions, allowing members to pool resources based on their income levels to receive medical care at significantly reduced costs (World Health Organization, 2005).

Members of Mutuelle de Santé benefit from access to medical treatment at local facilities, such as health posts and health centers, with minimal out-of-pocket expenses. At health centers and health posts, members pay only a nominal fee

of 200 Rwandan Francs (Frw). When receiving care at district, provincial, or referral hospitals, members pay only 10% of the total bill, with the remaining 90% covered by the insurance scheme, supported by the government. For those unable to afford even the minimal fees, government assistance ensures they are not denied care (C. Lu et al., 2012).

The contribution structure depends on the income of the person and varies from 3,000 Frw bis 7,000 Frw. per month. Extremely poor people also pay 3,000 Frw per person, with their contributions supplemented by government and donor support to ensure they have access to healthcare services (Kalk et al., 2010).

3. Training materials

To improve the knowledge of healthcare providers in Nyamasheke District, specific training materials on early detection and treatment of osteomyelitis were developed. This included a Manual on comprehensive knowledge of osteomyelitis, and a special Kibogora Osteomyelitis Screening Test (KOMS-Test).

To raise public awareness various training materials have been developed. These materials included leaflets, posters and banners, polo shirts and folders, filled with comprehensive information. Each training material has been carefully designed to contain important information and pictograms that highlight the early signs and symptoms of osteomyelitis.

To improve cooperation between hospitals and health centers, different materials were designed such as a discharge protocol, treatment pathways for hospitals and health centers and quarterly meetings of healthcare providers at Kibogora Hospital.

III. Phase III: Monitoring and evaluation of the prevention program

The study was conducted in Nyamasheke District hospitals, focusing on patients with osteomyelitis from Nyamasheke District and neighboring districts. A quasi-experimental design was employed, specifically adapted to a non-equivalent group design, to evaluate the effectiveness of a prevention program implemented only in Nyamasheke District. Patients were categorized based on their residence: those from Nyamasheke District, where comprehensive interventions and staff training were conducted, and those from neighboring districts where no such interventions occurred. The study aimed to explore differences in the progression and severity of osteomyelitis between these two groups. Data collected included patient demographics (gender, age, and geographic location), clinical information (diagnostic and therapeutic measures during up to three inpatient stays), and disease classification (acute or chronic osteomyelitis). The study also examined the time from early detection to hospital presentation.

Statistical analysis, including the chi-square test, was used to determine the significance of differences between the two groups, particularly in the progression from acute to chronic osteomyelitis and the severity of chronic cases. The database was designed to monitor the further course of acute osteomyelitis, specifically looking at whether it transformed into chronic osteomyelitis during treatment, and whether abscess formation had an impact on this progression. Additionally, the study investigated if there were differences in the severity of chronic osteomyelitis based on whether patients were from Nyamasheke District or neighboring districts without trained healthcare providers.

IV. Ethical considerations

Ethical approval from the Rwanda National Ethics Committee (RNEC) IRB: 00001497 OF IORG 0001100 was issued November 20th, 2020.

The researcher adhered to the concepts of human dignity and participatory choice, ensuring confidentiality and voluntary participation in the study.

To maintain confidentiality, no names were included in the questionnaires / checklists, and data were securely collected on a computer with a password accessible only to the researcher. Participants were assured that the information they provided would only be used for the purposes of the study.

In cases where a child was unable to provide necessary information, the parents or guardians were encouraged to participate in the research and provide information on the child's behalf.

C. RESULTS

I. Phase I: Prevalence of osteomyelitis-related operations and profile of patients having osteomyelitis who were treated in Nyamasheke District hospitals in Kibogora and Bushenge.

Using a descriptive, retrospective cross-sectional design to investigate the prevalence of osteomyelitis-related operations quantitative data were collected from medical records of 10,305 operations performed in the period from 2016-2020 in the two district hospitals in Kibogora and Bushenge.

1. Quantitative analysis

a) Prevalence of osteomyelitis-related operations

The sample size required for this study was calculated using Taro Yamane formula as follows:

$$\text{no} = \frac{10305}{1 + 10305 (0.05)^2}$$

N: Population size (10,305 Surgical cases)
no: Sample size to be determined
e: Marginal error (0.05)

With a desired confidence level of 95% and a margin of error of 5%, the sample size calculation yielded 385.

To ensure the representativeness of both hospitals, stratified sampling was used based on the proportion of operations at each hospital

Table 1: Sample size of Kibogora Hospital and Bushenge Hospital

Hospital	Operations	Sample to be taken
Bushenge	3,810	$(3810/ 10305) * 385 = 142$
Kibogora	6,495	$(6495/ 10305) * 385 = 243$
Total	10,305	385

To select medical records for the study, a systematic sampling approach with sampling interval $k = 27$ ($10,305:385=26,7$) was used. Eligible medical records within the defined time frame were systematically selected from the available

pool. This sampling method ensures that every record has an equal chance of being included in the study, reducing bias, and increasing the representativeness of the sample.

The prevalence of osteomyelitis-related operations was assessed with a total of 385 surgical procedures analysed. Of these, 278 were classified as negative for osteomyelitis, accounting for approximately 72% of all operations. In contrast, 107 surgical procedures were classified as positive for osteomyelitis, accounting for approximately 28% of all cases.

The prevalence of 28% proves that osteomyelitis is present in a significant proportion of the cases examined. Extrapolated to 10,305 operations, 2,885 operations were performed for osteomyelitis in the two hospitals in the 5 years 2016 to 2020. More than one in four operations were performed due to osteomyelitis.

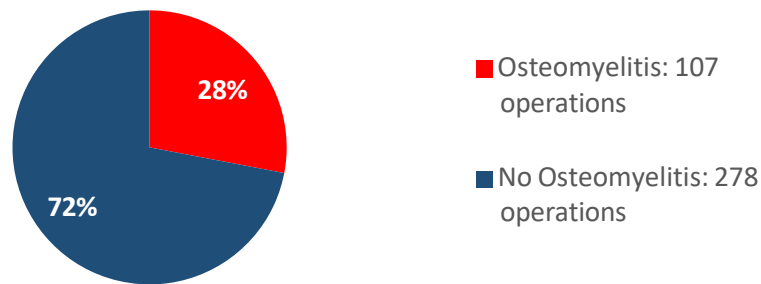


Figure 4: Prevalence of osteomyelitis-related operations in hospitals in Nyamasheke District in the period of 2016 to 2020

Of the 107 osteomyelitis-related operations, 93 operations (86.9%) were performed for chronic osteomyelitis and 14 surgeries (13.1%) were performed for acute osteomyelitis.

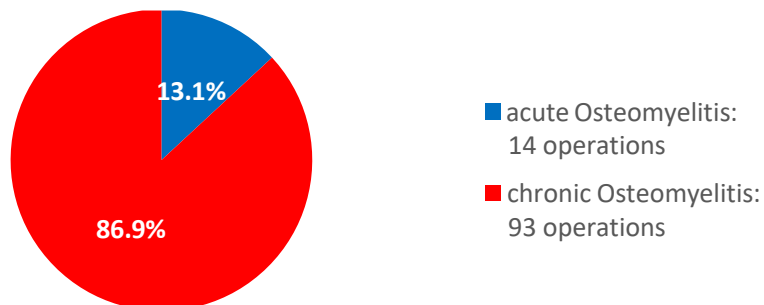


Figure 5: Distribution of acute and chronic osteomyelitis-related operations in hospitals in Nyamasheke District in the period of 2016 to 2020

b) Profile of patients with osteomyelitis

A profile evaluation of osteomyelitis patients in Nyamasheke District was conducted within a sample group of 385 surgical cases. Out of these, 107 cases were confirmed as osteomyelitis and were subsequently analyzed. Among the 107 operations performed, 33 patients required multiple surgeries. The patient profiles were specifically analyzed in the remaining 74 patients who underwent a single operation for osteomyelitis.

Patient demographic data were collected, including age, gender and health insurance. Geographic data categorized patients according to their residence in rural or urban areas. With regard to treatment, it was examined whether and for how long treatment was provided by a traditional healer. In addition, the time from the initial examination in a health center to the patient's presentation to the hospital was examined.

The gender distribution among the 74 patients revealed that 42 males accounted for 56.8% of the cases, and 32 females accounted for 43.2%.

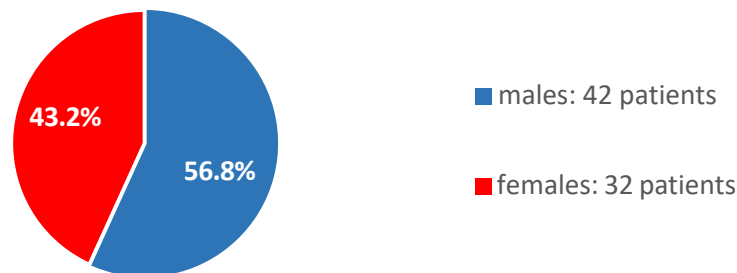


Figure 6: Gender distribution

The age distribution of the 74 patients varied, with the highest proportion (65%) of patients ranging from 0 to 18 years old, 19% in the range of 19 to 30 years, 16% were older than 30 years.

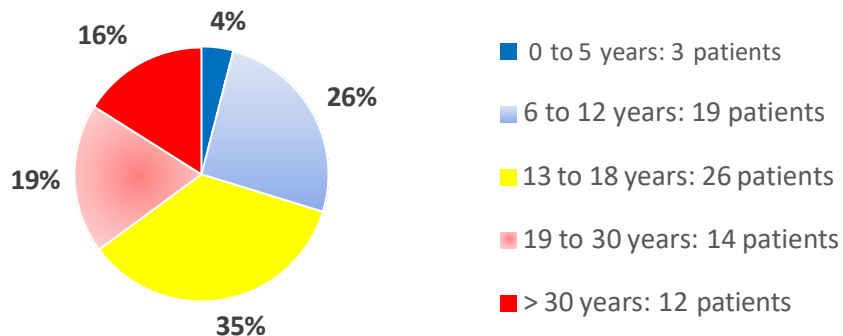


Figure 7: Age distribution

Of the group of 74 patients, 65 patients (87,8%) had a health insurance, 9 patients (12,2%) had no health insurance.

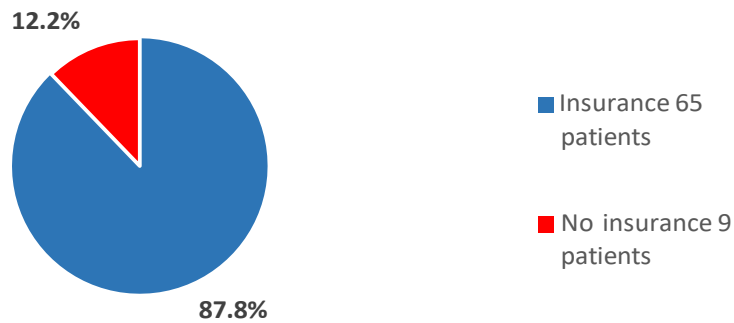


Figure 8: Health insurance

Of the group of 74 patients 58 patients (78.4%) resided in rural areas, while 16 patients (21.6) resided in urban areas



Figure 9: Residency

Of the group of 74 patients 12 patients (16,2%) were transferred to Kibogora and Bushenge Hospital within the first two weeks, 19 patients (25,7%) were transferred between 2 to 4 weeks and 9 patients (12,2%) between 4 to 6 weeks. In 34 patients (45,9%) the period was longer than 6 weeks.

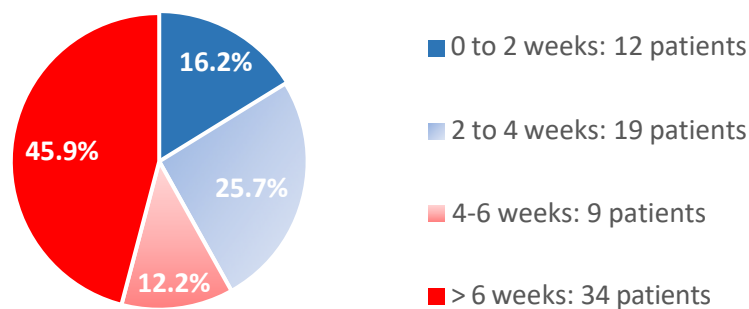


Figure 10: Transfer time from health centers to hospitals

Out of 74 patients, 24 (32.4%) sought treatment from traditional healers before seeking medical care.

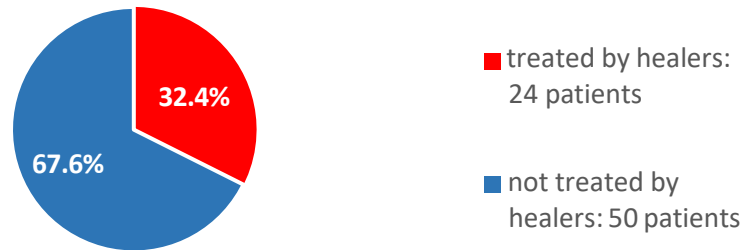


Figure 11: Treatment by traditional healers before transfer to district hospitals

By traditional healers two patients (8,3%) were treated up to 10 weeks, 6 patients (25%) up to 20 weeks and 9 patients (37,5%) up to 30 weeks. The remaining cases of 7 patients (29,2%) were treated for longer than 30 weeks.

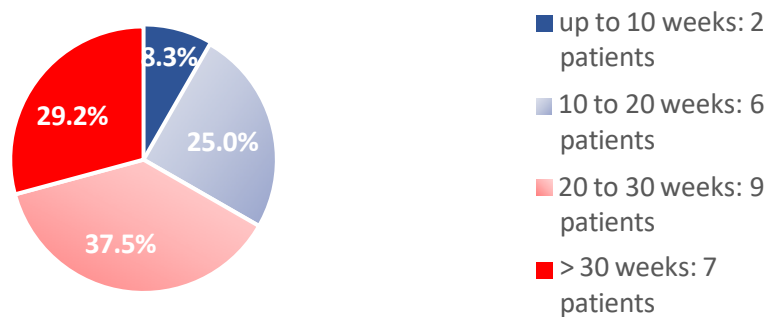


Figure 12: Treatment-time by traditional healers before transfer to district hospitals

Of the group of 74 patients 9 patients (12,2%) suffered from acute osteomyelitis and 65 patients (87,8%) suffered from chronic osteomyelitis.

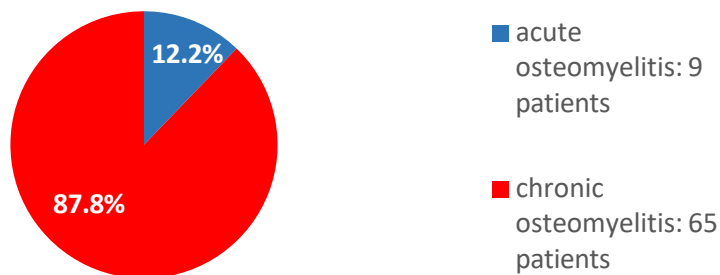


Figure 13: Distribution of acute and chronic osteomyelitis

2. Qualitative analysis

a) Interviews with nurses from health centers

- What experiences have you had with osteomyelitis in this healthcare setting?

Summary of answers: The findings from the in-depth interviews among nurses working in health centers highlight the significant impact of osteomyelitis as a serious health threat in the community. One nurse stated, *“Osteomyelitis is a serious health threat in our community! It attacks the bone and generally you don’t see it at the beginning, which makes patients coming too late to seek health care.”*

This opinion has been shared by others, highlighting that osteomyelitis often goes unrecognized in its early stages, leading to delayed health care-seeking behavior in patients. Six out of eight respondents said there are numerous cases of osteomyelitis in the community, with patients sometimes waiting until their condition worsens before seeking medical attention.

Nurses expressed difficulties in managing osteomyelitis cases, particularly regarding wound healing, even after referral to hospitals. The lack of a systematic reporting system was seen as a barrier to understanding the true extent of the problem. Despite efforts to provide primary care, including wound care, nurses expressed concerns about the lack of specific data on osteomyelitis cases.

They emphasized that osteomyelitis significantly affects patients’ lives, causes disability and affects their ability to work. Nurses also noted that cases of osteomyelitis are commonly seen in younger age groups, particularly those under 15 years old.

- When do you suspect osteomyelitis?

Summary of answers: Regarding the suspicion of osteomyelitis, nurses primarily rely on signs and symptoms such as swelling, sweating wounds, fever, and un-healing wounds, as expressed by one who stated, *“We base on signs and symptoms, namely swelling, sweating wounds, fever, un-healing wounds after a long-time suffering, etc.”*

Another nurse mentioned that suspicion arises when a wound is treated for about seven days without signs of healing, which leads to a referral due to uncertainty about the underlying cause.

They recognise osteomyelitis cases based on observable features such as fistulation, abscess or swelling. Suspicion becomes even greater when patients come to health centers with wounds of unknown origin and dressings fail to show progress over time. Severe inflammation reported by patients also raises suspicion of osteomyelitis

- What factors do you think are associated with osteomyelitis?

Summary of answers: According to many nurses, there are a variety of reasons that lead to delays in seeking medical care.

One nurse emphasized, *“Most of the patients we receive have infected wounds. They come after they waited for so long, some have been using traditional medication, others think that it is from poison by their enemies, and then they come when they find the situation worsening.”*

This sentiment highlights the complex interplay of cultural beliefs and delayed healthcare seeking behaviours that contribute to the development of advanced cases of osteomyelitis. Three out of eight nurses expressed frustration that patients stopped seeking medical care after the first treatment and instead opted for traditional remedies.

In addition, challenges arise from the health system response, including delays and lack of thorough evaluation when patients are referred between health facilities.

Transportation barriers further complicate access to timely care, particularly for patients who must travel long distances to health centers or hospitals. Malnutrition and weakened immunity, especially in children and young adults, are considered risk factors for osteomyelitis.

- Where do you see deficiencies in the treatment of osteomyelitis?

Summary of answers: The nurses at health center level complain that osteomyelitis treatment in hospitals is not properly managed. One nurse complained, *“You know, even when we suspect osteomyelitis on time, like children with high fever and swelling or abscess, honestly the hospital doesn’t help them much! They look at the case without a proper examination and just send them back to health center for wound dressing and continue antibiotics.”*

- How could osteomyelitis treatment be improved?

Summary of answers: Nurses’ perspectives shed light on several critical issues that need to be considered for better osteomyelitis management at both the health facilities and community levels.

One nurse emphasized: *“There is no follow-up at the community level and osteomyelitis is not considered a major health problem at various levels of the healthcare system.”*

Another nurse pointed out the challenges at the health centers, explaining: *“Of course, in the health center there is a lack of knowledge necessary to make a diagnosis or even raise a suspicion.”*

Additionally, there is consensus among the nurses at health centers about the critical role of hospitals in the treatment of osteomyelitis. One nurse expressed, *“It is very disappointing when they fail to diagnose and treat the patient properly.”*

- Which intervention at health center and community level could prevent osteomyelitis?

Summary of answers: Nurses highlighted several important interventions needed for early detection of osteomyelitis at both health center and community levels. They emphasised the urgent need for comprehensive training programs for nurses and community health workers necessary for recognising and reporting osteomyelitis. One nurse emphasised, *“We must have sufficient knowledge and skills among health center staff to recognize and treat osteomyelitis.”*

In addition, there was agreement that the hospital plays a crucial role in the diagnosis and treatment of osteomyelitis, followed by the health center staff who ensure continuity of treatment and follow-up care.

However, it was noted that there is currently no education and training conducted at any level.

- What is needed for early detection and better management of osteomyelitis?

Summary of answers: Nurses highlighted several needs to improve early detection, better treatment, education, and community-based follow-up of osteomyelitis cases. One nurse emphasized: *“We do not have enough knowledge about osteomyelitis: we delay suspecting the disease because we are not trained.”*

They emphasised the lack of sufficient knowledge and training among healthcare staff, leading to delays in diagnosing the disease. To address this problem, they called for help for earlier treatment.

In addition, great emphasis was placed on the need for regular training to improve the competency level of all healthcare providers.

Moreover, nurses emphasized the importance of decentralised services for the treatment of osteomyelitis, which, in addition to hospitals, allow the prescription of necessary medications and follow-up care at health centers. They also emphasised the need to provide various aids and instruments for osteomyelitis treatment in health centers and to train staff in their proper use.

b) Interviews with patients/parents

- How was the development of your osteomyelitis disease?

Summary of answers: Responses from patients and parents regarding the duration and onset of osteomyelitis varied widely, with durations ranging from one year to as long as ten years. One parent mentioned, *“The child has been suffering from osteomyelitis for one year. The disease originated from physical injury caused by someone who bit the child a lot. My leg got swollen and this*

lasted one week.” Another parent stated, *“For two years ago, it started by a small abscess that took a year and the whole leg got swollen.”*

- Why did you get osteomyelitis?

Summary of answers: The respondents identified various risk factors or causes for the onset of osteomyelitis. One parent mentioned, *“The diseases came on their own, we don’t know the reason why it came. Some people were telling us that it may have been caused by a snake bit.”* Another parent stated, *“The disease came as a such! I cannot explain the reason or any risk factor behind.”*

- Do you know other people suffering from osteomyelitis?

Summary of answers: Some stated they did not know anyone else suffering from the disease, while others mentioned acquaintances or neighbours who had been affected. One respondent shared, *“Yes, I know someone from my neighbours suffering from osteomyelitis.”*

- Did you use traditional medicine?

Summary of answers: The respondents sought treatments for osteomyelitis primarily in formal healthcare facilities, such as health centers and hospitals. However, some individuals also mentioned attempts to use traditional medicine before seeking professional medical care. One respondent stated, *“Meanwhile a Jehovah-witness put me on traditional medication, but it did not work.”* Another mentioned, *“I consulted the traditional healer for two weeks before consulting the nearest facility.”*

- When did you look for help in a health center?

Summary of answers: The duration of time individuals waited before consulting a health center varied among the respondents. Some looked for medical care promptly, with one respondent mentioning, *“It took just one day and immediately went to the health center.”* In contrast, others experienced delays, such as one respondent who stated, *“It took nine years before we consulted the health center.”*

- What are your health center experiences?

Summary of answers: The assistance provided at the health center varied among respondents, with some receiving immediate referral to a hospital, while others underwent treatment at the health center itself. One respondent mentioned, *“It took two days, and we were immediately referred to the hospital.”*

However, challenges such as financial constraints hindered some individuals from seeking further treatment, as illustrated by a respondent who stated, *“It is now very swollen, and we are not capable to go back to the hospital because we don’t have money.”*

- How was your disease treated?

Summary of answers: In the hospital, respondents received various forms of treatment, including surgeries and medications. One respondent mentioned, *“I have been operated and have some medicine for 1 month.”* Another respondent stated, *“Yes, I have consultation accompanied with radiological investigation, later followed by surgery.”*

Despite receiving treatment, some individuals expressed challenges, such as financial constraints and difficulties in accessing follow-up care.

- Which problems arose in the search for treatment?

Summary of answers: The responses from patients and parents highlighted various challenges encountered while seeking healthcare for osteomyelitis.

One individual expressed financial constraints, stating, *“We are poor, we cannot go back to the hospital for check-up, since it requires paying for public transport, and we are not capable of finding the money.”* Another emphasised delays in treatment, citing concerns that the disease wasn’t taken seriously until it became irreversible due to financial limitations.

Social stigma and discrimination were also mentioned, with one respondent recalling, *“We were forgotten by family members, and they stigmatised and discriminated against us a lot.”*

Financial instability and lack of medical insurance were common themes, as expressed by another respondent: *“We did not have medical insurance, without food, many issues.”*

II. Phase II: Development and implementation of the prevention program at community and primary healthcare levels.

1. Scoping review of the literature about osteomyelitis prevention programs.

The scoping review was conducted to investigate the literature on the existence and implementation of intervention models for preventing chronic osteomyelitis. Specifically, the scoping review sought to answer the following research questions:

Does a community intervention model exist for early detection of osteomyelitis to prevent chronic osteomyelitis in low-resource settings?

A total of 284 articles were identified through the initial database search. After screening titles and abstracts for relevance 53 articles were selected for full-text assessment. The need for community-based intervention program was discussed in 5 of the selected articles (Arowosegbe et al., 2021; Edmond & Wenzel, 2014; Mulualem et al., 2023; Schaffer et al., 2022; Singh et al., 2017). The authors of these 5 papers are optimistic that a community-based intervention model could be beneficial in preventing chronic osteomyelitis.

The scoping review did not reveal any existing community intervention program for early detection of osteomyelitis. There were, however, recommendations made for designing an intervention model for preventing chronic osteomyelitis. A range of strategies such as health education, awareness campaigns, community-based screening programs, and improvements in healthcare infrastructure were recommended. Integration of osteomyelitis prevention measures into existing primary healthcare services, including training of healthcare providers and provision of essential medical supplies was suggested (Edmond & Wenzel, 2015)

2. Development of the chronic osteomyelitis prevention program

A comprehensive workshop was conducted in April 2021, involving medical and public health professionals to provide medical knowledge and public health experience in planning the intervention model. The group was composed of eleven people: 3 orthopaedic surgeons from Germany, 1 orthopaedic surgeon, 2 general surgeons and 3 nurses from Kibogora Hospital and 1 expert in public health from Kibogora Polytechnic university.

The resulting conceptual model for the prevention program focused on three main areas: knowledge improvement, raising public awareness, and improving cooperation between hospitals and health centers.

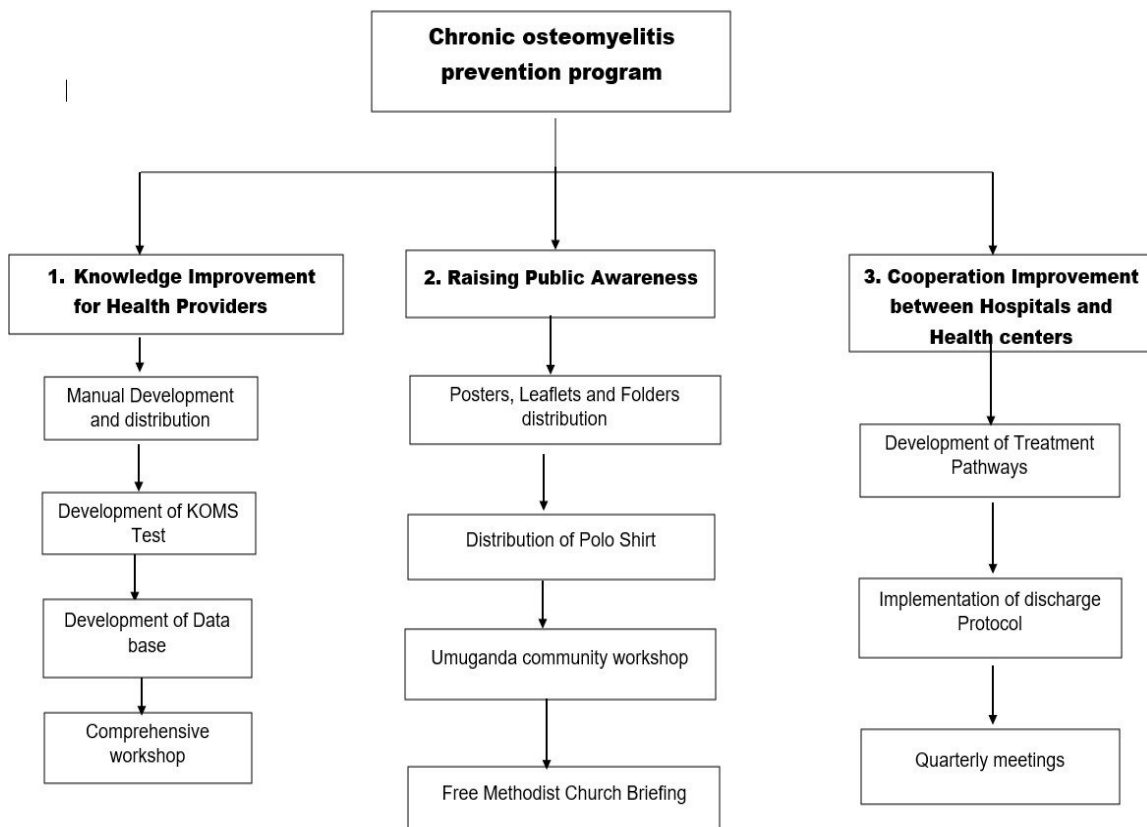


Figure 14: Structure of the developed chronic osteomyelitis prevention program

At the same time, it was decided to set up a comprehensive database to monitor the ongoing implementation process. This should create the opportunity to make any necessary adjustments during the project implementation. In addition, the database should provide the basis for the final project evaluation. The prevention program was to be implemented on a pilot basis in the Nyamasheke District and the results were to be presented to the Rwandan Ministry of Health after evaluation.

Data collectors were appointed at the hospitals in Kibogora and Bushenge to enter the data into the Excel file. Data manager at Bushenge Hospital forwarded the data to the data manager at Kibogora Hospital, who merged all the data. The data manager at Kibogora Hospital was also responsible for data analysis.

From May 1, 2021, to June 30, 2023, a total of 256 patients with a confirmed diagnosis of osteomyelitis were included in the database.

a) Development of training materials to improve knowledge of healthcare providers

To improve knowledge of healthcare providers in Nyamasheke District special training materials were developed about early detection and treatment. This included a Manual on comprehensive knowledge of osteomyelitis and a special Kibogora Osteomyelitis Screening Test (KOMS-Test).

A 15-pages Manual was written in English and translated in Kinyarwanda. The Manual contains the basic knowledge on osteomyelitis serving as a foundational resource to improve knowledge and skills of primary healthcare providers. In the Manual integrated is a classification of osteomyelitis.

The classification of osteomyelitis included in the Manual aims to improve comprehensive understanding and knowledge development in the low-resource setting area. Therefore, the classification is based on clinical signs, simple, applicable, and easily understandable. For these reasons, the classification of the Comprehensive Rehabilitation Services in Uganda (CoRSU) was selected (not published, personal noted).

According to this classification, osteomyelitis is categorised as acute if no changes on the bones are evident on the x-ray. Osteomyelitis with abscess is also classified as acute if the x-ray remains inconspicuous. However, if there are visible bone changes, it is categorised as chronic osteomyelitis.

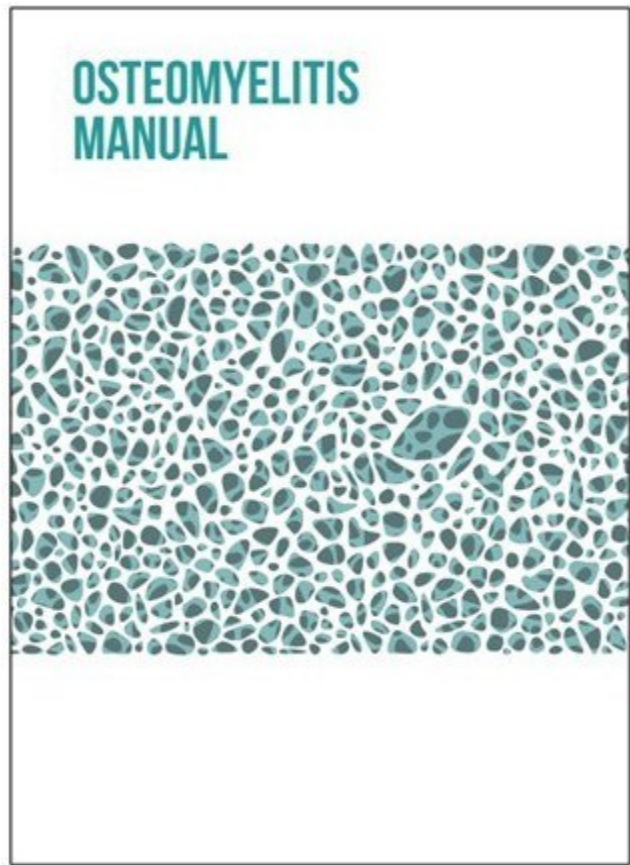
Acute osteomyelitis: clinical signs: pain, swelling, overheating, fever. x-ray is inconspicuous.

Chronic osteomyelitis: The CoRSU classification further distinguishes three degrees of chronic osteomyelitis: simple, difficult, and complex according to the x-ray changes.

- Simple: well-defined sequestrum with well-developed involucrum
- Difficult: absence of well-defined sequestrum, presence of multiple erosions and osteolytic bone cavities
- Complex: pathological fractures, septic arthritis, axial deformation, pseudarthrosis, and significant bone substance loss

The CoRSU classification was valuable for guiding therapeutic decisions, often involving surgical interventions.

- Simple: sequestrectomy, operable with a tourniquet, good chance of healing without recurrence
- Difficult: not operable with a tourniquet, may require blood transfusion, involves multifocal osteomyelitis, high risk of recurrence
- Complex: requires bone reconstruction



IGITABO – INDWARA YO KUMUNGWA KW’AMAGUFA (OSTEOMYELITIS)

1. EPIDEMIOLOJI

Indwara yo kumungwa kw’amagufa ikabije yandura binyuze mu maraso

- Imiterere y’igufwa rirwaye
- Amakuru ku burwayi
- Ibyiciro Byibimenyetso
- Gusuzuma
- Ubuvuzi
- Indwara ko kumungwa kw’amagufwa mu bana batarengeje ukwezi kumwe

Indwara yo kumungwa kw’amagufa ya karande

- Ibimenyetso
- Gusuzuma
- Ubwoko (Ibyiciro)
- Ukuvura gukwiye tugendeye ku bwoko

INDWARA YO KUMUNGWA KW’AMAGUFA IKABIJE YANDURA BINYUZE MU MARASO

1. IBIRANGA IMITERERE Y’IGUFA

Amezi 1 kugeza kuri 18 y’amavuko:
Imitsi itwara amaraso yambukiranya igufa ikagera mu ngingo. Bituma hireka amashyira mu ruringo.

Amezi 19 kugeza kumyaka 15:
Imitsi ntabwo yambukiranya cyeretse mu rutugu no mw’itako. Hashobora kwireka amshyira.

Imyaka 15 kugeza 16:
Inzira zose zirifunga. Izindi ngingo zose zirashobora kugira uburwayi.

2. AMAKURU KU BURWAYI

Gufatwa gutunguranye, kumva utameze neza mu mubiri, umuriro, ububabare, bishobora guterwaugukomereka byoroheje kurwara mu myanya y’ubuhumekero, umuha, umusonga.

IBIMENYETSO BY’ INDWARA YO KUMUNGWA KW’AMAGUFA
<ul style="list-style-type: none"> • Umuriro mwinshi • Kumva utamerewe neza mu mubiri • Kubabara • Kubabara mu magufwa • Muri rusange ububabare bw’amagufwa • Kubabara urimo gukoresha ururingo • Kubyimba kw’ingingo • Kubyimba kw’umubiri • Gushisha kw’umubiri • Kubabara bagukozeho • Gushyuhirana gukabije mu maboko n’amaguru • Ubwiyongere bukabije bwibimenyetso by’ubwirinzi mu maraso • Kwiyongera kwa CRP

(Unfallchirurg/ Trauma surgeon 1998 101:662-673)

3. IBYICIRO BYIBIMENYETSO

Icyiciro cya I:
Icyiciro cyo kubyimba k’umusokoro wo mumagufa: Ububabare buhoraho, bukabije. Umwana arashobora kwerekana aho ububabare buri kuko bwumvikanira kuruhu mugihe uhakanze. Mubisanzwe buhuye nu mwanya c igice cy’ amagufwa cyanduye. Kuri iki cyiciro umwana abagishobora kugenda kandi nta bimenyetso by’ubwandu bigaragarira hanze y’umubiri.

Figure 15: Excerpt from the Osteomyelitis Manual

About 150 copies were printed and distributed during the training sessions to the two hospitals and all health centers in Nyamasheke District

The Kibogora Osteomyelitis Screening Test (KOMS-Test) was developed to help health professionals to recognise osteomyelitis, especially in low-resource settings based only on clinical signs. The KOMS-Test is a tool that facilitates a preliminary differentiation between acute and chronic osteomyelitis based on straightforward clinical assessments. With the help of the KOMS-Test, nurses are able to identify whether antibiotic therapy is sufficient or require immediate referral to Kibogora Hospital.

Initially, nurses assess whether patients have experienced a trauma; if not, they proceed with the KOMS-Test. Nurses record the score based on symptoms and clinical signs reported by patients. The test comprises 60 points split into two groups: Group 1 and Group 2. After calculating the score, three decisions are possible:

- Group 1 scores (2 to 7 points): re-evaluation in 7 days
- Group 1 scores (10 to 17 points): prescribe antibiotics for 3 weeks and schedule a re-evaluation
- Group 2 scores: immediate hospital admission is recommended for any symptoms falling into this group

Of 100 patients who came to Kibogora Hospital with a positive KOMS test, 97 patients were confirmed to have osteomyelitis.

These results demonstrate that the KOMS test effectively identifies individuals with osteomyelitis and is a reliable and valuable screening tool for the detection of osteomyelitis.

**KIBOGORA HOSPITAL
OSTEOMYELITIS SCREENING-TEST (KOMS-TEST)** Date :

Name : First Name:

Date of birth:

First view		
1 st follow up		
2 nd follow up		
3 rd follow up		

GROUP 1

SYMPTOMS	POINTS	PATIENT
General feeling of discomfort	2	
Local overheating of extremities without trauma	5	
Local overheating of extremities with trauma	0	
Local pain in arm or leg without trauma	5	
Local pain in arm or leg with trauma	0	
Local swelling arm or leg without trauma	5	
Local swelling arm or leg with trauma	0	
SUBTOTAL	17	
2 to 7 points: Re-Evaluation in 7 days		
10 to 17 points: antibiotics for 3 weeks, then Re-Evaluation		

GROUP 2

SYMPTOMS	POINTS	PATIENT
Fever	7	
Non healing wound	6	
Secreting fistula	10	
Exposed bone	10	
Fracture without trauma	10	
SUBTOTAL	43	
any Symptom of the red group 2 : IMMEDIATE admission to Hospital		

TOTAL	60	
0 points: treatment finished		

Remarks:

Figure 16: KOMS-Test

One thousand copies of the KOMS-Test were printed and distributed to all hospitals and health centers in Nyamasheke District.

b) Development of training materials to raise awareness

To raise public awareness a variety of training materials were developed for distribution to people in the community of Nyamasheke District. These materials encompassed leaflets, banners, folders and polo shirts, each designed to provide comprehensive information. Each piece of training material included key information and pictograms highlighting the early signs and symptoms of osteomyelitis.

The posters and leaflets show simple, easy-to-understand pictograms with clinical findings as an image, each pictogram was also provided with the text for

the clinical sign. Pictograms showed the four main clinical signs such as pain, swelling, overheating and fever. The posters and leaflets were printed with the advice to think of osteomyelitis in the case of these clinical signs and to visit a health center.



Figure 17: Poster, leaflets

A total of 5,000 leaflets were distributed across the community. Posters were produced in both English and Kinyarwanda, in various sizes to ensure visibility and reach. Specifically, 4 posters in size A0, 70 posters in size A1, 30 posters in size A2, and 40 posters in size A3 were designed. Additionally, five large banners were produced. These materials were strategically placed in two hospitals, as well as in health centers and health posts, to maximize exposure and engagement.

Folders in the same design as the posters filled with information material were distributed to nurses in health centers and also to community health workers.



Figure 18: Folder with training materials



Figure 19: Folder with training materials

A total of 2,500 training folders in Kinyarwanda were produced and distributed.

The community health workers were each given a polo shirt with the clinical signs of acute osteomyelitis printed on the back of the shirt. These pictograms have so far been used in all training materials such as flyers, posters and folders. The 2,300 polo shirts are worn by community workers during training and on the way from the villages and hamlets to the health centers.

The symbols have a high recognition value, and the simple and easy-to-understand pictograms help to raise awareness among the population in the communities and villages.



Figure 20: Polo shirts



Figure 21: Pictograms on Polo shirts

A total of 2,300 Polo shirts were given to the community health workers.

c) Development of materials to improve cooperation between hospitals and health centers

For improving cooperation between hospitals and health centers special pathways were developed. These pathways served as a guiding framework for healthcare professionals.

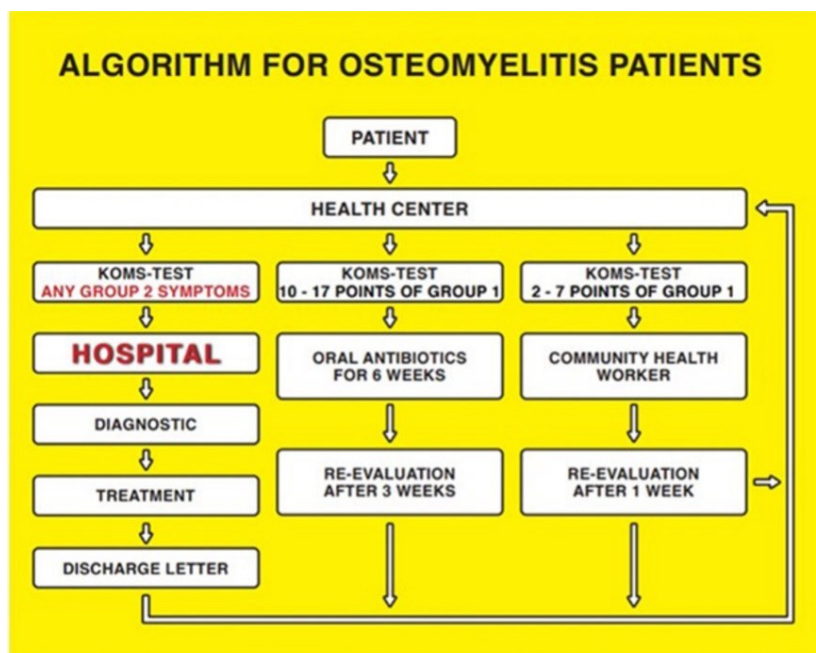


Figure 22: Treatment pathway for hospitals in Kibogora and Bushenge

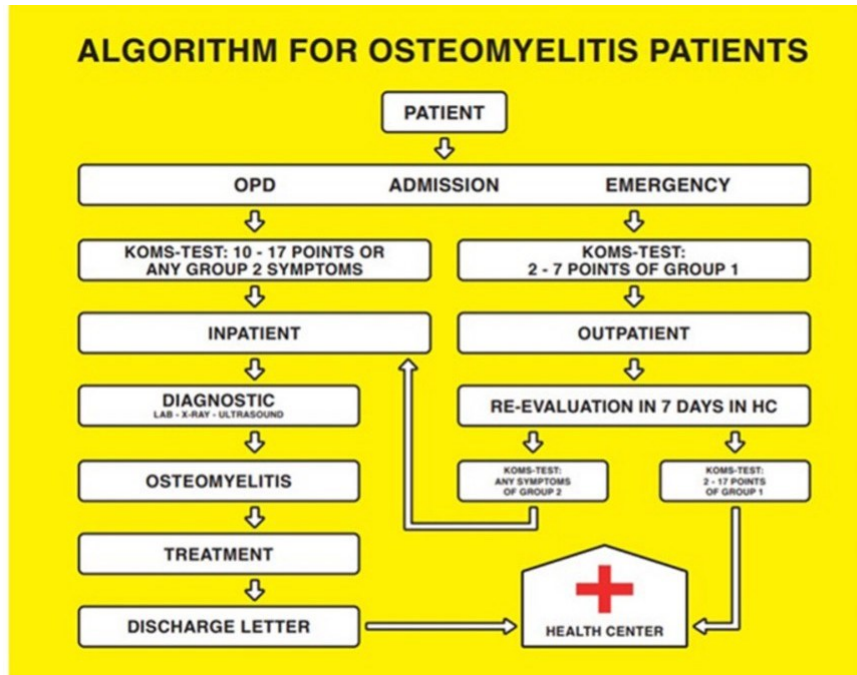


Figure 23: Treatment pathway for health centers

Follow-up care for osteomyelitis patients in hospitals includes the issuing of a detailed discharge letter. This letter was drafted to guide nurses at health centers and community health workers in promoting continuity of care. It should contain essential patient information such as demographics, treatment duration, diagnosis, prescribed therapy, follow-up treatment plan, medications, and details of the follow-up appointment.

The community health worker responsible at Kibogora Hospital communicates the next steps to the patient’s local community health worker upon discharge. Additionally, the patient’s follow-up appointment for osteomyelitis consultation must be scheduled and documented in the consultation calendar.

The review showed that the discharge letter had a high level of acceptance. A discharge letter was given to 98% of the patients.

**Kibogora Hospital
Surgery**

**Discharge Letter
for**

Family name:
First name:
Date of birth:
Residence:
Admitted from _____ to _____

Diagnosis:

Therapy:

Follow up treatment:

Medication:

Date of follow up:

Signature Physician

Figure 24: Discharge letter

3. Implementation of the prevention program in Nyamasheke district

a) Training of healthcare providers to improve knowledge

After all training materials had been created, all doctors, nurses in Kibogora and Bushenge Hospitals, nurses working at health centers and health posts as well as community health workers in the Nyamasheke District received multiple trainings.



Figure 25: Training of community health workers

For community health workers, the knowledge transfer focused mainly on basic clinical signs such as: pain, swelling, overheating and fever. Easy-to-understand training materials were developed and handed over to the community workers in a special folder.

Nurses at health center level have received the same training on basic clinical signs as community health workers. In addition, they were trained in the use of the developed Kibogora Osteomyelitis Screening Test.



Figure 26: Training in health center

The training of hospital's staff covered the areas of clinical diagnostics as taught in the health centers. In addition, the typical findings from imaging examinations were conveyed. Emphasis was placed on the classification of osteomyelitis because therapeutic implications can be derived from the classification used. The treatment pathways were explained and strongly recommended.

In addition, a special osteomyelitis consultation was set up at Kibogora Hospital.

In the period from May 1, 2021, to June 30, 2023, almost all employees in all health facilities in Nyamasheke District were trained 3 times. A total of 7.459 people from the health facilities of the Nyamasheke District were present.

Overall, the following people took part in the multiple training sessions: 152 staff from the hospitals in Kibogora and Bushenge

1.555 nurses from all 20 health centers in Nyamasheke District

5.752 trainings of community health workers belonging to the health centers

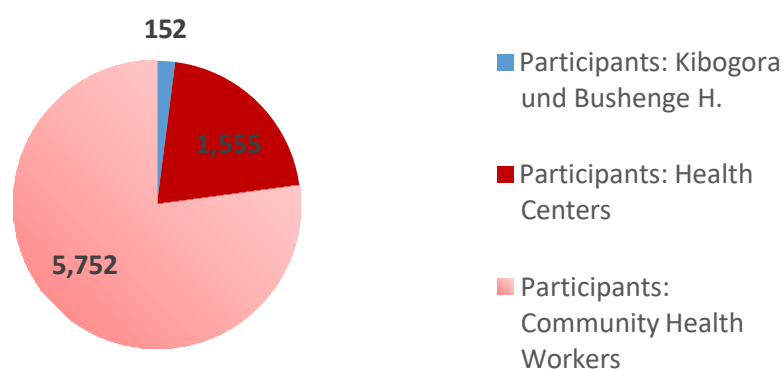


Figure 27: Number of participants in the training courses

b) Improve community awareness.

The population was sensitised by community health workers on the monthly community workdays, the “Umuganda”. On these days, community workers inform the community members about health and nutrition issues.

An additional dissemination of knowledge took place through Free Methodist Church of Rwanda. For supporting church leaders to increase the awareness of church members about osteomyelitis, a letter with key messages was designed.

This information was used to spread the message about early clinical signs and symptoms in the community.

XX. INDWARA YO KUMUNGWA KW'AMAGUFA (Chronic Osteomyelitis)

Kumugwa kw'amagufa (Osteomyelitis) ni indwara y'amagufa yibasira cyane cyane abana. Iterwa n'udukoko twa bagiteri tumunga amagufwa. Ntabwo ari indwara yandura, kandi ubushakashatsi bwagaragaje ko ku bantu 100 barwaye amagufwa 60 baba barwaye ubu burwayi bwo kumungwa kw'amagufa. Ishobora kuvurwa igakira iyo ivuwe neza kandi hakiri kare.

Ibimenyetso byayo :

- Ukubabara ukuguru cyangwa ukuboko.
- Kubyimba ahababara
- Kumva hashyushye ukozeho
- Kugira umuriro

Niba umwana wawe cyangwa uw'umuturanyi ababara ukuguru cyangwa ukuboko, habyimbye ,hashyushye kandi akagira umuriro usabwa kumwihutana kwa muganga kuko ubu burwayi bwihuta vuba bukungiza amagufa. Kuvura ubu burwayi bidatinze bizana amahirwe yo gukira kandi vuba bitagombeye kubagwa. Gutinda kwivuza bitera ubumuga ndetse byavamo no gutakaza ururingo cyangwa kubura ubuzima.

Niba umwana wawe agize umuriro abyimba kandi ababara, ihutire kumujoyana kwa muganga .

Dufate ko :

- ari indwara itandura
- ni indwara ivurwa igakira
- Kuyivuza kare bizana amahirwe yo gukira

Figure 28: Information through Free Methodist Church of Rwanda

c) Improve cooperation between healthcare providers

The developed pathways were presented in both hospitals and in all health centers. The procedures to be carried out step by step were carefully discussed with all doctors and nurses in the hospitals. The nurses in the health centers were trained in how and especially when the different treatment steps should be done depending on the result of the KOMS-Test.

In addition, quarterly meetings were planned and held at Kibogora Hospital as a central forum for multidisciplinary cooperation between doctors from both hospitals and senior nurses from all health centers and representatives of community health workers from both hospitals.

The participants discussed the progress of the project and discussed suggestions for optimising the ongoing implementation process. As a result of these discussions, the KOMS-Test was adapted in order to enable the health centers to improve the range of therapies.

III. Phase III: Monitoring and evaluation of the early detection program

1. Patient collective

Between May 1, 2021, and June 30, 2023, 256 patients were presented to Kibogora Hospital for treatment of osteomyelitis. The data from these 256 patients were recorded in a database and analysed according to gender, age, residency and severity of the disease.

Gender distribution among the 256 cases showed 158 males, accounting for 61,7% of the cases, and 98 females comprising 38,3%.

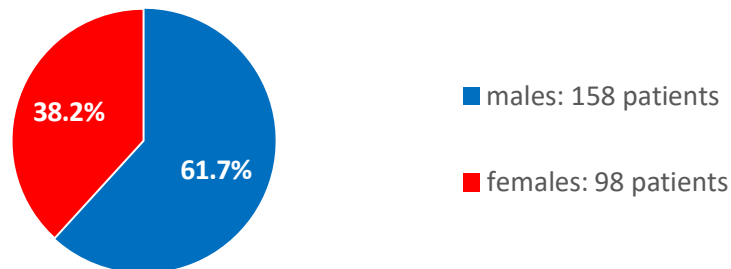


Figure 29: Gender Distribution

The age distribution of all 256 patients varied, with 22% of patients ranging between 1 to 10 years old, 36 % of patients between 11 to 20 years old, 17% in the range of 21 to 30 years, 25 % were older than 30 years.

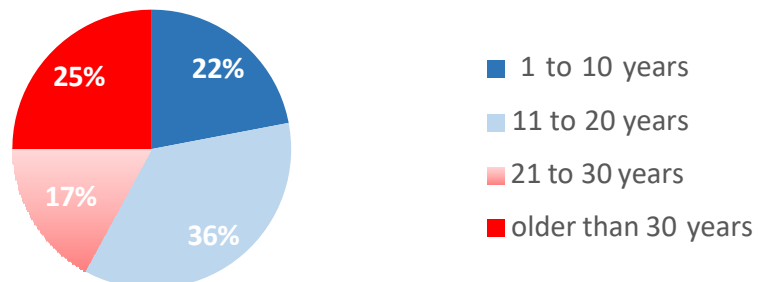


Figure 30: Age distribution of 256 patients

Of the 256 patients 225 (87,9%) patients lived in rural areas, while 31 (12,1%) patients resided in urban areas.

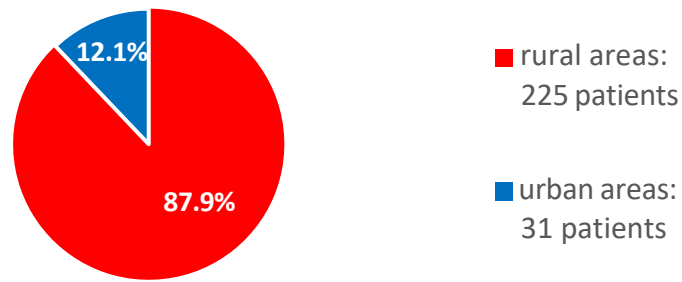


Figure 31: Residency

2. Diagnosis of all patients

Acute osteomyelitis was diagnosed in 128 patients (50%), the remaining 128 patients were already chronic.

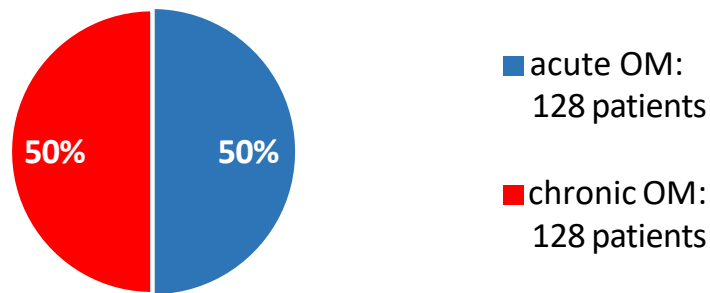


Figure 32: Patients treated at Kibogora Hospital for osteomyelitis between May 1, 2021, and June 30, 2023

a) Division by districts: Nyamasheke District - neighboring districts

Of the group of 256 patients, 172 came from Nyamasheke District and 84 patients came from other districts. Therefore, to evaluate the effectiveness of the program, 2 groups were formed.

The first group only included patients from Nyamasheke District. In Nyamasheke District, all employees from all health facilities were trained. Therefore, patients from Nyamasheke District could benefit from the early detection and prevention program for osteomyelitis.

The second group included patients who were not from Nyamasheke District. Outside of Nyamasheke District, the staff in the health facilities were not trained. Therefore, the early detection and prevention program had no influence on the time of diagnosis of osteomyelitis.

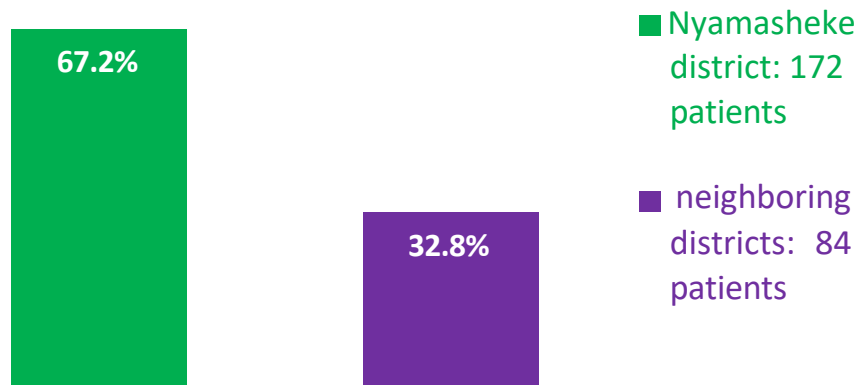


Figure 33: Osteomyelitis patients coming from Nyamasheke District or neighboring districts (total 256 patients)

b) Acute and chronic osteomyelitis depending on the district

Patients from Nyamasheke District had a higher proportion of acute cases compared to chronic cases. In the Nyamasheke group of 172 patients 101 patients (58.7%) of patients had an acute osteomyelitis. Chronic osteomyelitis was diagnosed in 71 patients (41.3%). In the group of 84 patients who came from neighboring districts in whom health facility staff were not trained, 27 patients (32,1%) suffered from acute osteomyelitis and 57 patients (67,9%) suffered from chronic osteomyelitis.

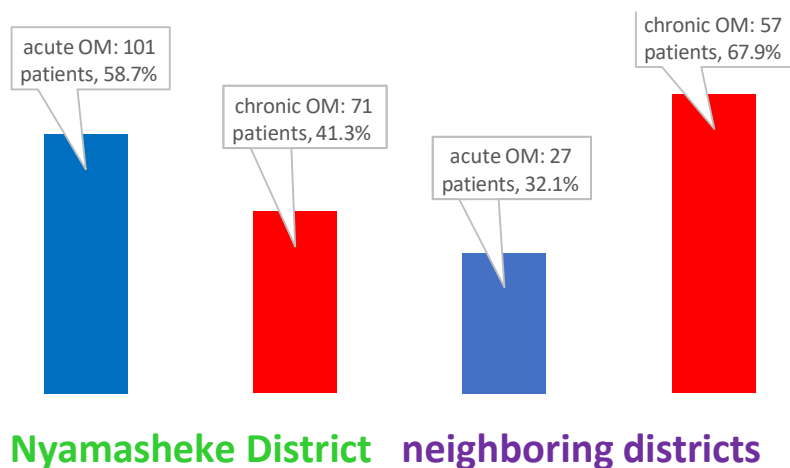


Figure 34: Acute and chronic osteomyelitis depending on the district

c) Significance

The difference between the distribution of acute and chronic osteomyelitis cases from patients who came from Nyamasheke District compared to patients who did not come from Nyamasheke District is significant. The statistical analysis revealed a chi-square (χ^2) = 5.23, and p-value less than 0.001

d) Incidence of osteomyelitis in Nyamasheke District

Between May 1, 2021, and June 30, 2023, 172 osteomyelitis cases from Nyamasheke District (83 new cases in one year) were recorded in the database at Kibogora hospital. The incidence in Nyamasheke District with a population of 434,121 is therefore 19.1 per 100,000 people per year.

3. Acute Osteomyelitis

The age distribution among the 128 patients diagnosed with acute osteomyelitis shows that 77 patients (60.2%) were under 20 years old, while 51 patients (39.8%) patients were over 20 years old.

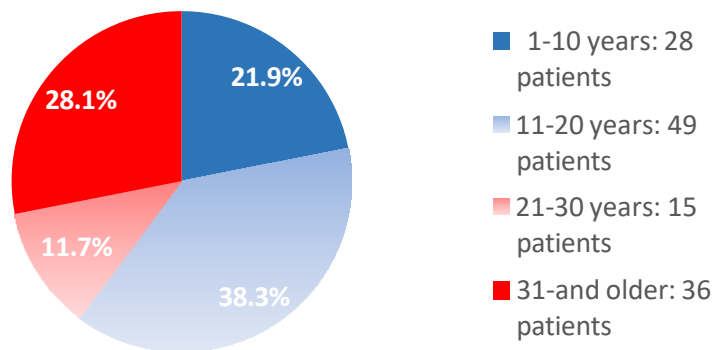


Figure 35: Age distribution of all 128 patients with acute osteomyelitis

Of 128 patients diagnosed with acute osteomyelitis, 15 patients developed chronic osteomyelitis during the course of the disease. This means that 87,5% of diagnosed and treated acute osteomyelitis cases healed completely with simple treatment methods and 11,7% of all acute osteomyelitis developed chronic osteomyelitis later. One patient was misdiagnosed.

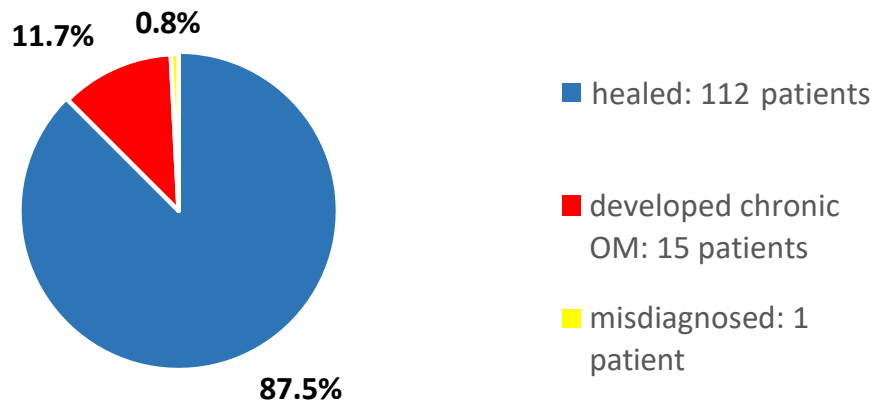


Figure 36: Healing process of all patients with acute osteomyelitis

Of the group of 128 patients suffering from acute osteomyelitis 30 patients were randomly selected from the database and clinically and radiologically examined in the period from July 17th to 21st, 2023, at Kibogora Hospital. In 85% of the patients examined, the osteomyelitis healed without sequelae, while 15% of the patients developed a chronic osteomyelitis.

a) Healing process of acute osteomyelitis with and without abscess

To clarify the question of whether the healing process depends on local abscess formation or not, the group of 128 patients with acute osteomyelitis was divided into two subgroups, one without an abscess formation (38 patients) and another with an abscess formation (90 patients).

Out of 38 patients diagnosed with acute osteomyelitis without an abscess, the data reveals that 34 patients healed completely (89.5%), while 4 cases progressed to chronic osteomyelitis.

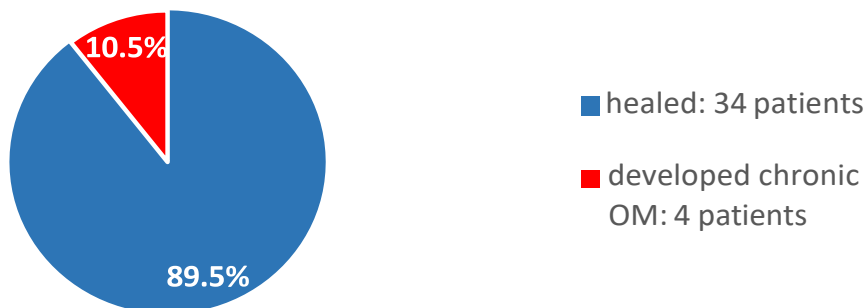


Figure 37: Healing process of 38 patients with acute osteomyelitis without abscess

Of the 90 patients initially diagnosed with acute osteomyelitis and with abscess formation, complete healing occurred in 78 patients (86,7%), whereas in 11 patients (12,2%) acute osteomyelitis progressed to chronic osteomyelitis. One patient was excluded due to an incorrect initial diagnosis.

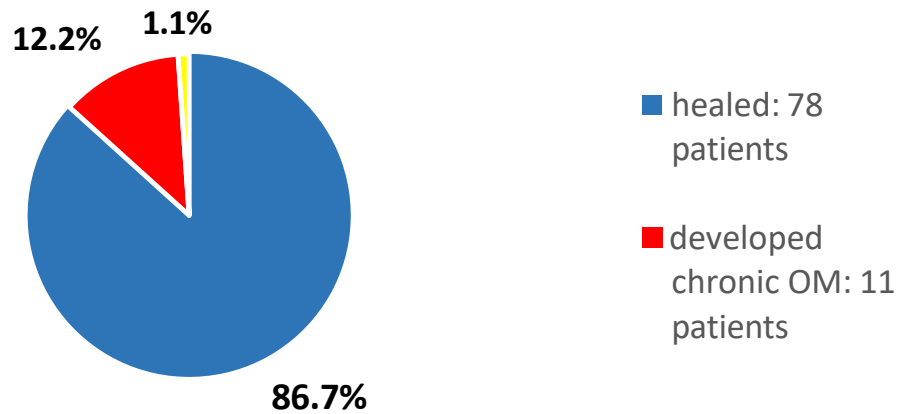


Figure 38: Healing process of 90 patients with acute osteomyelitis and abscess

4. Chronic Osteomyelitis

Of the group of 256 patients, 128 patients with a diagnosis of chronic osteomyelitis were classified into various degrees of severity. Simple chronic cases were detected in 54 patients, 62 already had difficult forms of osteomyelitis and 12 patients developed a chronic complex.

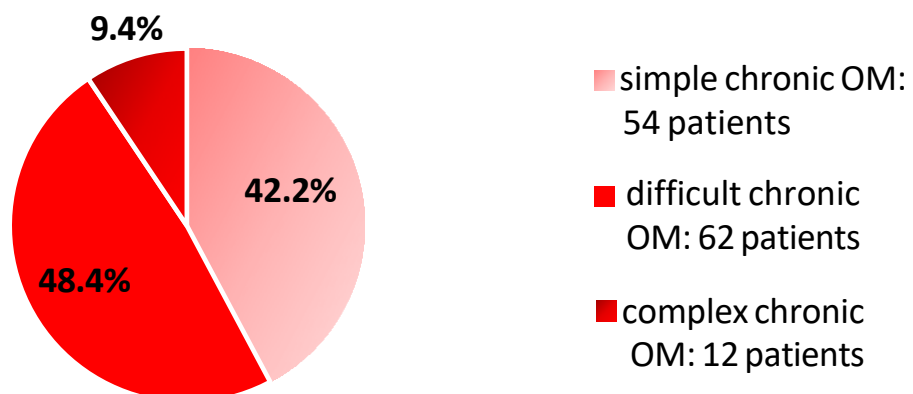


Figure 39: Different degrees of chronic osteomyelitis among the 128 patients.

Of particular importance in terms of treatment are difficult and complex cases of osteomyelitis. These were therefore grouped together and differentiated according to origin.

In the Nyamasheke group with 172 patients suffering from osteomyelitis 39 patients (22,7%) had difficult or complex cases of chronic osteomyelitis. In the group of 84 patients from neighboring districts, 35 patients (42%) had difficult or complex chronic osteomyelitis.

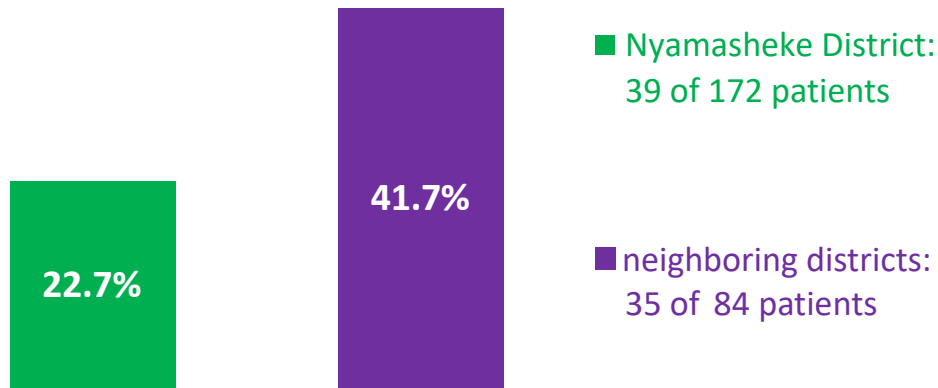


Figure 40: Chronic difficult and chronic complex cases in Nyamasheke District and neighboring districts.

Among the 172 patients with osteomyelitis from Nyamasheke District, 29 (16,8%) required a second hospitalization during their treatment course. In contrast, of the patients from outside Nyamasheke District 35 (29,8%) required a second hospitalization.

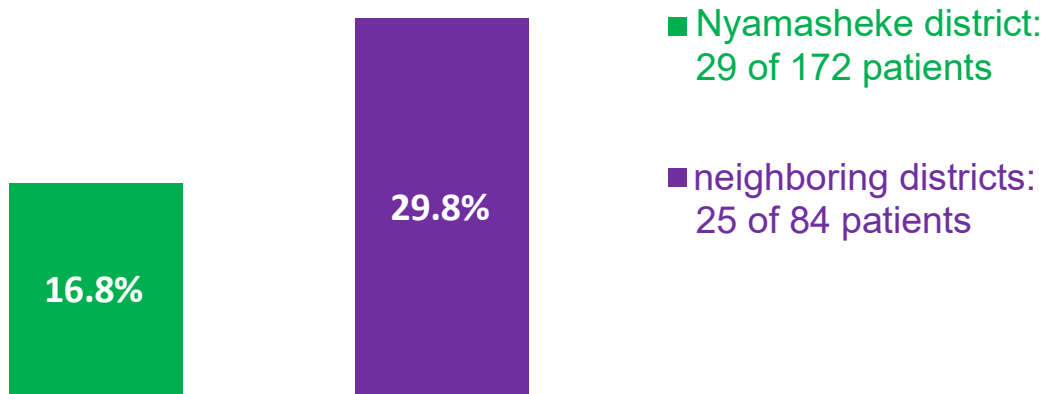


Figure 41: Need of second hospitalisation of patients coming from Nyamasheke District and neighboring districts

Similarly, 2,3% of patients coming from Nyamasheke District needed a third hospitalisation while patients coming from outside Nyamasheke District 3.6% required a third hospitalisation.

5. Impact of the prevention program

The main goal of the presented work was to reduce the high rate of chronic osteomyelitis. To detect osteomyelitis early in rural Rwanda a three-phase public health project was planned, developed, implemented, and evaluated.

The most important question to evaluate the program is whether the prevention program reduced the rate of chronic cases. The question can be answered by comparing the rate of acute and chronic osteomyelitis in Nyamasheke District before and after the implementation of the prevention program and comparing the results with neighboring districts without prevention program.

a) Comparison of acute and chronic osteomyelitis cases in Nyamasheke District before (Phase I) and after (Phase III) project implementation.

The results of the Phase I with 74 patients suffering from osteomyelitis revealed 9 acute cases (12.1%) and 65 (87.9%) chronic cases. In Phase III of 172 patients from Nyamasheke District, 101 patients were diagnosed with acute osteomyelitis (58.7%) and 71 with chronic osteomyelitis (41.3%).

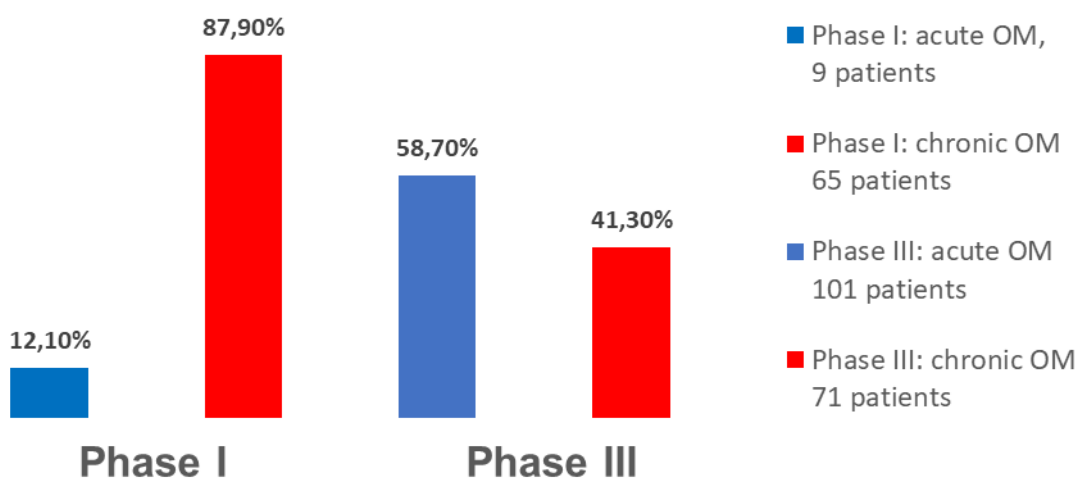


Figure 42: Acute and chronic cases; Phase I compared with Phase III

With a chi-square value of 62.34 and a p-value less than 0.001 a significant association between the variables (acute versus chronic) and the groups of Phase I and Phase III was found.

Table 2: Acute and chronic cases in Phase I and Phase III

Characteristics	Phase I		Phase III	
	Acute	Chronic	Acute	Chronic
Total	9 Pat.	65 Pat.	101 Pat.	71 Pat.
<i>The chi-square (χ^2) = 62.34, p-value < 0.001</i>				

b) Comparison of acute and chronic osteomyelitis cases in Nyamasheke District with other districts.

Phase III results show that in the Nyamasheke group of 172 patients 101 patients (58.7%) were diagnosed with acute osteomyelitis, while 71 patients (41%) were diagnosed with chronic osteomyelitis.

In the group of 84 patients from neighboring districts where health facility staff was not trained, 27 patients had acute osteomyelitis (32.1%) and 57 patients suffered from chronic osteomyelitis (67.9%).

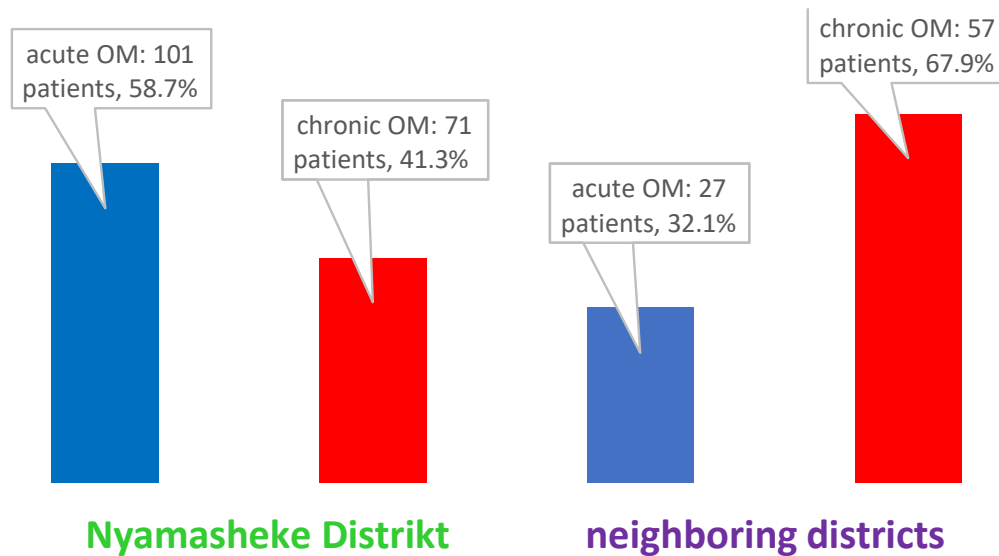


Figure 43: Acute and chronic cases in Nyamasheke District and outside Nyamasheke District

The difference between the distribution of acute and chronic osteomyelitis cases in Nyamasheke District compared to neighboring districts is significant. The statistical analysis revealed a chi-square value of 5.23, and p-value less than 0.001.

Table 3: Acute and chronic cases in Nyamasheke District and neighboring districts

Characteristics	Nyamasheke District		Neighboring districts	
	Acute	Chronic	Acute	Chronic
Total	101 Pat.	71 Pat.	27 Pat.	57 Pat.
<i>The chi-square (χ^2) = 5.23, p-value < 0.001</i>				

D. DISCUSSION

Osteomyelitis is an inflammatory process of bone and bone marrow caused by an infectious organism and leads to local bone destruction, necrosis and apposition of new bone (Callistus et al., 2015, Shirwaiker et al., 2015). Aetiology and treatment strategies depending on the clinical stage of the disease are well known and are standard medical practice. Osteomyelitis always begins acutely with nonspecific clinical signs. In this early stage, the disease can be treated by simple means or minor surgical procedures and in most cases heals completely. Untreated, after a period of 4 to 6 weeks, the disease progresses to the chronic stage with destruction of the bone and often disastrous consequences.

In many African countries, chronic osteomyelitis is a real public health problem (Callistus et al., 2015). Osteomyelitis also occurs in Rwanda. In recent years, about 90% of patients treated for osteomyelitis at Kibogora Hospital already had a chronic stage of the disease requiring severe and multiple surgical procedures.

In developed countries the disease occurs with an incidence of 8 -10 persons per 100,000 per year and can usually be cured in the early acute stage. In contrast, the incidence in developing countries is significantly higher (Jaramillo et al., 2017), with dramatic consequences for patients and significant socio-economic impacts for patients and the country. Chronic osteomyelitis can lead to social isolation as patients may be ostracized from their community (Ogunjumo, 1981).

What are the causes of the significantly high rates of chronic osteomyelitis and is there a way to reduce the rate of chronic osteomyelitis in underdeveloped areas? To investigate these questions a three-phase public health project was developed and implemented.

In Phase I, prevalence of osteomyelitis-related operations and Profile of patients with osteomyelitis were examined.

In Phase II, the project was developed and implemented to increase knowledge of healthcare providers, to raise awareness and to improve the management of osteomyelitis.

In Phase III, the results were monitored and evaluated

I. Phase I

A retrospective cross-sectional and mixed methods approach was used to obtain information on the prevalence of osteomyelitis related operations and the profile of patients with osteomyelitis operated on at Nyamasheke District hospitals in Kibogora and Bushenge were assessed.

For **quantitative analysis** data were collected from medical records of 10,305 operations performed in the two district hospitals during 2016-2020. The required sample size was calculated and resulted in 385 operations

Prevalence

Of these 385 operations 107 cases were performed for osteomyelitis, accounting for approximately 28% of all operations. Of these 107 operations 93 were performed for chronic osteomyelitis. This high prevalence of 28% underlines the great importance of osteomyelitis in Nyamasheke District. During 2016-2020, one in four operations in the district's surgical departments was performed for osteomyelitis,

Patients Profile

The assessment of the patient profile for those diagnosed with osteomyelitis was conducted among a cohort of patients undergoing surgery in hospitals within Nyamasheke District. A total of 385 surgical operations were analyzed within the same study group. The 107 operations performed for osteomyelitis were assigned to the patients. It was found that 33 patients required multiple operations for osteomyelitis. The Patients profile was analyzed in the remaining 74 patients who underwent only one operation for osteomyelitis.

Analysis of gender distribution showed that more male patients suffered from osteomyelitis and that osteomyelitis occurred most frequently in the age group up to 18 years (61%). This corresponds to Ibingira (2003) who found that in a rural setting of Uganda the highest incidence was observed in individuals aged 10 to 19 years.

Mulualem et al., 2023 also found that gender and age are significant predictors for osteomyelitis. In the study conducted by Olivier in sub-Saharan Africa in 2019, chronic osteomyelitis peaked between 10 and 21 years of age, with significantly more male than female patients (Olivier et al., 2019).

The analyses also identified lack of health insurance and living in rural areas as important predictors of osteomyelitis. In the collective of 74 patients, 12.2% had no health insurance and 78.4% lived in a rural area.

Treatment with traditional medicine proved to be another significant predictor. In the osteomyelitis group, 24 of 74 patients (32.4%) were treated by traditional healers before seeking medical help. Of these, 37.5% were treated for a few days to 10 weeks, almost half of them for up to 6 months, the remaining cases for up to a year or longer.

These results are like the results published by Ibingira (2003). He found that 44% of patients initially sought treatment through local herbal remedies before seeking medical care, indicating a prevalent reliance on traditional healing methods in the community. Additionally, a significant portion (37.5%) had spent approximately 10 weeks undergoing treatment from traditional healers before transitioning to formal medical care.

The analysis also revealed that out of 74 patients, 65 patients (87.8%) were operated on for chronic osteomyelitis. Nearly 90% of patients had chronic osteomyelitis at the time of their first surgery. This means that osteomyelitis was not detected and treated in a timely manner before the implementation of the prevention program.

Qualitative analysis data were gathered through semi-structured interviews with 12 nurses working in health centers belonging to Nyamasheke District hospitals. Open-ended questions to explore themes related to access to healthcare services, timeliness of care, patient satisfaction, clinical improvement, and any challenges or barriers encountered during treatment.

In addition, qualitative analysis data were gathered through patients and family members and focus group interviews with healthcare providers. Five patients and five family members were interviewed in a focus group for each district hospital.

The analyses of nurses' interviews revealed deficiency in medical knowledge in all medical structures. The results confirm that education and training are essential at all levels, from hospital staff including medical doctors, to nurses at health centers and from community health workers to patients, parents and teachers.

The nurses criticised that the exchange of information between the hospital, the health centers and the patients or parents does not work well. The nurses missed a treatment plan that clearly and bindingly shows diagnostic and treatment steps. For example, post-inpatient/post-operative treatment recommendations are not given to nurses or patients/parents.

The analyses of patients or parents interviews show deficiencies in the treatment of osteomyelitis in the health centers as well as in the hospitals. The communication between hospitals, health centers and community health workers must be improved.

Two other important arguments can be derived from the answers. The population is widely dispersed and largely far from the health centers. The hospitals are even further away. Walks of up to 90 minutes to the health centers are not uncommon. Poverty is often pointed out. The cost of transportation or the additional cost of treatment in a health center or hospital cannot be paid. The use of traditional medicine is an easily obtainable and inexpensive alternative. The importance of treatment is only recognized when advanced signs of chronic osteomyelitis are visible.

Acute osteomyelitis is usually not recognised in time and treated correctly, and acute osteomyelitis quickly develops into chronic osteomyelitis. Extensive training of medical staff and better cooperation in the various structures of the health system can effectively help to reduce the high rate of chronic osteomyelitis.

Raising awareness among the community is another key factor in planning a successful program. In this context, there are problems associated with the implementation area: living in a rural area, extreme poverty, lack of health insurance and seeking help from traditional healers.

Given the short period of time between an acute onset of the disease and the onset of chronic osteomyelitis with usually massive bone loss, the inevitably

unsuccessful treatment by traditional medicine is an important risk factor. Almost every second patient was treated with traditional medicine over a longer period, whereby acute osteomyelitis could develop into chronic osteomyelitis.

The qualitative analysis of the predictors through interviews with nurses and parents/ patients was crucial for the planning and implementation of the program. The program focused on three different priorities: improving knowledge for all healthcare providers, improving cooperation between hospitals and health centers and increasing public awareness to seek medical help at health centers very early.

II. Phase II

In Phase II of this project, the goal was to develop and implement an intervention model for early detection of osteomyelitis to prevent chronic osteomyelitis at the community and primary healthcare levels.

The first step was to conduct a comprehensive literature review. Osteomyelitis was described as a severe and major morbidity disease with a high incidence. But no community-based intervention model to prevent the chronic osteomyelitis in low-resource settings could be found (Ahorlu et al., 2018; Amazigo et al., 2012; Flor et al., 2020; Kim et al., 2016; McGowan et al., 2022; Yassin et al., 2013)

Only a few studies provided recommendations for community-based interventions to prevent chronic osteomyelitis (Arowosegbe et al., 2021; Edmond & Wenzel, 2014; Mulualem et al., 2023; Schaffer et al., 2022; Singh et al., 2017). Salam et al., 2014, recommended to improve knowledge in healthcare structures, awareness campaigns, and health infrastructure at primary health care levels. Edmond et al., 2014, also recommended improving healthcare providers' knowledge, providing essential medical supplies and referral pathways.

The second step focused on developing a program aimed at increasing knowledge of healthcare providers, raising public awareness, strengthening cooperation in the healthcare system, and establishing a monitoring system.

To improve the knowledge of healthcare providers a new Osteomyelitis Manual, available in English and in Kinyarwanda, was designed and the Kibogora osteomyelitis screening test (KOMS-Test) was developed.

The KOMS was found to be a reliable and valuable screening tool for the detection of osteomyelitis.

Multiple training materials to raise public health awareness were developed. Posters, brochures, folders, banners and polo shirts helped to improve the knowledge and skills of all healthcare providers and helped increase community and public awareness as well.

In addition, awareness raising interventions in community gatherings and meetings in “*Umuganda*” and churches resulted in positive effects demonstrated by the high number of people attending and seeking information.

Materials to enhance cooperation between healthcare facilities were provided. This package included health educational materials, such as guiding flowcharts for referral and treatment pathways, discharge protocols, and quarterly meetings between doctors from both hospitals, senior nurses from all health centers and representatives of community health workers from both hospitals. The quarterly meetings have significantly contributed to the evolution and acceptance of developed treatment pathways. In addition, the meetings helped to improve database management in order to document the development and progression of the disease and the course of therapy.

The particular difficulty in implementing this prevention program is that the outbreak of osteomyelitis is not known and the time window in which a successful intervention must take place is very short with a maximum of 6 weeks. Training courses were carried out in all health facilities almost simultaneously to quickly provide all healthcare providers with the necessary knowledge. Also improvement of cooperation could start simultaneously. In addition, simultaneous training of all health care providers led to a rapid increase in awareness of the community because community health workers were able to immediately apply the knowledge and spread it throughout the hamlets. They also had the knowledge to sensitise the population within the framework of “*Umuganda*”.

Almost all healthcare providers were trained three times during the program: staff at Kibogora and Bushenge Hospital, nurses at the 20 associated health centers and community health workers associated with each health center. A total of 7,459 participants from all health facilities in Nyamasheke District were present during the three training periods.

Cooperation between government agencies, non-governmental organizations, and community stakeholders is essential for achieving meaningful impact and sustainability (Alderwick et al., 2021). To ensure this, this project established and regularly held quarterly meetings between the hospital, local government and community.

III. Phase III: Monitoring and evaluation of the Prevention program.

The primary goal of the project was to reduce the number of chronic osteomyelitis cases by promoting early detection and treatment. After development, the prevention program was implemented in the Nyamasheke District between May 1, 2021, and June 30, 2023. During this period, all patients coming to Bushenge Hospital because of osteomyelitis were transferred to Kibogora Hospital. In total, 256 patients with osteomyelitis were presented at Kibogora Hospital for further diagnosis or therapy. All data from these patients were recorded in the database specially developed for the program.

The analysis showed that the majority of patients were male and younger than 30 years old. Almost 90% of all patients came from rural areas. Comparable results were already found in the patient analysis in Phase I.

Exactly half of the 256 patients were diagnosed with acute osteomyelitis, the other half of the patients showed chronic osteomyelitis with varying degrees of severity.

Further analysis of the data revealed that 172 patients came from Nyamasheke District while the remaining 84 patients were referred from neighboring districts to Kibogora Hospital. Since extensive training only took place in the Nyamasheke district, the group of patients from other districts could be seen as a comparison group.

Acute osteomyelitis was diagnosed in 58.7% of cases in patients coming from Nyamasheke District versus 32.1% in patients coming from neighboring districts. The rate of chronic osteomyelitis was 41.3% in Nyamasheke district and 67.9% in other districts.

With 172 new cases in 25 months and a population of 434,121 in Nyamasheke District, the incidence is 19.46 per 100,000 person-years in Nyamasheke District.

Compared to Phase I results, the rate of patients suffering from chronic osteomyelitis in the Nyamasheke District could be reduced from 87,8% to 41.3%. These results demonstrate that the osteomyelitis project was successful in achieving its intended objectives in Nyamasheke District, potentially due to improved awareness, healthcare access, and treatment-seeking behaviour among the population.

Of 128 patients with acute osteomyelitis, 90 patients (70.3%) had an abscess. The results show that with timely and consistent treatment, the treatment result is independent of whether an abscess was present at the initial diagnosis or not.

Of particular interest was the further healing process in patients diagnosed with acute osteomyelitis. Acute osteomyelitis was diagnosed in 128 patients, and all were treated with antibiotic therapy and, if necessary, abscess removal. Of these 128 patients, 11.7% developed chronic osteomyelitis. One of the reasons for the relapse rate may be that the abscess was not cleared out thoroughly or that the antibiotic treatment was not sufficient. At Kibogora Hospital a microbiological determination of germs is not possible, nor a testing for effective antibiotic treatment.

The training also had a positive effect on the severity of chronic osteomyelitis. The treatment results for simple osteomyelitis cases are better than for complex osteomyelitis. Therefore, it is important to prevent the development of a simple chronic to complex chronic form of osteomyelitis. The prevention program had a positive effect on this problem. Difficult or complex cases of osteomyelitis were found in patients outside Nyamasheke District almost twice as often as in patients from Nyamasheke District.

To develop chronic osteomyelitis, more than 6 weeks of pain and abscess formation must have passed since the onset of the disease. The question therefore arises as to why patients do not appear in time for clarification or treatment. The same question was already discussed in Phase I. and the same implementation site-related problems are still responsible. The reasons are the long and arduous ways on foot to a health center and the longer way to the hospital, which is not possible without transportation. The necessary transport costs cannot be paid by the patients or their parents, nor can they pay the costs of an inpatient stay.

Therefore, people often wait for spontaneous healing or seek help from a local healer which is always ineffective in the end.

Nevertheless, the data provides strong evidence of a significant reduction in chronic cases and an increase in detected acute cases. This result shows that knowledge improvement, community awareness campaigns and a better cooperation between the health facilities have effectively improved the early diagnosis and management of osteomyelitis and prevented the progression to chronic stages.

Finally, osteomyelitis has an important socio-economic impact. According to Ogunjumo, 2006, one of the most challenging aspects of chronic osteomyelitis is the social stigma. This stigma can lead to social isolation, as patients may be ostracized by their communities. Additionally, the suggestion of amputation, which may be a necessary treatment in some cases, is often rejected by patients due to socio-cultural beliefs and the socio-economic implications of losing a limb. In many societies, particularly in developing regions, amputation not only leads to physical disability but also to a significant loss of status and livelihood, as the ability to work is closely tied to physical capability.

Chronic osteomyelitis also leads to a loss of valuable manpower, as patients often lose time from school or work. Ibingira (2003) noted that the inability to work not only affects the individual's income but also places a strain on the family's financial resources, further exacerbating poverty.

The financial burden of managing chronic osteomyelitis is considerable. Deo (2018) reported that the prolonged use of expensive antibiotics, extended

hospital stays, and the need for multiple surgeries all contribute to the high cost of treatment. The need for repeated surgical interventions, extended hospital stays, and the management of complications such as pathological fractures and the need for internal or external fixators require substantial healthcare resources (Stanley et al., 2010).

The socioeconomic impact of chronic osteomyelitis becomes even clearer when considering the results presented in Phase I. Over a five-year period, 10,305 surgeries were performed in Nyamasheke District, with 28% of these surgeries related to osteomyelitis. This means that 2,885 surgeries were performed for osteomyelitis with insurance costs ranging from \$350 to \$500 per surgery.

In addition, most patients at Nyamasheke District were charged between \$35 and \$50 upon discharge, which is 10% of hospital costs. This highlights the significant financial burden on patients.

In conclusion, chronic osteomyelitis is not only a severe medical problem, but also a socio-economic burden that requires urgent attention. The disease's impact extends beyond the physical health of the patient, affecting their social standing, economic stability, and overall quality of life.

SUMMARY

Osteomyelitis is an inflammatory disease of the bone and bone marrow that is most often caused by a bacterial infection. This disease is very common in underdeveloped regions and particularly affects children and adolescents. However, if diagnosed early, the disease can be cured and usually heals without consequences.

In underdeveloped countries the disease is often recognized too late. Simple acute osteomyelitis rapidly progresses to chronic osteomyelitis with catastrophic destruction of the affected bone, with associated personal and socio-economic consequences for the patient and the community.

The presented work deals with this topic: is there a possibility to reduce the development of chronic osteomyelitis in rural Rwanda through a prevention program for the early detection and treatment of acute osteomyelitis?

No chronic osteomyelitis prevention program has been found in the literature. With this project, for the first time, such a complex program was planned, developed, implemented in rural areas, continuously monitored and finally evaluated. The project was implemented as a pilot project in Nyamasheke District in Rwanda from May 1, 2021, to June 30, 2023, as a three-phase public health project.

Phase I aimed to assess the prevalence of osteomyelitis-related operations through a quantitative evaluation and to analyze the profile of patients suffering from osteomyelitis who underwent surgery in hospitals in Nyamasheke District between 2016 and 2020. It was found that more than one in four operations were performed for osteomyelitis during this period (prevalence of 28%). In 86.9% of osteomyelitis-related surgeries, the osteomyelitis was already chronic.

The qualitative evaluation revealed that knowledge about osteomyelitis was inadequate among all healthcare providers and that collaboration between healthcare facilities was not optimal. In general, there was a lack of awareness of this disease. Other important causes were implementation site related problems such as: long, difficult and impassable routes to health facilities, poverty and no health insurance. Due to these problems, over 40% of patients received more or less efficient treatment from a local traditional healer.

A general challenge is that osteomyelitis can develop at any time without prior notice and that acute osteomyelitis quickly develops into chronic osteomyelitis within 4 to a maximum of 6 weeks.

In Phase II the program was planned and implemented. The focus was on expanding knowledge about the disease, raising public awareness and improving cooperation between healthcare providers. All the necessary materials to implement these three main topics were designed and widely distributed to the various participants. Due to the complexity of the problem, all healthcare providers were offered three training courses, each of which was attended by a high number of participants. A total of 7,459 people attended all training courses.

The results were recorded in a comprehensive database created specifically for this purpose and evaluated in phase III. It turned out that the primary goal of the project had been achieved. In comparison with the analysis from phase I, the rate of chronic osteomyelitis in the Nyamasheke District was reduced from 87,9% to 41.3%.

A control group with patients suffering from osteomyelitis coming from neighboring districts was formed. Healthcare providers in these districts were not trained but referred patients to Kibogora Hospital for treatment. The comparison of patients from the Nyamasheke District with those from the neighboring districts showed that in the Nyamasheke District with trained healthcare providers, osteomyelitis was recognized in the acute stage in 58.7%, in the neighboring districts only in 32.1%. Accordingly, the rate of chronic osteomyelitis patients in Nyamasheke District was significantly lower at 41.3% compared to 67.9% of chronically infected patients in neighboring districts. The database also made it possible to make statements about the further course of acute osteomyelitis cases. Chronic osteomyelitis subsequently developed in 15% of cases.

Osteomyelitis also has a socio-economic component, and the impact of the disease can be devastating to the patient's social status, economic stability and overall quality of life.

In summary, the developed and implemented osteomyelitis program to reduce chronic osteomyelitis through early detection of Osteomyelitis in the rural Nyamasheke District in Rwanda was successful and effective.

ZUSAMMENFASSUNG:

Osteomyelitis ist eine entzündliche Erkrankung des Knochens und des Knochenmarks, die meistens durch eine bakterielle Infektion verursacht wird. Diese Krankheit kommt in unterentwickelten Regionen sehr häufig vor und betrifft vor allem Kinder und Jugendliche. Bei frühzeitiger Diagnose ist die Erkrankung gut therapierbar und heilt in der Regel folgenlos aus. In unterentwickelten Ländern wird die Erkrankung oft zu spät erkannt. Eine einfache akute Osteomyelitis entwickelt sich schnell zu einer chronischen Osteomyelitis mit katastrophaler Zerstörung des betroffenen Knochens mit den entsprechenden drastischen persönlichen und sozioökonomischen Folgen für den Patienten und die Gemeinschaft.

Die vorgestellte Arbeit befasst sich mit diesem Thema: Gibt es eine Möglichkeit, die Entwicklung einer chronischen Osteomyelitis im ländlichen Ruanda durch ein Präventionsprogramm zur Früherkennung und Behandlung einer akuten Osteomyelitis zu reduzieren?

In der Literatur wurde kein Programm zur Prävention chronischer Osteomyelitis gefunden. Mit dem vorliegenden Projekt wurde somit erstmals ein derart komplexes Programm geplant, entwickelt, im ländlichen Raum umgesetzt, kontinuierlich überwacht und abschließend ausgewertet. Das Projekt wurde als Pilotprojekt im Distrikt Nyamasheke in Ruanda vom 1. Mai 2021 bis 30. Juni 2023 als dreiphasiges öffentliches Gesundheitsprojekt durchgeführt.

Phase I zielte darauf ab, durch eine quantitative Auswertung die Prävalenz von Osteomyelitis bedingten Operationen zu erfassen, sowie das Profil der an Osteomyelitis erkrankten Patienten zu analysieren, die in Krankenhäusern des Nyamasheke Distriktes zwischen 2016 und 2020 operiert wurden. Es wurde festgestellt, dass in diesem Zeitraum mehr als jede vierte Operation wegen einer Osteomyelitis durchgeführt wurde (Prävalenz von 28 %). Bei 86,9 % aller Osteomyelitis bedingten Operationen erfolgte die Operation wegen der Folgen einer chronischen Osteomyelitis.

Die qualitative Auswertung ergab, dass das Wissen über Osteomyelitis bei allen Gesundheitsdienstleistern unzureichend und dass die Zusammenarbeit zwischen den Gesundheitseinrichtungen nicht optimal war. Generell konnte ein Mangel an Bewusstsein für diese Erkrankung festgestellt werden. Als weitere wichtige Ursachen für die Entwicklung einer chronischen Osteomyelitis fanden sich standortbezogene Probleme wie keine Krankenversicherung, lange, schwierige und unpassierbare Wege zu den Gesundheitseinrichtungen und extreme Armut.

Bei über 40% der Patienten erfolgte eine mehr oder weniger effiziente Behandlung durch einen lokalen traditionellen Heiler.

Eine generelle Herausforderung für ein Vorsorgeprogramm zur Früherkennung einer Osteomyelitis ist, dass sich diese jederzeit und ohne spezielle Vorankündigung entwickeln kann und dass sich aus einer akuten Osteomyelitis schnell, innerhalb von 4 bis maximal 6 Wochen, eine chronische Osteomyelitis ausbildet.

In Phase II wurde das Programm geplant. Der Schwerpunkt lag auf der Erweiterung des Wissens über die Krankheit, der Sensibilisierung der Öffentlichkeit und der Verbesserung der Zusammenarbeit aller Gesundheitsdienstleister. Alle notwendigen Materialien zur Umsetzung dieser drei Hauptthemen wurden entworfen und flächendeckend an die verschiedenen Teilnehmer verteilt. Aufgrund der Komplexität der Problematik wurden allen Gesundheitsdienstleistern drei Schulungen angeboten, die jeweils von einer hohen Teilnehmerzahl besucht wurden. An allen Schulungen nahmen insgesamt 7.459 Personen teil.

In Phase III wurden die Daten der eigens dafür erstellten umfangreichen Datenbank ausgewertet. Es stellte sich heraus, dass das Hauptziel des Projekts erreicht wurde. Im Vergleich zur Analyse aus Phase I konnte die Rate an chronischer Osteomyelitis Erkrankter im Nyamasheke Distrikt von 87,9 % auf 41,3 % gesenkt werden.

Eine Kontrollgruppe mit an Osteomyelitis erkrankten Patienten aus Nachbardistrikten konnte gebildet werden. Die Gesundheitsdienstleister dieser Distrikte wurden nicht geschult, überwiesen jedoch die Patienten zur Behandlung ins Kibogora Hospital. Der Vergleich der Patienten aus dem Nyamasheke Distrikt mit denen aus den Nachbardistrikten zeigte, dass im Nyamasheke Distrikt mit geschulten Gesundheitsdienstleistern in 58,7 % die Osteomyelitis noch im akuten Stadium erkannt wurde, in den Nachbarbezirken lediglich in 32,1 %. Dementsprechend war die Rate bereits an chronischer Osteomyelitis Erkrankter im Nyamasheke Distrikt mit 41,3 % deutlich niedriger im Vergleich zu 67,9 % chronisch infizierter Patienten in benachbarten Distrikten. Die Datenbank erlaubte auch Aussagen über den weiteren Verlauf akuter Osteomyelitis-Fälle. In 15 % der Fälle entwickelte sich anschließend noch eine chronische Osteomyelitis.

Zusammenfassend lässt sich sagen, dass das entwickelte und implementierte Osteomyelitis-Programm zur Reduzierung chronischer Osteomyelitis durch Früherkennung von Osteomyelitis noch im akuten Stadium im ländlichen Nyamasheke Distrikt in Ruanda erfolgreich und effektiv war.

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A. APPENDIX

LIST OF ACADEMIC TEACHERS

My Academic teachers at Philipps University of Marburg, Germany:

Prof. Dr. med. Peter Schuler

My Academic Teachers at the Mount Kenya University, Rwanda:

Prof. Joseph Ntaganira, Prof. Erigene Rutayisire,

Prof. Benon Asimwe, Dr. Monica Mochama, Dr. Hilda Vasanthakaalam

My Academic Teachers at the University of Rwanda, Rwanda:

Prof. Laetitia Nyirazinyoye, Prof. Jeanine Condo,

Dr. Rex Wong, Dr. Jean Paul Semasake Sengoma

ACKNOWLEDGMENTS

I would like to express my deepest gratitude to my supervisor, Prof. Dr. Peter Schuler, Germany, for his invaluable guidance, support, and encouragement throughout the entire duration of my doctoral research. His expertise, patience, and constructive feedback have been instrumental in shaping this thesis and fostering my academic growth.

I am also immensely grateful to Dr. Erich Feltes, Germany, and Dr. Michael Weber, Germany, for their insightful comments, suggestions, and contributions to this work. Their diverse perspectives and expertise have significantly enriched the quality of my research.

My sincere thanks go to the Medical Faculty of the Philipps University of Marburg, Germany.

I am deeply grateful to my family for their unwavering love, encouragement, and understanding during this challenging journey. Their support sustained me through moments of doubt and kept me motivated to pursue excellence.

Lastly, I would like to acknowledge the financial support provided by The Rotary Foundation (TRF) and German Government. Their investment in my academic pursuits has been invaluable.