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DEPARTMENT OF SURGERY

PEDIATRIC INTESTINAL OBSTRUCTION: ETIOLOGICAL ANALYSIS AND FACTORS INFLUENCING SHORT TERM OUTCOMES IN RWANDAN UNIVERSITY TEACHING HOSPITALS

By

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August, 2021

DECLARATION

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We hereby declare that this dissertation ***"pediatric intestinal obstruction: etiological analysis and factors influencing short term outcomes in Rwandan university teaching hospitals"*** was submitted by TWAHIRWA Isaie with our approval.

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DEDICATION

This work is dedicated to my family: My beloved wife, **CYUZUZO HABIYAREMYE FABIOLA** and my beloved son **HABINEZA M. DEREK**. Without your love and support, this dissertation could have not been completed.

It is also dedicated to my mother, brothers and sisters.

Finally, I dedicate this work to young students interested in surgery and clinical research in particular.

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LIST OF ABBREVIATIONS

ALT: Alanine aminotransferase

AST: Aspartate aminotransferase

C-D: Clavien-Dindo

CHUB: Centre hospitalier universitaire de Butare

CHUK: Centre hospitalier universitaire de Kigali

CMHS: College of medicine and health sciences

CNS: Central nervous system

EPV: Event per variable

HDU: High dependency unit

HR: Heart rate

ICU: Intensive care unit

IRB: Institutional review board

IV: Intravenous

KFH: King Faisal Hospital

RHPC: Rwanda housing and population census

RMH: Rwanda military hospital

RR: Respiratory rate

NGT: Nasogastric tube

PICU: Pediatric intensive care unit

SD: Standard deviation

SPSS: Statistical package for the social sciences

SSI: Surgical site infection

TB: Tuberculosis

WBC: White blood cell count

ABSTRACT

Introduction: Intestinal obstruction is a common presentation in pediatric surgical emergencies, and presents with different etiologies depending on country or region. Its morbidity and mortality are high in developing countries, with variable influencing factors. Both the etiologies and outcomes are not documented in Rwanda.

Objectives: We conducted this study to determine the etiologies, morbidity and mortality of pediatric intestinal obstructions, and assess the factors associated with the outcomes of these conditions in Rwandan university teaching hospitals.

Methods: This was a cross sectional observational study conducted on pediatric patients with intestinal obstruction in 2 Rwandan university teachings hospitals: CHUK and CHUB. The patients were followed since admission until discharge, and we documented their basic characteristics, diagnosis, operative details and post-operative outcomes. Data were collected using data collection form, electronically captured and analysed using SPSS software. Descriptive statistics were used to generate frequencies and percentages of categorical variables. Bivariate and multivariate analysis was done to assess correlations between variables and factors associated with morbidity and mortality.

Results: In total, 65 patients have been followed in this study. They were predominantly male (75.38%). The majority of patients were below age 6 years and 86.15% had low socio-economic status. The mean duration of symptoms was 11.23 days. Intussusception was the most common etiology (33.85%). Other common etiologies were hirschsprung disease (20%), incarcerated inguinal and umbilical hernias (9.23%), intestinal worms' impaction (7.69%) and adhesions (7.69%). The mortality and morbidity were 9.23% and 38.46% respectively. The most common complications were surgical site infection (9.23%) and sepsis (9.23%). The length of hospital stay was 8 ± 6 days (range: 1-34 days). Preoperative anemia (Hb<10g/dl), and finding of gangrenous bowels at the time of laparotomy and bowel resection were the factors associated with post-operative complications.

Conclusion: Intussusception is the most common etiology of pediatric intestinal obstruction in 2 Rwandan university teaching hospitals. The outcomes are influenced by the preoperative anemia, gangrenous bowels at the time of laparotomy and bowel resection. We recommend a countrywide survey on etiologies and outcomes of intestinal obstruction in pediatric patients.

Key words: *Pediatric, Etiology, Intestinal Obstruction, Outcome, Rwanda*

I. INTRODUCTION

1.1.Background

Intestinal obstruction is defined as an interruption of forward flow of contents within the intestinal lumen(1). It affects patients of all ages from birth, and can occur at any level of gastrointestinal tract with various causes(2). The pathophysiology of intestinal obstruction in children is similar to that of adults but there is an exception due to frequent congenital causes. It is the common cause of pediatric surgical emergency especially in developing world , with significant morbidity(3).

The outcomes of children with intestinal obstruction are multifactorial, and they can be divided into 3 categories: patient related, disease related and facility setting related factors. The patient related factors include age, presence of congenital condition, and medical comorbidity. Disease related factors include the specific etiology, duration, bowel status, hydration status, electrolytes imbalance, sepsis and type of surgery. Facility setting is an important factor and it include availability of competent team of surgeons, nurses, pediatricians and anesthesiologists, diagnostic modalities, theater, laboratory, pre and postoperative intensive care units and medications. In addition, overall health system for timely diagnosis and referral if indicated may highly contribute to the outcome.

In developing countries, children with intestinal obstruction are at high risk of morbidity and mortality for particular factors. It has been shown that there is a high burden of unmet surgical need in general, but specifically very high in pediatric population(4–7). There is also shortage of general surgeons and pediatric surgeons in Africa, and it was reported to be 1 general surgeon per million and 0.26 pediatric surgeons per million(8–10). In East Africa, there is only 0.53 pediatric surgeons/100.000 and those available mostly reside in cities(11). Those 2 factors may be the cause of late presentation and associated poor outcomes. One cross sectional study on delays of mortality in children below 5 years in Rwanda, reported 59% of patients who died at home before consulting health facility(6). This shows that also delay in presentation is a major factor of mortality and having a real prevalence and mortality due to intestinal obstruction is challenging due a number of patients who do not reach hospitals. Other known burden of conditions like malnutrition, HIV/AIDS and TB may also be a contributing factor to morbidity and mortality of children with intestinal obstruction in developing countries.

In this analytical cross sectional study, we have evaluated and analysed different etiologies of intestinal obstruction in the pediatric population at 2 Rwandan university teaching hospitals, as well as different factors influencing the outcomes.

1.2.Study justification

We conducted this study because of several reasons. First, pediatric intestinal obstruction is a common pediatric surgical emergency condition. Second, in our settings, there is no published data for the etiologies and outcomes of intestinal obstruction in pediatric patients. Other studies which were done in different settings focused on neonatal groups and others combined neonatal and older children. Third, this age group comprises the majority of Rwandan population according to Rwanda population and housing census 4 (RHPC) of 2012, where the population below 15 years accounted 41%(12). These numbers were 39.5% by the end of 2019, according to UN population(13). We believe that this research will help in raising awareness and future evidence based planning and management for better outcomes of pediatric patients with intestinal obstruction.

1.3.Research question

Our research aims to answer the question "What are the causes of intestinal obstruction and the factors influencing the outcome in pediatric patients"?

1.4.Definitions

In our study; we defined pediatric population from 1 month to 15 years. This population is divided into different age groups:

- Infant: 1 month to 1 year
- Toddler: 1 to 3 years
- Preschool: 3 to 6 years
- School age child: 6 to 12 years
- Adolescent: 12 to 15 years

Intestinal obstruction was defined as clinically and/or radiologically confirmed interruption of forward flow of intestinal contents. As there are many ways to classify intestinal obstruction in children, in our study we considered simple classification into congenital and acquired etiologies. All congenital etiologies presented after neonatal period that include stenosis or atresia, malrotation with volvulus, duplication cyst, annular pancreas, congenital band, hirschsprung disease and anorectal malformations were included. Acquired etiologies like intussusception, hypertrophic pyloric stenosis, hernias, intestinal worms, strictures, adhesions, neoplastic, etc. were considered. All detailed etiologies were considered individually in description and analysis and both acute and acute on chronic cases were included.

We defined outcome in terms of events and changes, occurred during the admission period. They include adverse events and abnormal physiological changes presented as morbidity and mortality, and normal recovery followed by discharge at home. Postoperative adverse events were classified according to clavien-Dindo, into 5 grades (**Table 1**).

Table 1 Clavien-Dindo classification of surgical complications(14)

Grade	Definition
Grade I	Any deviation from the normal postoperative course, and without the need for pharmacological treatment, surgical, endoscopic, and radiological interventions. Drugs as antiemetics, antipyretics, analgesics, diuretics, electrolytes, and physiotherapy are the only allowed therapeutic regimens. It's also includes wound infections opened at the bedside.
Grade II	Pharmacological treatment with drugs other than such allowed for grade I Complications are required. It does also include blood transfusions and total parenteral nutrition.
Grade III	Surgical, endoscopic or radiological intervention are required
Grade IIIa	Intervention required but not under general anesthesia
Grade IIIb	Intervention is required under general anesthesia
Grade IV	Life-threatening complication that requires ICU management. It also include CNS complications
Grade Iva	Single organ dysfunction, including dialysis.
Grade IVb	Multiorgan dysfunction
Grade V	Death of a patient

1.5.Aim

To assess the etiologies and factors influencing outcome of pediatric intestinal obstruction in 2 university teaching hospitals in Rwanda; university teaching hospital of Kigali (CHUK) and university teaching hospital of Butare (CHUB).

1.6.**Objectives**

- To determine the common etiologies of pediatric intestinal obstruction at CHUK and CHUB
- To determine the mortality and morbidity associated with pediatric intestinal obstruction
- To identify the factors influencing the outcome of intestinal obstruction in pediatric patients

II. LITERATURE REVIEW

1.1 Epidemiology

Intestinal obstruction is among the common cause of emergency admissions in children all over the world(15). There is a global variation in epidemiology of intestinal obstruction in children and it is underreported in Africa(9,16).There is a male predominance with a male to female ratio ranging between 1.8-3.5:1 and the reason behind is unknown(3,9,15,17). The majority of patients (>80%) present before 5 years(3,15,16). A lot of studies have been done to evaluate the epidemiology of intestinal obstruction in adult patients in Rwanda, but the deficit exists in pediatric population.

1.2 Pathophysiology and presentation

The common presentations of intestinal obstruction are abdominal pain, abdominal distension, vomiting, and failure to pass stool; but diarrheic tool with blood or mucus are not uncommon in some cases of intestinal obstruction(18). Generally there is early vomiting and less distension with higher obstruction, while the distension is marked and vomiting delayed in lower obstruction. The presentation can be acute, subacute or chronic depending on the underlying etiology. Age at presentation can be characteristic of underlying condition, like infantile pyloric stenosis which occurs around 3 weeks and intussusception which is common at 6-11 months(18). Initially in course of obstruction there is accumulation of gas and fluids proximal to the site of obstruction, which leads to increase bowel activity and colicky pain. With progression of disease, stasis of intestinal contents and bowel distension rise intraluminal and intramural pressure until the blood supply is compromised leading to ischemia, necrosis and eventual perforation. There is also bacterial translocation secondary to stasis, which potentiates vomiting and leads to sepsis. Vomiting and sometimes diarrhea predispose the patient to dehydration and electrolyte imbalance, which get worse overtime and can lead to death if no intervention done on time. The onset and progression of symptoms depend and characterize the underlying etiology.

1.3 Etiologies of intestinal obstruction

Etiologies of intestinal obstruction are described in different ways. It can be classified as congenital versus acquired, or dynamic versus adynamic(18). In dynamic intestinal obstruction there is peristalsis working against obstruction and can be intraluminal, intramural or extramural. Other classify it based on level of obstruction as small bowel versus large bowel obstruction or, high small bowel, lower small bowel and large bowel obstruction(18).

In general, the causes of intestinal obstruction in children include intussusception, congenital bands and postoperative adhesions, worm impaction, strangulated abdominal wall hernias, internal hernias, delayed presentation of congenital conditions like volvulus, anorectal malformations, Meckel's diverticulum and hirschsprung disease(15,16,19). Rare causes has been reported including congenital mesenteric defect, bezoars, superior mesenteric syndrome, omphalomesenteric duct remnant, entrapment in ileocecal recess and tumors(2,20,21).

There is a high variability in etiologies of intestinal obstruction and this variation was noted in different parts of the world, geographic region, among age and socioeconomic groups (20). This variation is also recorded in different region and hospitals of the same country(3,15). In studies carried out in different countries of Africa; Hirschsprung disease was the common cause in Malawi, intussusception common cause in Uganda and Ghana(22,23), while ascaris plug was the leading cause in Kenya(3,9). In studies done elsewhere, intussusception was the main cause in Indian centers, china and Nepal(17,24,25) and adhesions commonest cause in Taiwan(26). From the results of our search, no data was found stating the pattern of etiologies of intestinal obstruction in the pediatric population in Rwanda.

1.4 Management

The management of intestinal obstruction in children starts immediately after admission at emergency, and it is done simultaneously with diagnostic process. The priority consists of assessment of patient's hemodynamic status, followed by taking a full history; perform complete physical examination, laboratory and imaging investigations if required. Rapid IV access and IV fluid bolus 20ml/kg of normal saline or ringer's lactate are provided in sicker children with severe dehydration or shock. Other emergency management consists of insertion of nasogastric tube for decompression, nil per oral, analgesia and antibiotics according to patient condition(15,27). After correcting patient's shock, maintenance iv fluids with electrolytes and glucose are prescribed while waiting for definitive surgical management.

Diagnostic imaging is requested based on history and physical examination findings and they are not required in certain circumstances like strangulated external hernias. The commonly useful imaging are plain abdominal x-ray, abdominal ultrasound and contrast studies. Rectal biopsy is the definitive diagnostic study in hirschsprung disease, but it will not delay management in case of emergency.

Definitive management comes after patient optimization, and may be operative or non-operative depending on cause and presentation. Non operative management can be opted for conditions like intussusception and obstruction on adhesions(28–30). Hydrostatic or air enema is the preferred non-operative management for intussusception and its choice and its success depends on how and when the patient presented(28).

Patients with adhesive bowel obstruction and without features of strangulation respond well with initial management by nil per oral, NGT and rehydration, followed by gastrografin administration for failed cases after 48 hours(28,30). Operative management can be done using open or laparoscopic techniques depending on condition, setting and surgeon expertise(28,31). Laparoscopic management was evaluated in conditions like duodenal obstruction, malrotation, intussusception and Hirschsprung disease with good results, however good patients' selection is required(28,31–33). Selection of the type of management is important as it contributes to the patient's outcome.

1.5 Outcome of intestinal obstruction in children

Outcome is divided into short and long term outcomes depending on timeline of occurrence. Short-term outcomes are defined as those occurring during admission, or more specifically within 30 days of illness. The outcomes of intestinal obstruction in children vary from country to country. The predicting factors include facility settings, patient age, underlying cause, delay presentation, associated anomalies, and medical comorbidities(8,15,16,26). Reported mortality ranges from 3-11.2(15,16,23), and the morbidity varies from 4% to 60%(16,25). The common morbidities include surgical site infection (SSI), sepsis, fascial dehiscence, stoma related complications, and enterocutaneous fistula. Developing countries have particularly a high rate of morbidity and mortality secondary to lack of qualified surgeons and insufficient resources(2,3,8). A retrospective study which was done in Rwanda 10 years ago, showed a 35% morbidity rate and 28% mortality in children with intussusception, and the underlying factors of mortality were having complications and female sex(34).

III. STUDY METHODS

2. 1 Study sites and settings

In Rwanda, there are 5 major national referral hospitals including CHUK, CHUB, RMH, KFH and Ndera neuropsychiatric center. One of the 5 referral hospitals is private, and other 4 are public. In current referral system, national referral hospitals manage patients from district, provincial and regional referral hospitals. One of the reasons of referring a pediatric patient is lack of surgical team, anesthesia team or intensive care monitoring facility. Some district and provincial hospitals have surgical and anesthesia team, that can manage uncomplicated surgical conditions. Our study was conducted in 2 university teaching hospitals in Rwanda (CHUB and CHUK). University teaching hospital of Butare, a 500 beds hospital, is located in Southern province and receives children transferred from majority of districts and provincial hospitals of southern and western provinces. The university teaching hospital of Kigali is located in center of Kigali city, with 519 beds capacity and receives children from Kigali city and Northern Province.

The settings are almost similar, with some differences. In both hospitals, children with acute surgical conditions pass through general pediatric emergency, where they are received by pediatric and surgical teams. At CHUB, the surgical team is led by a consultant general surgeon and general surgery resident, while at CHUK the team is led by a pediatric surgeon, pediatric surgery fellow and general surgery resident. Children with complex surgical conditions from CHUB referral zone are referred to CHUK where there is a pediatric surgeon. Post-operatively, patients are admitted in the pediatric department and followed by both surgical and pediatric teams. CHUK has a pediatric intensive care unit (PICU) and HDU which manage critically sick children with either medical or surgical conditions. Pediatric patients in need of intensive care management at CHUB may be admitted in adult intensive care unit.

3.2 Study design

This was an analytical cross sectional study. Enrolled patients were followed from admission to discharge.

3.3 Study description

Patient that were included in our study were identified through the pediatric emergency department. Data of patients admitted with intestinal obstruction were collected prospectively, and included patient demographics, diagnosis, management and outcome. The Causes of obstruction was evaluated generally and analyzed per sex, socioeconomic status and age group. The management details including intraoperative details and post-operative course of illness were documented. The relationship between different risk factors and outcome was statistically assessed.

3.4 Study population

The study included all pediatric patients, from 1month to 15 years admitted with confirmed (clinically by surgical team and radiologically if required) intestinal obstruction.

3.4.1 Inclusion criteria

All pediatric patients from 1 month to 15 years, admitted in CHUK and CHUB through pediatric emergency department with intestinal obstruction over the period of study.

3.4.2 Exclusion criteria

- The patients with functional intestinal obstruction as complication of another abdominal operation
- Patients transferred in other hospital before surgery or formal discharge

3.5 Study variables

Our study variables include:

- Patient demographics: age and gender, ubudehe category, province of origin
- Duration of symptoms
- Etiology of obstruction
- Associated congenital anomalies
- Vital signs at admission
- Associated medical conditions
- Basic laboratory results
- Type of management: operative versus non-operative
- Primary surgeon category (resident or consultant)
- Duration of surgery
- Post-operative disposition
- Post-operative complications
- Duration of first feeding after surgery
- Hospital stay
- Overall outcome: discharged home or died.

3.6 Outcome of interest

Our outcomes were defined according to Clavien-Dindo postoperative complications classification.

- ❖ Primary outcome
  - Morbidity
- ❖ Secondary outcomes
  - Mortality

3.7 Study procedures

3.7.1 Procedure of enrollment

The patients were enrolled after being admitted and diagnosed with intestinal obstruction. All patients who met inclusion criteria and whose parents signed a consent have been enrolled.

3.7.2 Follow up

The enrolled patients were followed since admission, their characteristics documented and then there was a daily follow up for the management offered, in-hospital complications and final outcome at discharge.

3.7.3 Sample size

The sample size was calculated using formula for cross sectional studies and based on set confidence interval of 95% (Z), estimated prevalence from pivot study of 4.1, and precision level of 5%.

$$\mathrm{n} = \frac{Z^2 P(1-P)}{d^2}$$

The calculated sample size was **60** patients. Those patients were prospectively recruited in both hospitals until we get the full sample.

3.7.4 Statistical analysis

- Our data was analysed using statistical package for social sciences (SPSS) version 24.
- Descriptive statistics were used to generate frequencies and percentages of categorical variables, as well as medians and interquartile range for continuous variables.
- Chi square test was used for analysis of categorical variables
- Multivariate analysis was performed for different factors associated with morbidity and mortality.
- The result was significant if p value was <0.05

3.8 **Ethical considerations**

3.8.1 Confidentiality

- Information collected for every patient was confidential
- Every patient was identified with a study id
- Filled data collection forms were kept in a locker accessible only to the researcher
- Data was kept in password protected file after entry into a computer soft ware

3.8.2 Informed consent

- Every patient was enrolled in the study after the parent or legal guardian signed a consent
- Explanations regarding the study were provided by the investigator or another designed collaborator before signing the consent
- Explanations were provided to children 10-15 years so that they can sign an assent

3.8.3 Ethical approval

Ethical approval was requested from the college of medicine and health sciences (CMHS) institutional review board and both CHUB and CHUK ethical committees before starting the research.

4 RESULTS

4.1.Demographics and general characteristics

In total, 65 patients with ages ranging from 1 month to 15 years were included in this study. Infant group (1month-1 year) accounted for the largest number (n=25, 38.46%) of patients, followed by toddler group (n=17, 26.15%) (**Table 2**). They were predominantly male (n=49, 75.38%), with male to female ratio of 3:1. More than a half (n=35, 53.85%) patients were from CHUK. The majority of patients (n=38, 58%) had a low socioeconomic status (ubudehe category 1 and 2) and southern province accounted a largest number of patients among others (n=25, 38.46%). 8 patients (12.31%) presented with comorbidities that included malnutrition (4), congenital heart disease (2), malaria (1) and spinal bifida (1).

The mean duration of symptoms was 11.23 days with a standard deviation (SD) of 15.11 days (**Table 2**). Preoperatively, basic investigations were recorded including FBC and electrolytes. In total, 12 (18.46%) patients had anemia and 27 (42.86%) had one or more of the electrolytes imbalances (**Table 3**).

Table 2 Patient's basic demographics

Variable		Frequency	Percentage (%)
Hospital	CHUB	30	46.15
	CHUK	35	53.85
Age	1-12 months	25	38.46
	1-3 years	17	26.15
	3-6 years	14	21.54
	6-12 years	6	9.23
	12-15 years	3	4.62
Sex	Male	49	75.38
	Female	16	24.62
Socioeconomic category	Low (Ubudehe 1&2)	38	58.46
	High (Ubudehe 3&4)	27	41.54
Province of origin	Kigali city	9	13.85
	Southern	25	38.46
	Eastern	6	9.23
	Western	15	23.08
	Northern	10	15.38
Total		65	100

CHUB *(Centre hospitalier universitaire de Butare),* **CHUK** *(Centre hospitalier universitaire de Kigali),* **SD** *(standard deviation),* **UBUDEHE CATEGORY** (*Economic grading used in Rwanda, based on income of population. Category 1 is the lowest and category 4 the highest)*

Table 3 Clinical characteristics

Variable		N	%
Comorbidity	Yes	8	12.31
	No	57	87.69
Anemia	Yes	12	18.46
	No	53	81.54
Electrolytes imbalance	Yes	27	41.54
	No	38	58.46
Mean duration of symptoms in days (SD)	**11.23 (15.11) days**		

SD *(standard deviation)***, anemia (**Hb <10g/dl), **electrolytes imbalance (***any of low Na+, K+, Cl-)*

4.2. Etiologies of intestinal obstruction

Intussusception was the most common cause of intestinal obstruction overall (n=22, 33.85%), and in all age groups (**Table 4**). Other common etiologies included Hirschsprung disease (n=13, 20%), umbilical and inguinal hernias (n=6, 9.23%), adhesions (n=5, 7.69%), intestinal worms (n=5, 7.69%) and hypertrophic pyloric stenosis (n=5, 7.69%) (**Table 4**). Etiologies were grouped into congenital and acquired conditions. Only 20 (30.77%) patients presented with congenital conditions and all were below 6 years. The remaining 45(69.23%) patients had acquired etiologies.

Table 4 Etiologies of intestinal obstruction

Etiology	Number (N)	%
Intussusception	22	33.85
Hirschsprung disease	13	20.00
Hernias (inguinal and umbilical)	6	9.23
Adhesions	5	7.69
Intestinal worms	5	7.69
HPS	5	7.69
Malrotation	2	3.08
Congenital band	2	3.08
Constipation	1	1.54
Duodenal atresia	1	1.54
Jejunal web	1	1.54
Ileosigmoid knotting	1	1.54
Imperforate anus	1	1.54
Total	**65**	**100%**

4.3. Management details

In total, 63 of the 65 patients (97%) were operated, and 2 were managed non-operatively**.** The majority of patients (n=49, 77.78%) were operated by the consultants .The bowel status at the time of surgery was assessed and 46(73%) patients had viable bowels. **Table 5** illustrates the details of management including type of surgery, primary surgeon, bowels status, procedure performed and post-operative disposition**.**

Table 5 Management details

variable		**N^{o}**	**%**
Primary surgeon	Resident	14	22.22
	Consultant	49	77.78
Management approach	Operative	63	96.92
	Non operative	2	3.08
Bowel status	Viable	46	73.02
	Gangrenous	17	26.98
Procedure performed	Obstruction relieve without resection	31	49.21
	Bowel resection	32	50.79
Procedure after resection	Resection and anastomosis	14	22.22
	Resection and stoma	17	26.98
	Resection, stoma and anastomosis	1	1.59
Post-operative Disposition	General ward	49	77.78
	ICU	4	6.35
	HDU	10	15.87
Post-operative complications	Yes	25	38.46
	No	38	61.54
Over all outcome	Mortality	6	9.23
	Survival	59	90.77

ICU (*intensive care unit)***, HDU** *(high dependency unit)*

4.4 Short term post-operative outcomes

Overall, 25 (38.46%) patients had one or more complications after surgery (**Table 6**). Those complications were graded according to clavien-Dindo classification from I-V (**Figure1**). The grade I and II were considered minor complications and grade III-V as major complications (F**igure 2**). The majority of patients (56%) had minor complications (C-D grade I and II) (**figure 1**). only 11 out 25 patients had major complications, representing 17.46% of the population. The common post-operative complications were SSI (9.23%) and sepsis (9.23%). The mean length of hospital stay was 8 days with standard deviation (SD) of 6 days, and it ranged between 1-34 days. The mortality rate was 9.23%. **Table 6** summarizes all post-operative complications.

Table 6 post-operative complications

Type of complication	Frequency	Percentage (%)
Surgical site infection	6	9.23
Prolonged ileus (> 4 days)	3	4.61
Atelectasis/pneumonia	2	3.17
Electrolytes imbalance	2	3.17
Hematoma formation	1	1.5
Anemia (not requiring transfusion)	1	1.58
Sepsis	6	9.23
Intra-abdominal abscess	3	4.61
Wound dehiscence	3	4.61
Stoma complications	2	3.17

Figure 1 Postoperative complication by Clavien-Dindo classification

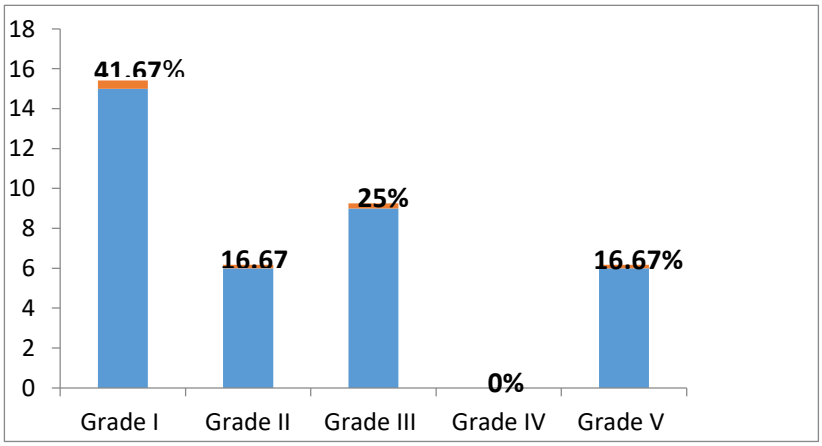
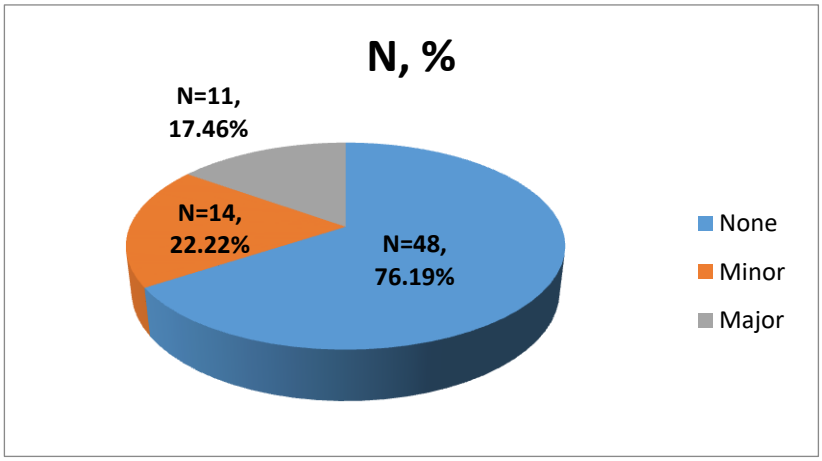


Figure 2 Severity of post-operative complications



Minor *(C-D grade I and II)*, **Major** *(C-D ≥ III grade)*, **none** *(no complication)*

Among the 6 cases of mortality, only 2 were due to major complications requiring reoperation (intrabdominal abscess and fascia dehiscence). Other 4 did not have major complications, but 2 of them were hemodynamically unstable before operation and were admitted in ICU after surgery. The remaining 2 patients had only minor complications including electrolytes imbalance and sepsis.

4.4.1 Analysis of factors associated with post-operative outcomes

Different factors including age, sex, socioeconomic status, comorbidity, anemia at admission, etiology, bowel status, performed procedure, primary surgeon, and duration of symptoms, were analysed for their association with morbidity and mortality (**Table 7**). On bivariate analysis, the post-operative complications were associated with **anemia before surgery**, **bowel status at operation** and **bowel resection**.

Table 7 Analysis of factors associated with post-operative complications.

Variable		**Post-operative Complication**		**P value**
		No	**Yes**	
		N (%)	**N (%)**	
Age	1-12 months	16 (42.10)	8 (32)	0.464
	1-3 years	7 (18.42)	10 (40)	
	3-6 years	9 (23.68)	4 (16)	
	6-12 years	4 (10.52)	2 (8)	
	12-15 years	2 (5.26)	1 (4)	
Sex	Male	30 (78.95)	17 (68)	0.329
	Female	8 (21.05)	8 (32)	
Comorbidity	Yes	4 (10.53)	4 (16)	0.523
	No	34 (89.47)	21 (84)	
Duration of symptoms	< 5 days	19 (50)	11 (44)	0.418
	≥5 days	19 (50)	14 (56)	
SES	Low	23 (60.53)	15 (60)	0.967
	High	15 (39.47)	10 (40)	
Etiology	Congenital	12 (31.58)	8 (32)	0.972
	Acquired	26 (64.42)	17 (68)	
Primary surgeon	Consultant	30 (78.95)	19 (76)	0.783
	Resident	8 (21.05)	6 (24)	
Anemia	Yes	2 (5.26)	10 (40)	**0.001**
	No	36 (94.74)	15 (60)	
Electrolyte abnormality	Yes	17 (45.95)	10 (41.67)	0.742
	No	20 (54.05)	14 (58.33)	
Bowel status	Viable	33 (86.84)	13 (52)	**0.002**
	Gangrenous	5 (13.16)	12 (48)|	
Bowel resection	Yes	15 (39.47)	17 (68)	**0.027**
	No	23 (60.53)	8 (32)	

SES *(socio-economic status),* **anemia** *(defined by Hb< 10g/dl*), **Electrolytes abnormality** *(Any of low Na+, K+, or Cl-)*

Analysis was also done for factors associated with mortality. Anemia and low socio-economic status were significantly associated with mortality (**Table 8**).

Table 8 Analysis of factors associated with mortality

Variable		**Post-operative mortality**		
		No	**Yes**	**P value**
		N (%)	**N (%)**	
Age	1-12 months	21 (36.84)	3 (50)	0.425
	1-3 years	14 (24.56)	3 (50)	
	3-6 years	13 (22.81)	0	
	6-12 years	6 (10. 53)	0	
	12-15 years	3 (5.26)	0	
Sex	Male	42 (73.68)	5(83.330	0.606
	Female	15 (26.32)	1 (16.670	
Duration of Symptoms	< 5 days	28 (49.12)	2 (33.33)	0.383
	≥5 days	29 (50.88)	4 (66.67)	
Comorbidity	Yes	6 (10.53)	2 (33.33)	0.110
	No	51 (89.47)	4 (66.67)	
SES	Low	32 (56.14)	6 (100)	**0.037**
	High	25 (43.86)	0	
Anemia	Yes	9 (15.79)	3 (50)	**0.042**
	No	48 (84.21)	3 (50)	
Electrolytes abnormality	Yes	24 (42.11)	3 (50)	0.766
	No	31 (54.39)	3 (50)	
Diagnosis	Congenital	17 (29.82)	3 (50)	0.313
	Acquired	40 (70.18)	3 (50)	
Primary surgeon	Consultant	44 (77.19)	5 (83.33)	0.731
	Resident	13 (22.81)	1 (16.67)	
Bowel status	Viable	42 (73.68)	4 (66.67)	0.713
	Gangrenous	15 (26.32)	2 (33.33)	
Bowel resection	Yes	28 (49.12)	4 (66.67)	0.414
	No	29 (50.88)	2 (33.33)	

SES *(socio-economic status)*, **anemia** *(defined by Hb< 10g/dl*), **Electrolytes abnormality** *(Any of low Na+, K+, or Cl-)*

Multivariate analysis was done for factors significantly associated with morbidity from bivariate analysis, and **gangrenous bowel** and **anemia** at presentation remained associated with morbidity. The multivariate analysis was not done for factors associated with mortality due to low event per variable (EPV) (Considering the recommendation to do multivariate analysis if event per variable is at least 10:1).

Table 11 Multivariate analysis of factors associated with post-operative complications

Factor	Adjusted Odds ratio	95% confidence interval	P value
Gangrenous bowel	**4.25**	**1.10, 16.33**	**0.003**
Bowel resection	0.96	0.32, 2.88	0.945
Anemia	**3.38**	**1.17, 1.60**	**0.027**

5 DISCUSSION

This study evaluated the etiologies of intestinal obstruction and factors associated with outcome in 2 Rwandan university teaching hospitals. We found multiple causes of intestinal obstruction in children, and they were predominantly in infants (n=25, 38.46%), toddlers (n=17, 26.15%) and preschool children (n=14, 21.54%). Intussusception was the commonest cause of intestinal obstruction in our study in all age groups. Other common causes were hirschsprung disease, abdominal wall hernias, intestinal worms and postoperative adhesions.

The etiologies of pediatric intestinal obstruction in our study have similarities with other places, with differences noted with others. Our study findings confirmed the variability of etiologies of intestinal obstruction in different regions. Intussusception was the most common cause in our settings as in many other centers, including studies in UK, India, Nigeria, and Nepal(2,15,16,25). Hirschsprung disease was the second cause of intestinal obstruction in our study. This condition has been prevalent in pediatric patients, especially in centers of developing countries like Malawi and Nigeria(35–37). Different to developing countries, this condition commonly present in neonatal period or early infancy in developed settings. Intestinal worms which is the common cause of intestinal obstruction in some of developing countries like Kenyan and Indian centers(3,38), accounted only for 7.6% in our study population. This may be due to different policies put in place in Rwanda, including systematic children deworming and water supply and sanitation. This finding also shows that there is still a need for measures to eradicate this poor hygiene related condition. Other top etiologies of intestinal obstruction in some centers like hernias and adhesions were respectively 3rd and 4th common conditions in our study. This global variation in etiologies of intestinal obstruction in children calls for clinicians caring for pediatric patients to consider their local data for better planning and prioritization.

The majority of our patients (n=56, 86.15%) were below the age of 6 years. We think that this can be explained by predominance of intussusception; a well-known common condition in this age group. In addition, a large number of congenital conditions (n=20 30.77%) can be another explanation. However, the predominance within this age group was similar to findings in other studies(3,9).

As in other studies, there was predominance of intestinal obstruction in male children (n=49, 75.38%), the underlying reason remaining unknown(3,9,15,17,25). There is a need for further studies to determine the reason of this predominance.

The mean duration of symptoms was long in our patients (11 days). This may be due to limited capacity of primary health facilities to detect different conditions that cause intestinal obstruction and refer them in timely fashion. On other hand, parents may delay by first consulting traditional healers as it was shown in previous study on delays of child mortality(6). The similar study in Kenya revealed a mean duration of symptoms of 6 days(3). Further assessment is needed to find causes of this delay and establish evidence based solutions.

Intestinal obstruction was predominant among patients with low socioeconomic status (60%). There are possible hypothetical explanations about this finding. First, the patients in high socioeconomic status with congenital causes are likely to consult early before 1 month. Second, they are likely to consult private hospitals and we don't find them often in our public hospitals. Third, patients with inguinal or umbilical hernias in high socio-economic status consult early and get operated as elective before complications. Lastly, this socio-economic categorization is subjective and may not reflect the true difference in patient's economic status, biasing our finding. Nevertheless these possible hypotheses, this relationship needs more attention in next studies.

The outcomes of our patients were measured in terms of morbidity and mortality, and were 38.46% and 9.23% respectively. The big numbers of complications were minor, whereas the major complications accounted 17.46%. The most common complications were surgical site infection (SSI) and sepsis, both accounting for 48% of all complications. This was similar to other researchers findings including Ogundoyin et al finding in Nigeria, and Khursheed in an Indian center, where SSI and sepsis were also the common complications representing 40.77% and 25.1% respectively(16,38). Apart from death, the common major complications were intra-abdominal abscess, stoma related complications and wound/fascia dehiscence all requiring reoperation. The major complications represented 16.16% in Ogundoyin et al study findings(16). Such complications represented 10% in Khursheed et al study, including burst abdomen, fecal fistula and acute renal failure(38).

The morbidity in our study was high (38.46%), compared to many study findings (4-33%) (8,25,38). However, a study in Nigeria by Ogundoyin et al reported a higher morbidity of 60.78%. This difference may be attributed to the variability of patient's characteristics and the definition of morbidity. The reviewed previous studies did not use Clavien-Dindo classification of surgical complications as in our study, and often overlooked the minor complications.

The mortality in our study is lower compared to the findings in previous local study of 2012 by Ngendahayo et al, where the mortality rate was 28% among patients with intussusception. This indicates an appreciable improvement of Rwandan health system over the last 8 years. This mortality was comparable to that found from retrospective review of 11.2% by Adam G. in Ghana(23), but it was higher compared to other study findings in different countries like Kenya, Malawi, Nigeria and India, ranging from 2.9%-7.8% (3,9,15–17,38). This difference in mortality can be due to the fact that each country or center has different patient's characteristics, and facility settings.

The length of hospital stay in our study was $8 \pm 6\ days$. It was compared to findings in other countries and it is quite similar to that of Adam G. et al in Ghana which was $8.2 \pm$ 5.7 days(23). This was smaller compared to duration of 13 ± 13.7 days found by Shah et al in Malawi(9), but longer to the study finding of 6 days in Nepal by Hazra et al(25). The longer hospital stay can predispose to other medical problems as hospital acquired infections and malnutrition, which can further increase the morbidity rate.

There were 3 factors associated with morbidity and they include the finding of gangrenous bowels at the time of operation, bowel resection and low hemoglobin at admission. Bowel strangulation in case of intestinal obstruction may depend on nature of etiology, but it is often due to time spent from onset to intervention. The patients presenting with intestinal strangulation will often come with severe dehydration and electrolytes imbalance secondary to longstanding vomiting or fluids shift. In addition, the level of bacterial load and contamination during bowel resection are high, which leads to systemic or abdominal sepsis. All these factors explain high complications rate in this category of patients. Initial assessment should focus on identifying the patients with strangulated bowels, as it is important for communication with parents before surgery for possibility of high morbidity. Preoperative anemia is a known modifiable risk factor associated with increased complications after emergency laparotomy(39). Anemia in our patients can be related to other prevalent comorbidities in our population including malnutrition and malaria and if combined can result in observed high morbidity. So far there is no valid recommendation on management of mild to moderate anemia in patients undergoing laparotomy.

The mortality was associated with low socio-economic status and anemia at admission. Patients in low socio-economic are likely to present late, and at risk of malnutrition and anemia. As previously discussed, anemia was shown to contribute in post-operative complications for patients undergoing laparotomy. In one review by Anil J. et al, reported different factors associated with mortality including delayed diagnosis, low socio-economic status, anesthesia complications and lack of ICU(18).

Our study has several limitations. Due to intermittent technical problems in laboratory, we did not get some investigations like liver and renal function tests of a big number of patients. Consequently we were unable to analyse the effect of organ failure at admission on outcome. The sample size in our study could have not detected the statistical difference which can be detected with a bigger sample. The factors associated with mortality was not analysed with multivariate statistics due to low event per variable (EPV). The definition of pediatrics population is different through literature and this can also explain the variability of results in different studies.

6 CONCLUSION AND R ECOMMENDATIONS

6.1 Conclusion

We conducted this prospective observational study in 2 Rwandan university teaching hospitals in order to assess the etiologies of intestinal obstruction in pediatric patients, as well as factors associated with morbidity and mortality.

Intestinal obstruction is a common condition in pediatric surgical patients in Rwanda university teaching hospitals. Intussusception is the common cause of intestinal obstruction. Other common causes of intestinal obstruction are hirschsprung disease, abdominal wall hernias, intestinal worms, adhesions and hypertrophic pyloric stenosis. Other rare causes include malrotation, duodenal atresia, jejunal web, congenital band, imperforate anus and ileosigmoid knotting. Intestinal obstruction is common in male, low socio-economic status and below 6 years patients. The morbidity and mortality are high in our patients, and associated with low hemoglobin at admission and finding of gangrenous bowels at the time of surgery.

6.2 Recommendations

The following recommendations are addressed to health care providers daily caring on pediatric patients, ministry of health and teaching hospitals:

1. Conducting a countrywide study to evaluate the etiologies of intestinal obstruction in pediatric patients.
2. An assessment of reasons of delayed consultation of children with intestinal obstruction
3. Training and regular mentorship of district hospital physicians about early recognition, initial management and timely referral of children with intestinal obstruction.
4. Establish the protocol on management of moderate anemia of children who will undergo emergency laparotomy.
5. Early evaluation and identification of patients with possible intestinal strangulation, and provide the optimal perioperative care to improve their outcome.

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APPENDICES

1. Data collection form

Form number:

Study ID:

Project title	**ETIOLOGICAL ANALYSIS AND FACTORS INFLUENCING SHORTERM OUTCOMES OF PEDIATRIC INTESTINAL OBSTRUCTION IN 2 RWANDAN UNIVERITY TEACHING HOSPITALS**	
Investigator	Dr TWAHIRWA Isaie	Tel: 0783330394 Email: twahirwa60@gmail.com
Patient name		ID:
Patient characteristics and demographics	Age	
	Sex	
	Ubudehe category	
	Home province	
	Home district	
Etiology of obstruction		
Duration of symptoms		
Associated comorbidity (Concurrent medical condition)		
Vitals signs at admission	Heart rate:	Respiratory rate:
	Saturation:	Temperature:
Level of consciousness	Normal	Decreased
Hydration status	Buccal mucosa (dry or normal)	
	Capillary refill time (normal or decreased)	
	Extremities (cold or warm)	
	Peripheral pulses (normal, decreased or increased)	
	Urine output (low or normal)	
	Sunken eyes (yes, no)	

	Conjunctiva (pale, normal)		
Laboratory investigations	WBC		
	Hemoglobin		
	Platelets		
	Urea		
	Creatinine		
	AST		
	ALT		
	Sodium		
	Potassium		
	Chloride		
Management details	Non operative		
	Operative		
	Operative finding		
	Operation performed		
Primary surgeon experience	Resident under consultant supervision		
	Resident alone		
	Consultant		
Postoperative disposition	General ward	HDU	ICU
Post-operative complications	Time of feeding		
	SSI (superficial or deep)		
	Wound dehiscence		
	`Unplanned reoperation		
	Stoma complication (prolapse, retraction or necrosis)		
	Post-operative fever		
	Overall days of hospital stay		
	Death		
	Any other complication not specified above		

2. Ethical approvals

2.1 CMHS-IRB approval

UNIVERSITY of RWANDA

COLLEGE OF MEDICINE AND HEALTH SCIENCES

DIRECTORATE OF RESEARCH & INNOVATION

CMHS INSTITUTIONAL REVIEW BOARD (IRB)

Kigali, 20th May 2020

Dr TWAHIRWA Isaie
School of Medicine and Pharmacy, CMHS, UR

Approval Notice: No 076/CMHS IRB/2020

Your Project Title ***"Pediatric Intestinal Obstruction: Etiological Analysis And Factors Influencing Short Term Outcomes (In Hospital) In 2 University Teaching Hospitals-University Teaching Hospital Of Kigali (CHUK) And University Teaching Hospital Of Butare (CHUB)"*** has been evaluated by CMHS Institutional Review Board.

		Involved in the decision		
			No (Reason)	
Name of Members	**Institute**	Yes	**Absent**	**Withdrawn from the proceeding**
Prof Kato J. Njunwa	UR-CMHS		X	
Prof Jean Bosco Gahutu	UR-CMHS	X		
Dr Brenda Asiimwe-Kateera	UR-CMHS	X		
Prof Ntaganira Joseph	UR-CMHS	X		
Dr Tumusiime K. David	UR-CMHS	X		
Dr Kayonga N. Egide	UR-CMHS	X		
Mr Kanyoni Maurice	UR-CMHS		X	
Prof Munyanshongore Cyprien	UR-CMHS	X		
Mrs Ruzindana Landrine	Kicukiro district		X	
Dr Gishoma Darius	UR-CMHS	X		
Dr Donatilla Mukamana	UR-CMHS	X		
Prof Kyamanywa Patrick	UR-CMHS		X	
Prof Condo Umutesi Jeannine	UR-CMHS		X	
Dr Nyirazinyoye Laetitia	UR-CMHS	X		
Dr Nkeramihigo Emmanuel	UR-CMHS		X	
Sr Maliboli Marie Josee	CHUK	X		
Dr Mudenge Charles	Centre Psycho-Social	X		

After reviewing your protocol during the IRB meeting of where quorum was met and revisions made on the advice of the CMHS IRB submitted on 20th May 2020, **Approval has been granted to your study.**
Please note that approval of the protocol and consent form is valid for **12 months**.

You are responsible for fulfilling the following requirements:

1. Changes, amendments, and addenda to the protocol or consent form must be submitted to the committee for review and approval, prior to activation of the changes.
2. Only approved consent forms are to be used in the enrolment of participants.
3. All consent forms signed by subjects should be retained on file. The IRB may conduct audits of all study records, and consent documentation may be part of such audits.
4. A continuing review application must be submitted to the IRB in a timely fashion and before expiry of this approval
5. Failure to submit a continuing review application will result in termination of the study
6. Notify the IRB committee once the study is finished

Sincerely,

Date of Approval: The 20th May 2020

Expiration date: The 20th May 2021

Professor GAHUTU Jean Bosco
Chairperson Institutional Review Board
University of Rwanda College of Medicine and Health Sciences

Cc:

- Principal College of Medicine and Health Sciences, UR
- University Director of Research and Postgraduate Studies, UR

2.2 CHUK approval

CENTRE HOSPITALIER UNIVERSITAIRE
UNIVERSITY TEACHING HOSPITAL

Quality Health Care
Training & Research

Ethics Committee / Comité d'éthique

13,Jul,2020 *Ref.:EC/CHUK/054/2020*

Review Approval Notice

Dear TWAHIRWA Isaie,

*Your research project: "**pediatric intestinal obstruction: etiological analysis and factors influencing short term outcomes (in hospital) in university teaching hospitals-university teaching hospital of Kigali (CHUK) and university teaching hospital of Butare (CHUB).** "*

During the meeting of the Ethics Committee of University Teaching Hospital of Kigali (CHUK) that was held on 13,Jul,2020 to evaluate your request for ethical approval of the above mentioned research project, we are pleased to inform you that the Ethics Committee/CHUK has approved your research project.

You are required to present the results of your study to CHUK Ethics Committee before publication by using this link:www.chuk.rw/research/fullreport/?appid=118&&chuk.

PS: Please note that the present approval is valid for 12 months.

Yours sincerely,

Dr Emmanuel Rusingiza Kamanzi
The Chairperson, Ethics Committee,
University Teaching Hospital of Kigali

ETHICS COMMITTEE
CHUK

2.3 CHUB approval

CENTRE HOSPITALIER UNIVERSITAIRE
UNIVERSITY TEACHING HOSPITAL

CENTRE HOSPITALIER UNIVERSITAIRE DE BUTARE (CHUB)
OFFICE OF DIRECTOR GENERAL

Huye, ..15./.07./2020

N° Ref: CHUB/DG/SA/07/123/../2020

Isaie TWAHIRWA
CMHS, School of Medicine and Pharmacy
PGY III. General Surgery
Phone: +250783330394
Email: twahirwa60@gmail.com

Dear Twahirwa,

Re: Your request for data collection

Reference made to your letter requesting for permission to collect the data within University Teaching Hospital of Butare for your research proposal entitled ***"Pediatric intestinal obstruction: etiological analysis and factors influencing short term outcomes (in hospital) in 2 University Teaching Hospitals* (CHUK and CHUB)"**, based to the approval **No: RC/UTHB/012/2020** from our Research-Ethics Committee, we are pleased to inform you that you are accepted to collect data within University Teaching Hospital of Butare. Please note that your final document will be submitted in our research office.

Sincerely,

Dr. Augustin SENDEGEYA
Director General of CHUB

Cc:

- Ag. Head of Clinical Education and Research Division
- Ag. Director of Research
- Chairperson of Research-Ethics Committee
- Head of Surgical Department
- Ag. Research officer