

**PREVALENCE AND RISK FACTORS FOR INCARCERATION IN CHILDREN  
MANAGED FOR UMBILICAL HERNIAS AT KENYATTA NATIONAL HOSPITAL**

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A RESEARCH SUBMITTED AS PART OF FULFILMENT FOR THE AWARD OF MASTER  
OF MEDICINE IN PAEDIATRIC SURGERY,  
UNIVERSITY OF NAIROBI

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## **DECLARATION**

This research is my original work and it has not been undertaken before, neither has any publication on the subject matter been done. Whenever I have used any person's work, I have accordingly acknowledged and referenced.

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## **ACKNOWLEDGEMENT**

First and foremost, I am grateful to God, the Almighty for the bountiful blessings bestowed on me during this time that were necessary to complete this book.

I recognize and appreciate the support from all my teacher at the department of surgery and paediatric surgical unit at the University of Nairobi and Kenyatta National Hospital.

I am especially grateful for the assistance given to me by my supervisors Dr. F. Osawa, Dr. P. Mwika and Dr. T. Jumbi whose patience, wisdom and encouragement made this possible.

Finally I must express my very profound gratitude to my family, friends and colleagues for providing me with continuous encouragement throughout my years of study and through the process of writing this book.

## **LIST OF ABBREVIATIONS**

BWS	Beckwith Wiedemann Syndrome
BMI	Body mass index
ERC	Ethics Research Committee
ICU	Intensive Care Unit
KNH	Kenyatta National Hospital
UH	Umbilical hernia
UON	University of Nairobi

## **DEFINITION OF TERMS**

**Umbilical hernia:** Protrusion of abdominal content through a defect at the umbilical ring.

**Incarceration:** Entrapment of the hernia content within the defect i.e. irreducible hernia

**Strangulation:** compromise of blood supply to the bowel resulting from incarceration and may lead to bowel ischemia, gangrene and perforation

**Comorbidity:** is the presence of one or more additional conditions often co-occurring with a primary condition. Comorbidity describes the effect of all other conditions an individual patient might have other than the primary condition of interest.

**Respiratory tract infections:** are infectious diseases involving the respiratory tract. These infections are associated with cough that if persistent may predispose to UH formation and incarceration.

**Chronic cough:** cough that persists beyond four weeks in children.

**Bladder outlet obstruction:** occurs when there is a blockage at the base or neck of the bladder that reduces or stops the flow of urine into the urethra.

**Chronic constipation:** unsatisfactory defecation characterized by infrequent stool, difficult stool passage or both at least for previous 3 months.

## Table of contents

### Contents

DECLARATION	ii
SUPERVISORS' DECLARATION	iii
DEPARTMENTAL APPROVAL	iv
ACKNOWLEDGEMENT	v
LIST OF ABBREVIATIONS	vi
DEFINITION OF TERMS	vii
ABSTRACT	x
CHAPTER ONE: INTRODUCTION	1
CHAPTER TWO: LITERATURE REVIEW	3
2.1 SURGICAL ANATOMY OF UHs	3
2.2 DEMOGRAPHICS	3
2.2.1 Incidence	3
2.3 INCARCERATION OF UMBILICAL HERNIA	4
2.3.1 Risk factors for incarceration	5
2.4 MANAGEMENT	7
2.5 OUTCOMES	8
2.6 STUDY JUSTIFICATION	9
2.7 STUDY QUESTIONS	9
2.8 OBJECTIVES OF THE STUDY:	9
2.8.1 Broad objective:	9
2.8.2 Specific objectives:	9
CHAPTER THREE: METHODOLOGY	10
3.1 Study Design	10
3.2 Study Site	10
3.3 Study Population	10
3.3.1 Inclusion Criteria	10
3.3.2 Exclusion Criteria	10
3.4 Sample Size	10
3.5 Study Variables	10
3.7 Study Flow	12

3.8 Ethical Considerations	12
3.9 Quality Assurance	12
3.10 Data Collection	13
3.11 Data Management	13
3.12 Data Analysis	13
3.13 Reporting of Findings	14
3.15 Study Timelines	15
3.16 Study Budget	15
CHAPTER 3: RESULTS	16
CHAPTER 4: DISCUSSION	26
STUDY LIMITATION	29
CONCLUSION AND RECOMMENDATION	29
REFERENCES	30
ANNEXES	35
ANNEX 1: DATA COLLECTION TOOL	35

## **ABSTRACT**

**Background of the study:** Umbilical hernia is common among children. The natural history is spontaneous involution of the defect by 5 years of age but can progress into adulthood. Most published literature recommends that asymptomatic umbilical hernias can be safely observed until 5 years of age while awaiting spontaneous closure. These recommendations are based on epidemiological studies mainly carried out in developed countries and on Caucasian population that report low incarceration rates hence no significant morbidity and mortality

In Africa and black population in general higher incidence of incarcerations are reported with potentially serious complications. Therefore, the expectant management approach based on close observation and follow up until involution recommended by most western authors may not be feasible in Africa and some authors are advocating for operative intervention of umbilical hernia at the time of diagnosis due to high complication rates

Despite the high incarceration rates in African population, umbilical hernias are poorly studied with paucity of local data. Therefore, more studies are needed to clearly understand the prevalence and risk factors for incarceration in black population.

**Objective:** To determine the prevalence and risk factors for incarceration in children managed for umbilical hernias at Kenyatta National Hospital

**Materials and methods:** This was a retrospective cross-sectional analytical study carried out at Kenyatta National Hospital health information department. A census of all children 13 years and below managed for umbilical hernias between January 2014 to December 2020 were carried out and their records retrieved. Data collection was by data extraction tool and was analyzed using SPSS 24.0. Data included the age at presentation, sex, weight, height, defect size, nutritional status, presence of comorbidities, and was presented as frequencies, proportions and percentages in tables and graphs. Pearson chi-square tests and logistic regression analysis was used to determine the factors responsible for incarceration in paediatric umbilical hernias at KNH. Odds ratio as well as 95% confidence interval were reported where applicable. Statistical significance for all tests was considered where the  $p < 0.05$ .

**Results:** A total of 268 children managed for umbilical hernias were enrolled in the study. 147 (54.9%) were male and 121 (45.1%) were female. The mean age was 2.87 ranging from 1 month to 13 years. 131 (48.9%) were incarcerated while 137 (51.1%) were non-incarcerated. Among the

risk factors assessed, incarceration was commonly observed in those below 2 year of age (60%), medium defect size (0.5-1.5cm) and those with comorbidities, chronic cough being the most common, with significances of 0.002, 0.00, and 0.00 respectively. There was no significant association between incarceration and gender and nutritional status. It was noted that a combination of age below 2 years, medium defect size and chronic cough was mostly associated with incarceration, [ $R^2 = 0.246$ , 68.3%].

**Conclusion:** The prevalence of incarcerated umbilical hernia in children in our environment is high and there exist a significant association between age, defect size, comorbidity and incarceration. A process of active observation is advisable if feasible. However, due to poor follow-up in our environment and similar environments, elective repair of umbilical hernia at the time of diagnosis is recommended.

## **CHAPTER ONE: INTRODUCTION**

Umbilical hernia is a bulge at the site of the umbilicus with associated fascial defect. It is a frequent pathology of the anterior abdominal wall in children. It is formed as a result of incomplete closure or failure of closure of the umbilical ring, leaving a defect through which herniation of intra-abdominal content can occur (1).

The incidence of umbilical hernia is estimated to be 15% in children (2). It varies with age, race, gestational age and coexisting conditions (3). They are more common in blacks, premature, low birth weight, syndromic babies, children with connective tissue disorders and children with pathologies that lead to increased intra-abdominal pressure (4–6). The incidence is higher in black population ranging from 25-58% compared with 2-20% in Caucasians (7). It occurs with equal frequency in boys and girls (3).

Umbilical hernias mainly become problematic when they start to incarcerate. The rate of incarceration of umbilical hernia in the general population is low, it however differs based on geographical location, race, age, gender, nutrition status and comorbidity (8). Studies in the west and on Caucasian population indicate incarceration rates between 0.19% to 4.5% (2,9,10). In contrast similar studies on African population and blacks in general showed as high as 44.2% incarceration rates (11).

Similarly, the timing of incarceration was noted to be earlier in African population. Fall et al. had an average age of incarceration of 14 months (ranging from 8 months to 3years) in their study done in Senegal (12). Amah et al. in their study done in Nigeria 67% of patients with incarceration were younger than 4 years and 33% younger than 2 years (13). In contrast Ireland et al. found a mean age of incarceration of 5 years in Australia (10). The sequelae of incarceration include: obstruction, strangulation, perforation and evisceration. This could result in significant bowel loss hence morbidity and mortality.

The majority of umbilical hernias close spontaneously by 5 years of age hence expectant management policy is advocated (14). Operative intervention is reserved for symptomatic patients. Surgical management for asymptomatic patients remains controversial and depends on surgeon's preference and institutional practice (9,15–19). Some African authors advocate for surgical intervention of all umbilical hernias at the time of diagnosis on the basis of higher rate of

incarceration, earlier age of incarceration and the fact that close observation may not be feasible where access to healthcare is a challenges (12,20).

Currently there are no consensus recommendations or practice guidelines regarding the appropriate timing of repair of umbilical hernia(16–19), therefore more data on the rate of incarceration, determining factors and optimal age of incarceration will help in determining the need for prophylactic repair to avoid complications.

The aim of this study was therefore to determine the rate of incarceration and the likely determining factors for incarceration. The results of this study will contribute to better understanding the disease process and formulation of local practice guidelines.

## **CHAPTER TWO: LITERATURE REVIEW**

### **2.1 SURGICAL ANATOMY OF UHs**

Umbilical hernia is a protrusion of abdominal content through the umbilical ring which is a dense fascial ring that represents a defect in the linea alba (1). Naturally the umbilical ring is strongly reinforced by round ligament superiorly which crosses the ring to insert to its inferior margin, inferiorly by the urachus and median umbilical ligaments and laterally by the umbilical fascia (thickened transversalis fascia) to facilitate timely closure of the ring. The variation of the anatomy of the umbilical region that alters the relationship of the umbilical ring to the linea alba, round ligament, urachus, median umbilical ligaments and umbilical fascia leads to a defect formation that predispose to umbilical hernia (7,21,22)

On the surface, the umbilicus of the newborn has been classified into three anatomical types by Anderson et al (23). The 'normal' type where the cord extends completely into the abdominal wall which is mainly found in Caucasian newborns. The 'skin' type where the cord stops ¼ inch from the abdominal wall joined by tubular projection of peritoneum lined integument. This is more common in blacks. The 'amniotic' type in which the cord runs directly into the abdominal wall formed by a rim of a small circle of amnion. The skin type is mainly associated with umbilical hernia formation (23).

### **2.2 DEMOGRAPHICS**

#### **2.2.1 Incidence**

The commonness of umbilical hernia among African children is well recognized, although few enquiries have been made to study the natural history of the disease and its importance (7,14,24). The reason for the high incidence in blacks is not known but it has been thought to be due to variant anatomy (21). The 'skin type' umbilicus as described by Anderson which is mainly found in blacks is associated with larger defect size, proboscis and predisposes to umbilical hernia formation. A study done in Nigeria to determine the type of umbilicus in African newborns showed 97% had 'skin' type and 3% had 'normal' type (23).

Others theorize that the presence of potbelly of toddlers in exaggerated form in African child due to bulky carbohydrate diet, common occurrence of considerable hepatosplenomegaly and weak abdominal musculature due to anemia play a role in the development of umbilical hernia in African population (7). Mahorner et.al attributed the high incidence in black as a result of absence of

umbilical fascia seen mostly in blacks than whites (24). Other risk factors for the development of umbilical hernia include;

**Genetics:** Occurrence of UH is in part dependent on the child's inherited status. The development of the anterior abdominal wall depends on differential growth of embryonic tissues. Even Though there is no single isolated gene specific for its occurrence, its association with syndromes and other genetic anomalies presumes genetic involvement. Syndromes causing defective abdominal wall musculature either by hypotonia or as a disorder of connective tissue favor the development of umbilical hernia e.g. down's, Cretinism, BWS, Cutis Laxa and Hurler's syndrome (25).

**Family history:** UH is more common in twins. It is also a frequent observation that if one infant has UH the next one in the family has one also. Jaffe et.al noted family history in one or both parents in many black kids with umbilical hernia (24).

**Mode of delivery:** There is higher incidence in breech delivery due to extensive cord traction (1)

**Birth weight and prematurity:** UH is seen in more than 80% of infants weighing <1200g compared with 21% of infants weighing >2500 g at birth (5,6).

### 2.3 INCARCERATION OF UMBILICAL HERNIA

Umbilical hernia mainly presents as an asymptomatic bulge of the umbilicus that is more prominent when coughing, crying or straining(26). Symptomatic presentations of irreducible bulge and abdominal pain indicate incarceration. Incarceration basically is entrapment of the hernia content within the defect. Complications arising from umbilical hernia incarceration include; obstruction, strangulation, perforation and evisceration (27).

Complications usually start with incarceration which can be simple or complex. Simple incarceration presents as an irreducible bulge associated with abdominal pain but with no signs and symptoms of bowel obstruction. Management is by manual reduction either by taxis or at surgery. Complex incarceration happens after a prolonged bowel entrapment leading to luminal occlusion. In addition to the abdominal pain, there is associated vomiting, abdominal distention and constipation. Strangulation comes in when occlusion causes bowel wall edema from lymphovascular obstruction leading to ischemia, necrosis, gangrene and subsequent perforation (28,29).

Evisceration on the other hand is an exceptionally rare but potentially fatal complication (30,31). It is thought to be precipitated by umbilical sepsis, ulceration or conditions that raise intra-abdominal pressure e.g. chronic cough, excessive crying, ascites or positive pressure ventilation (32,33). Mortality is high in patients who do not get access to emergency surgical intervention(30).

### 2.3.1 Risk factors for incarceration

**Race/geographical:** Literature from developed countries indicates that incarcerations of umbilical hernia are rare. Mistel et.al reported an incidence of 1 in 1500 umbilical hernias (34,35). Okada et al. in their literature review dating back more than 40 years found only 38 cases of incarcerated umbilical hernia worldwide (36). Papagrigoriadis et al. in their 20 year retrospective study done at King's college hospital in London found only 3 incarcerated cases but the surprising thing was that all the 3 cases happened in black children (2). Even though the incidence of incarceration in African children is not known, it appears to be higher than the west. For example in Nigeria the rate of incarceration is estimated to be 44.2% (11). One study conducted over a period of five years showed 41 children had emergency surgery for incarcerated umbilical hernia (12). In Nigeria at Jos University hospital 23 children had emergency surgery for incarceration (33). In a comparison study between umbilical hernias and inguinal hernias carried out by Gabriel Ngom et al. in Senegal, incarceration rate of umbilical hernia was 20% compared to 6% in inguinal hernia (20). They recommended that umbilical hernias in black children should be treated with the same attitude as that of inguinal hernias hence should be operated upon diagnosis (20).

**Age:** Incarceration of umbilical hernias have been observed to occur earlier than expected age of spontaneous closure more so in African studies (13,33). The main factor contributing to incarceration of umbilical hernias in children is younger age (27). The mean age of incarceration in the study by Ngom et al. was 10 months with extremes of 1month to 13.5 years (20). In a 3 year retrospective study in Burkina Faso over two third of those with incarcerations were under 5 with extremes of 2 months and 13 years (37). 67% of cases with incarcerations in the study by Ameh et al. in Nigeria were under 4 years of age with 33% of them below 2 years (13). These findings are identical to those reported by Harouna et al. in Niger (38) and Fall et al in Senegal who reported a mean age of 14 months (12). Studies from the developed world have reported older ages of incarceration. Ireland et al. from Australia found a mean age of incarceration of 5 years (10) while Zendejas et al. from the United States reported a mean age of 4.7 (3).

**Defect size:** Lassalatta et al. classified umbilical hernia defect size by measuring the diameter into; small (<0.5cm), medium (0.5-1.5cm) and large (>1.5cm) (39). Surgical closure is indicated in hernias with large defects and in those the defect size is increasing (18). Even though umbilical hernia can incarcerate regardless of the size of the defect, the majority of incarcerations happen in small and medium size defects (36,37,39,40). In the study by Okada et al. 52% of patients with incarceration had medium sized fascial defect, 24% had small sized defect and 24% had large size defect (36). 80% of children with incarcerations in the Ngom et al. study had a defect size less than 1.5 cm (20). From these studies one will argue that umbilical hernias with medium and small defects should be considered for prophylactic surgery as they are the most likely to incarcerate. Defect size is measured with the subject in supine position and the abdominal wall relaxed by use of either an ultrasound machine or by the tip of the examiner's finger during examination or intraoperatively using a ruler (4,41).

**Comorbidities:** Conditions that leads to increased intra-abdominal pressures have been implicated both in the formation of umbilical hernias as well as increased risk of incarceration (3,7,23). These conditions include; respiratory tract infections causing excessive/chronic cough, chronic constipation, bladder outlet obstruction and ascites. E.Bandre et al reported some aspects of seasonal variability where high incarceration rates are observed in cold seasons when respiratory tract infections are relatively common (37). In a series of 35 patients with strangulated hernia reported by Ngom et al. Sixty-five percent had rhinitis, asthma or pneumonia (42). This increase in incarceration is explained by an increase in abdominal pressure during attacks of cough which forcefully propels bowel loops through a narrow hernia neck.

**Malnutrition:** Patients with malnutrition have poorly developed abdominal wall musculature and tone. This delays spontaneous closure of the umbilical hernia predisposing to increased risk of incarceration (7,24). In addition, malnutrition promotes developments of certain infectious pathologies particularly broncho-pneumopathies and ascites which increase intra-abdominal pressure. 57% of patients with incarceration in the study by Bandre et al. had a history of malnutrition and 56% of those had respiratory infections (37).

Numerous options are available to assess the nutritional status of a child, broadly classified as objective and subjective modalities (43). Objective assessment can either be anthropometric measurements of body composition or measurement of serum protein levels. Subjective

assessment includes incorporation of both subjective data from patient's history and anthropometric body composition measurements. Anthropometric nutritional assessment modalities are objective assessment tools involving measurements of body dimensions and compositions to evaluate the nutritional status and growth. The most basics are age, sex, weight, height and head circumference. This is a common and inexpensive method to assess growth and nutritional status, which can also be charted on a standardized growth curve for comparison with normative data. Once a patient is over two years of age, weight to height ratio can best be reflected using body mass index (BMI) or expression of BMI as a Z score (43).

$$\text{Z-score} = \frac{\text{measured value} - \text{median value of the reference population}}{\text{Standard deviation of the reference population}}$$

#### **Standard deviation of the reference population**

*Gender:* Even though no variation in gender is reported in the occurrence of umbilical hernia in most literature (3), there have been reports of higher incidence of incarcerations in females (44). It is not clear why the incidence of incarceration is higher in girls than boys but Ladd and Gross have suggested that it is possibly related to the less well-developed musculature in females hence delay in spontaneous closure (45). Mawera et al in their study, 60% of the patients with incarceration were females and the average age was 2.5 years compared with an average 13 years in boys (24).

#### **2.4 MANAGEMENT**

There is significant variability surrounding surgical repair of asymptomatic umbilical hernia (17). Most surgeons advocate for surgical closure if hernia persists by the age of five (15). This is attributed to the fact that up to 90% of the hernias should have spontaneously closed by then and spontaneous closure is unlikely beyond this age (19,46). This practice of delaying repair up to 5 years of age is based on epidemiological data from developed countries suggesting low-risk of complications (15). They recommend an expectant management approach which involves close observation and follow up, parental education on complications and access to healthcare facilities (16–18). Considerations for early operative interventions include symptomatic hernias, large or enlarging defects, parental concerns and access to healthcare (18).

Epidemiological studies from African population greatly differ from those from developed countries in terms of expected age of spontaneous closure, rate of incarcerations, and age of

incarceration, parental literacy levels and accessibility to healthcare (11–13,20,33,37). In African population up to 64% of umbilical hernias have been found to persist beyond 6 years of age with up to 27% of adults living with the condition hence the majority of umbilical hernias in African population end up in surgical closure (23). In Africa higher rates of incarcerations of umbilical hernia are observed with most of the incarcerations occurring way before the expected age of spontaneous closure. Low literacy levels among parents, poverty and poor access to healthcare increases the risk of complications in Africa (12). Therefore umbilical hernia is a potentially serious condition in developing countries where accessibility to healthcare is often difficult hence absence of any possibility of active monitoring of hernias (37). This has made some African authors to recommend repair of all umbilical hernias in children at the time of diagnosis while others recommend that priority should be given to those who live one hour away from surgical resources (12,20,37).

## 2.5 OUTCOMES

Umbilical hernia surgery is thought to be straightforward repair with no significant challenges and minimal postoperative morbidity and mortality (3). Only two deaths have been reported in literature from the west (15) but mortality in Africa is estimated to be as high as 3-9% (37). This mortality is high for a condition whose treatment is simple in the absence of complications and is attributed to delay in consultation and poor general condition of the patient upon admission (11). Higher postoperative complication rates are found in patients who present with complicated umbilical hernias (27). Commonly encountered postoperative complications include; wound infection, hematoma and seroma formation, cosmetic complications (granuloma and scarring) and recurrence. Incidence of wound infection ranges from 0.8% in America to 33.3% in Nigeria with the deference attributed to higher rates of incarceration in African population (16).

Post-operative recurrence is very rare with incidence ranging from 0.27- 2.44% (3). The most significant predictors of recurrence were found to be the presence of preoperative complications and the type of suture material used (3). Zendejas et al. found that hernias repaired with non-absorbable sutures, especially silk were nearly 6 times more likely to recur due to increased tissue reactivity. No Relationship was found between recurrence and age, gender, ethnicity, prematurity, defect size or surgical technique (3). The incidence of cosmetic complication, hematoma and seroma formation is reported to less than 2% (47).

## 2.6 STUDY JUSTIFICATION

Dissimilarities exist in literature between those encountered in developed countries and those reported in recent years by African authors. With the likelihood of higher complication rates of umbilical hernias in African children, poor access to healthcare and earlier age of incarceration than expected age for spontaneous closure, perhaps it is time to reexamine the current recommendation of expectant management in African children. Some of the African authors quoted above recommend repair of all umbilical hernias in children while others recommend that priority should be given to those who live distant from surgical resources, however most agree that more research is necessary to determine the actual incidence of incarceration and to identify which patients are at greatest risk of incarceration. In fact, no work has been carried out on this condition in children in this country. Therefore, this study will aim at providing more data and perhaps more knowledge on this topic. Finally, the study will provide information to help in formulation of local guidelines in the management of pediatric umbilical hernias.

## 2.7 STUDY QUESTIONS

1. What is the prevalence of incarceration in children managed for umbilical hernias at Kenyatta National Hospital?
2. What are the risk factors for incarceration in children managed for umbilical hernias at Kenyatta National Hospital?

## 2.8 OBJECTIVES OF THE STUDY:

### 2.8.1 Broad objective:

To determine the prevalence and risk factors for incarceration in children managed for umbilical hernias at Kenyatta National Hospital

### 2.8.2 Specific objectives:

1. To determine the rate of incarceration in children managed for umbilical hernias at KNH
2. To determine risk factors for incarceration in children managed for umbilical hernia in KNH including age, gender, defect size, nutritional status and comorbid conditions.

## **CHAPTER THREE: METHODOLOGY**

### **3.1 Study Design**

This was a retrospective cross sectional analytical study conducted among children managed for umbilical hernias at the Kenyatta National hospital.

### **3.2 Study Site**

The study was conducted at the Kenyatta National hospital, Nairobi Kenya. KNH hospital is the largest referral hospital in Kenya in Nairobi County. The hospital has a total bed capacity of 1800 and with functional surgical, pediatric, medical, obstetrics and gynecology units, 24 theaters and a 20 bed HDU/ICU. It also has a functional imaging department with an X-ray, ultrasound, CT scan and MRI. The management of patients with umbilical hernia is undertaken from the pediatric emergency unit, pediatric surgery outpatient clinic and the inpatient departments.

### **3.3 Study Population**

The study population were all children aged 13 years and below managed for umbilical hernias between January 2014 and December 2020 at KNH.

#### **3.3.1 Inclusion Criteria**

The study included all Children aged 13 years and below managed for umbilical hernias at KNH during the study period.

#### **3.3.2 Exclusion Criteria**

- I. Patients with missing files.

### **3.4 Sample Size**

A census of all patients in the study population who meet the inclusion criteria.

### **3.5 Study Variables**

The study variables are documented in the patient's clinical and operative records. Comorbid conditions that were of interest to this study were those that lead to increased intra-abdominal

pressures which have been implicated both in the formation of umbilical hernias as well as increased risk of incarceration. These conditions include; respiratory tract infections causing excessive/chronic cough, chronic constipation, bladder outlet obstruction and ascites. A patient who presents with UH is routinely questioned and examined for comorbidities during history taking and physical examination and the findings recorded in the file.

Table 1

The following table shows the study variables for assessment

Objective	Variables	Source of Data
Demographic characteristics	Age, gender.	File
Describe the pattern of presentation	Incarcerated Not incarcerated	File
Defect size	small (<0.5cm), medium (0.5-1.5cm) and large (>1.5cm)	File
Nutritional status	Weight, height	File
Presence of comorbidities	Chronic cough, Ascites, chronic constipation, bladder outlet obstructions, connective tissue disorders, others.	File

### 3.7 Study Flow

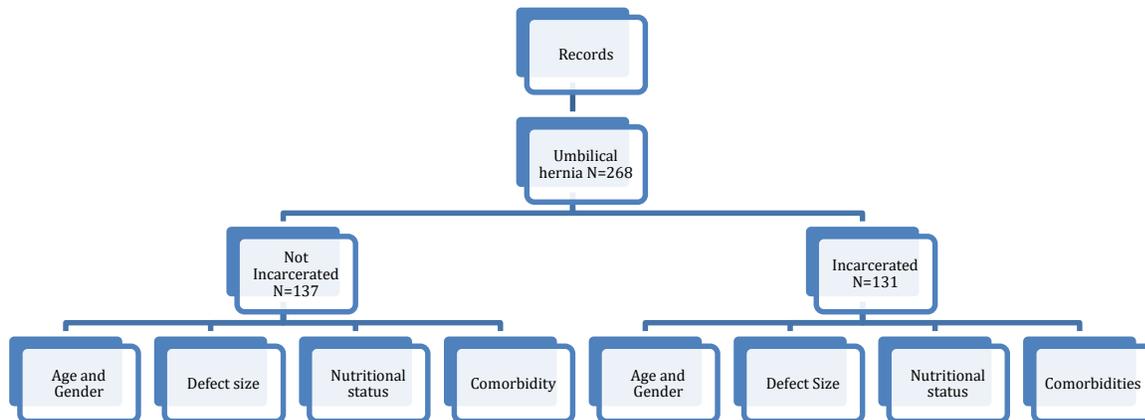


Figure 2: Study Flow Diagram

### 3.8 Ethical Considerations

The study proposal was submitted to the KNH-UON ethics and research committee (ERC). All patients' information were held in confidentiality and were used for the purpose for which this study is intended for only. This study did not include any invasive processes. There was no extra cost encountered by the patient. The findings of the study shall be disseminated to the KNH and University of Nairobi, presented in medical conferences, and published in medical journals and public media where necessary for the benefit of the medical profession and the public.

### 3.9 Quality Assurance

The researcher had trained two research assistants, post graduate residents from the department of paediatric surgery. They were keenly taken through the data collection tool, trained on retrieval of information from the medical records, data collection and handling, checking the accuracy of the data collected and maintenance of confidentiality to maintain the quality of abstracted data. The researcher and the research assistants adhered to the study protocol and ensured that the

methodology is rigorously adhered to. Cleaning and duplication was done before data analysis and the procedures documented.

### 3.10 Data Collection

This was carried out by the principal investigator and research assistants. It was done by collecting clinical information as captured in the patient's files after receiving permission to access the information from ERC and the hospital management.

File retrieval was done both electronic and manual. Electronic retrieval was done by searching the database for umbilical hernia using disease code and file numbers retrieved. Using file numbers files were retrieved manually from the filing area, and using a separate room, information were extracted from the file before returning them to the filing area. The data extracted was filled in the data collection tool. The collected data was identified by assigning study specific unique identifiers to the study participants. All electronic data were stored in an external hard drive and password protected after encryption.

### 3.11 Data Management

All data collected from the study questionnaires were uploaded into a password protected excel sheet and stored using non-identifiers so as to maintain confidentiality. The data was compiled, cross-checked and rectified as per the data collection tool. The data collection sheet was kept in a lockable cabinet with access restricted to the investigator and supervisors.

### 3.12 Data Analysis

The collected data was uploaded onto the SPSS version 24 software for cleaning, coding and analysis. The demographic characteristic age was analyzed and presented as mean with standard deviation, while sex, and co-morbidity were reported as frequencies and percentages. The size of umbilical defect in children was analyzed and reported as frequencies and percentages after being categorized into small (<0.5cm), medium (0.5-1.5cm) and large (>1.5cm).

The nutritional status of children were determined with the use of weight for age, height for age and body mass index (BMI) where applicable which were then categorized as overweight, normal weight or underweight, and reported as frequencies and proportions. The general descriptive

analysis of the comorbidities were presented as frequencies and proportions, and then for each patient the comorbidities were categorized for purpose of bivariate and multivariate analysis. The rate of incarceration of paediatric umbilical hernias at KNH was calculated as a proportion of those with presence of incarceration over the total number, and reported as a percentage.

Pearson chi-square tests and logistic regression analysis were used to determine the factors responsible for incarceration in paediatric umbilical hernias at KNH. Odds ratio as well as 95% confidence interval were reported where applicable. Statistical significance for all tests were considered where the  $p < 0.05$ .

### 3.13 Reporting of Findings

The study was conducted in three phases: phase one entailed recruitment and data collection, followed by data analysis and presentation to the hospital and the University of Nairobi. The third phase will entail feedback to the key stakeholders. The recommendations from these feedback sessions will be incorporated into the final report before publication in peer reviewed journals.

### 3.14 Study Limitations

Patients with missing clinical data. The study is restricted by availability and accuracy of records included in the survey as in all retrospective studies. This will be mitigated by thorough scrutiny and counterchecking of data.

### 3.15 Study Timelines

DURATION							
	Dec 20	Jan 21	Feb 21	Mar 21	Apr 21	May 21	Jun 21
Proposal Development							
Ethical Review							
Data Collection							
Data Analysis							
Manuscript development							

### 3.16 Study Budget

ITEM	COST(KSHS)-estimated
Ethics Review/NACOSTI	15,000
Stationery	10,000
Printing	10,000
Research Assistants	40,000
Statistician	40,000
Airtime	10,000
Record Retrieval	5,000
Miscellaneous	10,000
<b>Total</b>	<b>140,000</b>

## CHAPTER 3: RESULTS

### 3.1. Demographic Data

#### a. General observations

A total of 268 cases [147 (54.9%) male, 121 (45.1%) females] were recorded in the data collection. The mean age was 2.87 ranging from 0.1-13 years with cases of umbilical hernias distributed along the different age groups as outlined in *Table 1*. *Table 1* below also summarizes the means and standard deviation of some of the variables obtained in the present study.

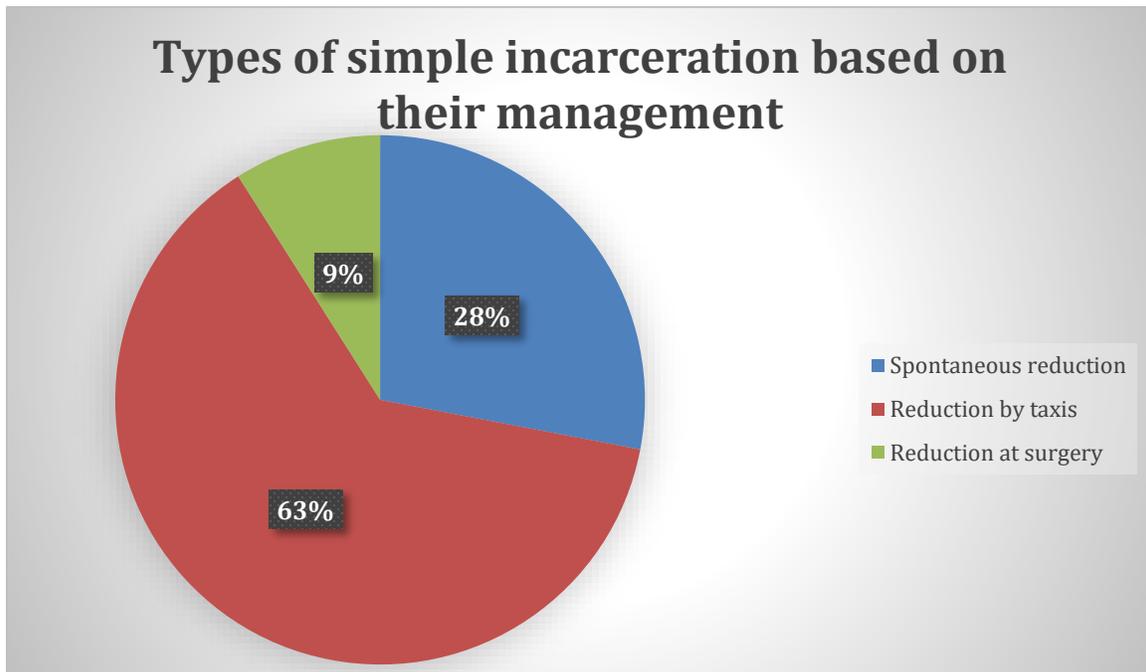
Table 1: Summary of Demographic data

Demographics	Number (n)	Percentage (%)
Age groups:		
0-23 months	128	47.8
2-6 years	109	40.7
7-12 years	25	9.3
>13yrs	6	2.2
<b>Variable</b>	Mean $\pm$ Standard deviation	Range (min-max)
Birth weight (Kg)	3.10 $\pm$ 0.47	1.20-5.0 Kg
Admission weight (Kg)	13.66 $\pm$ 9.83	2.0-50.0 Kg
Height (cm)	91.89 $\pm$ 20.34	45-130 cm

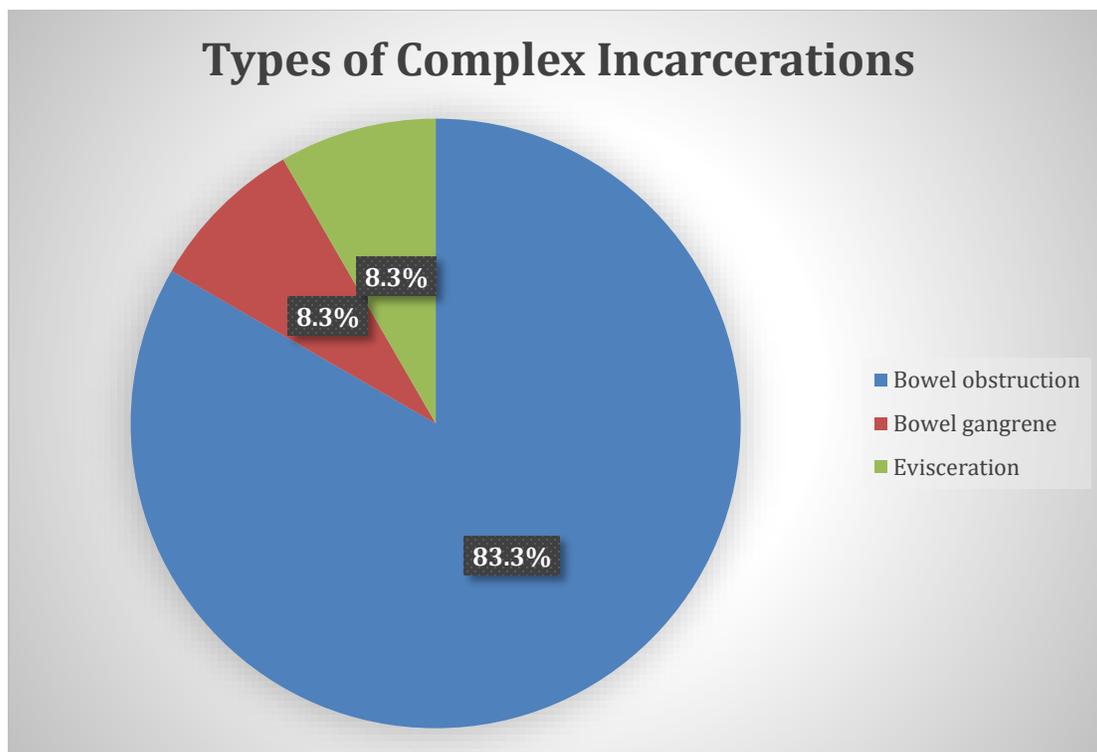
### 3.2. Prevalence of Incarceration in children managed for Umbilical Hernias at KNH

Of the 268 cases of umbilical hernia examined, 131 (48.9%) were incarcerated while 137 (51.1%) were non-incarcerated. Of the 131 incarcerated, 118 (90.1%) were noted to be simple incarcerations (without bowel obstruction, strangulation or evisceration) while 13 (9.9%) were complex (with either bowel obstruction, strangulation or evisceration). The 118 cases of simple incarcerations were further classified based on their management into those that underwent spontaneous reduction, reduced by taxis or reduction at surgery observed in 28.0% (33 cases), 63.0% (74 cases) and 9.0% (11 cases) respectively. The 12 cases of complex incarcerations were further subdivided into those that were complicated by bowel obstruction, bowel strangulation

(gangrene) or evisceration and were seen in 83.3% (10 cases), 8.3% (1 case) and 8.3% (1 case) respectively. *Figures 1 and 2* below present summaries of the above.



**Figure 1:** Types of Simple Incarceration based on their Management



**Figure 2: Types of Complex Incarcerations**

**b. Age and Gender**

As regards to age, a Kruskal-Wallis H test showed that there was a statistically significant difference in the rate of incarceration between the different age groups as outlined in *Table 2*,  $H(2) = 14.299$ ,  $p = 0.003$ , with a mean rank of 118.34 for infants (0-23 months), 149.60 for pre-school (2-6 years), 146.40 for school-going (7-12 years), and 155.33 for adolescents (13-18 years). Post-hoc findings further showed the difference observed to be particularly between infants and pre-school age groups ( $p = 0.000$ ).

From the findings in Mann-Whitney Test, it was observed that the difference in the rate of incarceration according to sex was not statistically significant ( $U = 8740.0$ ,  $p = 0.779$ ), *Table 2*.

Table 2: Prevalence of incarceration according to age and sex

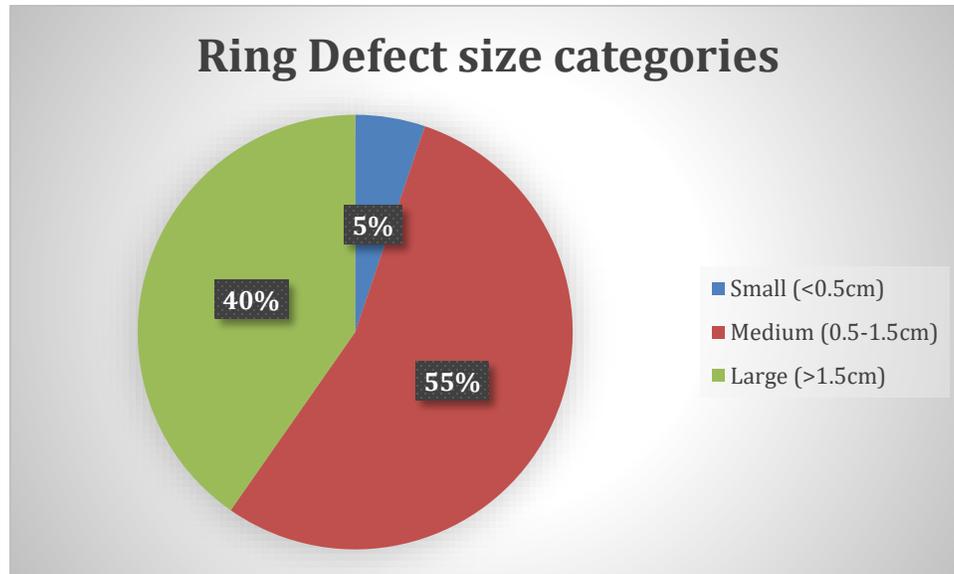
Demographics	Incarcerated		Non-incarcerated		P value
	No.	%	No	%	
Age:					
0-23 months	78	59.5	50	36.5	0.003
2-6 years	41	31.3	68	49.6	
7-12 years	10	7.6	15	10.9	
>13yrs	2	1.5	4	2.9	
Sex:					
Male	73	55.7	74	54.0	0.779
Female	58	44.3	63	46.0	

**c. Ring Defect Sizes and Categories**

The mean ring defect size was  $1.70 \pm 1.03$  (0.10-9.00) cm for all hernias with percentage distribution based on size (small, medium and large) as outlined in *Figure 3* below.

Kruskal-Wallis H test showed statistically significant difference in the rate of incarceration between the different ring defect size categories as outlined in *Table 3*,  $H(2) = 19.623$ ,  $p =$

0.000, with a mean rank of 123.43 for small (<0.5cm), 119.23 for medium (0.5-1.5cm) and 156.57 for Large (>1.5cm) defect ring sizes. Post-hoc findings further showed the difference observed to be particularly between medium and large ring defect sizes (p= 0.000).



**Figure 3:** Prevalence of ring size defects

Table 3: Prevalence of incarceration according to defect size

Demographics	Incarcerated		Non-incarcerated		P value
	No.	%	No	%	
Defect size:					
Small(<0.5cm)	8	6.1	6	4.4	0.000
Medium (0.5-1.5cm)	88	67.2	58	42.3	
Large (>1.5cm)	35	26.7	73	53.3	

**d. Nutritional Status**

Findings from Kruskal-Wallis H test showed that the difference in the rate of incarceration between the different groups of nutritional status was not statistically significant, H (2) =

2.003,  $p = 0.367$ , with a mean rank of 134.36 for underweight, 124.13 for normal weight and 138.91 for overweight nutritional status categories *Table 4*.

Table 4: Prevalence of incarceration according to nutritional status

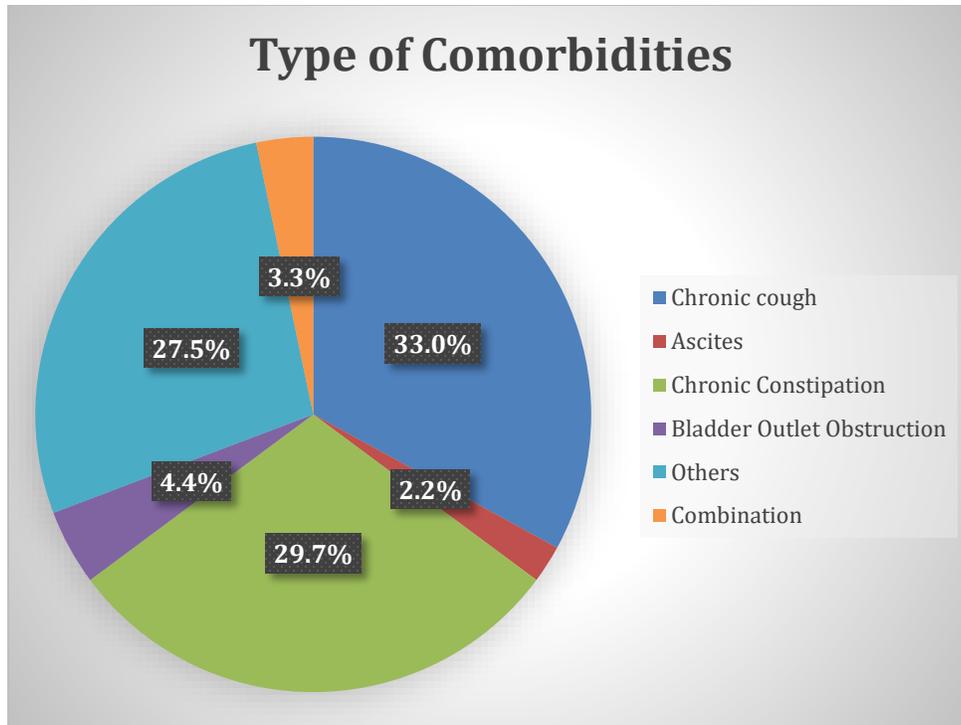
Demographics	Incarcerated		Non-incarcerated		P value
	No.	%	No	%	
Nutritional status:					0.367
Underweight	24	19.7	32	24.1	
Normal weight	87	71.3	84	63.2	
overweight	11	9.0	17	12.8	

**e. Presence and type of comorbidities**

Umbilical hernias were associated with comorbidities in 34% of cases, most common being chronic cough (33%) as outlined in *Figure 4* below. Mann-Whitney Test findings showed statistically significant difference in the rate of incarceration according to presence of comorbidities ( $U = 5646.0$ ,  $p = .000$ ), *Table 5*.

Table 5: Prevalence of incarceration according to co-morbidities

Demographics	Incarcerated		Non-incarcerated		P value
	No.	%	No	%	
Co-morbidity					0.000
Present	62	47.7	29	21.2	
absent	68	52.3	108	78.8	



**Figure 4:** Prevalence of co-morbidities

### **3.3. Risk Factors for Incarceration of Umbilical Hernias**

Among the risk factors assessed, incarceration was more commonly observed in males (56%) and in the first age group (0-23 months: 60%) with the last age group (>13 years) reporting the lowest prevalence (1.5%). Incarceration was highest in those below 2 years and almost all happened in those below 6 years (98.5%). When present, incarceration commonly occurred in the presence of co-morbidities (52.3%), most common being chronic cough (35.5%) and least associated with bladder outlet obstruction (4.8%). As regards to the ring defect size, it commonly occurred (67.2%) in the presence of a medium sized (0.5 - 1.5 cm) defect with a mean defect size of  $1.4 \pm 0.87182$  cm. Binary logistic regression indicated a correlation between incarceration and age, defect size as well as presence of comorbidities with significances of 0.002, 0.00, and 0.00 respectively [Table 6]. This was not observed with the other variables (sex and nutritional status). Of note, regarding the odds for incarceration, those aged <24 months were 0.391 more likely to compared to those >24 months, defects size <1.5 more likely than >1.5 and those with co-morbidities 0.295 times more like to get incarcerated than those without [Table 7]. Logistic regression models simulated with several combinations of age, defect size and comorbidity were

generated and their Nagelkerke R Square as well as their classification accuracy recorded for comparison [Table 8]. It was noted that a combination of age below 2 years, medium defect size and co-morbidity (chronic cough) was mostly associated with incarceration, [ $R^2 = 0.246$ , 68.3%].

**Table 6:** Association of risk factors and incarceration rate

Demographics	Incarcerated		Non-incarcerated		Odds ratio	Confidence interval	P value
	No.	%	No	%			
Age:					<b>Base: &gt;13 yr</b>		
0-23 months	78	59.5	50	36.5	0.829	0.145-	0.003
2-6 years	41	31.3	68	49.6	0.750	4.730	
7-12 years	10	7.6	15	10.9	0.321	0.115-	
>13yrs	2	1.5	4	2.9	-	4.898 0.057- 1.815	
Sex:					<b>Base:Female</b>		
Male	73	55.7	74	54.0	0.933	0.577-	0.779
Female	58	44.3	63	46.0	-	1.510	
Defect size:					<b>Base &gt;1.5</b>		
Small(<0.5cm)	8	6.1	6	4.4	0.316	0.188-	0.000
Medium (0.5-1.5cm)	88	67.2	58	42.3	0.360	0.532 0.116-	
Large (>1.5cm)	35	26.7	73	53.3	-	1.116	
Nutritional status:					<b>Base:</b>		
Underweight	24	19.7	32	24.1	<b>overweight</b>	0.071-	0.367
Normal weight	87	71.3	84	63.2	0.288	1.167	
overweight	11	9.0	17	12.8	0.863	0.342-	
					-	2.175	
Co-morbidity					<b>Base: absent</b>		
Present	68	52.3	29	21.2	0.295	0.172-	0.000
absent	62	47.7	108	78.8	-	0.503	

**Table 7: Association of risk factors and incarceration rate/logistic regression dichotomy table.**

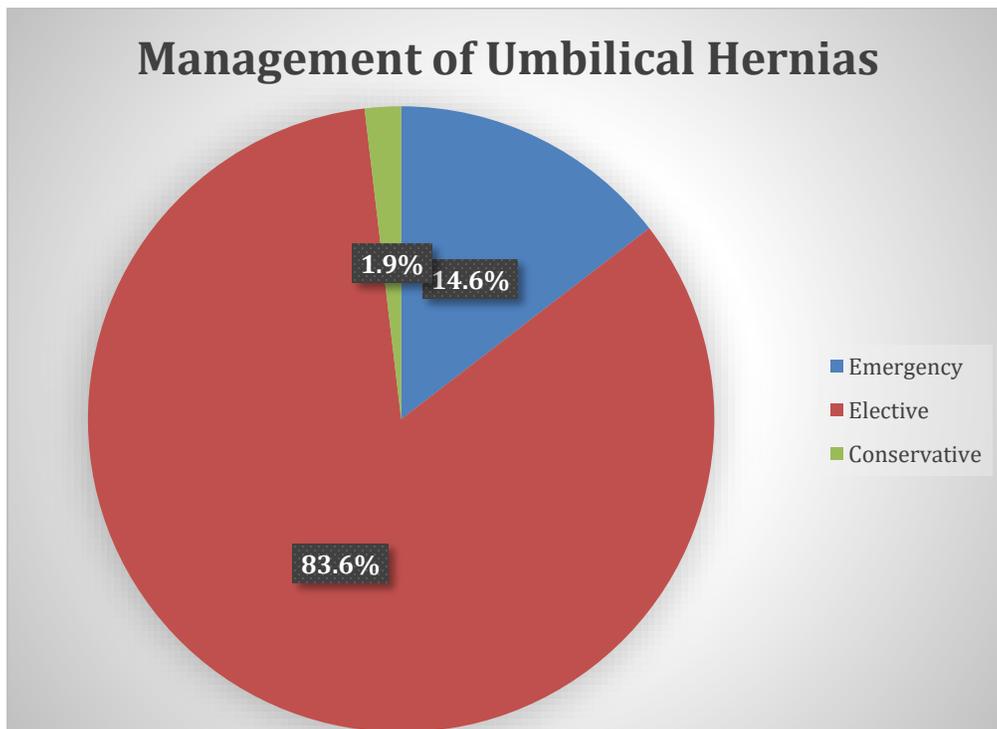
Demographics	Incarcerated		Non-incarcerated		Odds ratio	Confidence interval	P value
	No.	%	No	%			
Age:					<b>Base:&gt;24</b>		
<24 months	78	59.5	50	36.5	<b> yrs</b>	0.239-	0.000
>24 months	53	40.5	87	63.5	0.391	0.639	
					-	-	
Sex:					<b>Base:Fem</b>		
Male	73	55.7	74	54	<b> ale</b>	0.577-	0.779
Female	58	44.3	63	46	0.933	1.510	
					-	-	
Defect size:					<b>Base:&gt;1.5</b>		
<1.5cm	90	68.7	50	36.5	0.262	0.158 -	0.000
>1.5cm	41	31.3	87	63.5	-	.435	
						-	
Nutritional status:					<b>Base:</b>		
Malnourished	35	26.7	49	35.8	<b> Well</b>		0.111
Well nourished	96	73.3	88	64.2	<b> nourishe</b>	0.907-	
					<b> d</b>	2.572	
					1.527	-	
					-		
Co-morbidity					<b>Base:</b>		
Present	68	52.3	29	21.2	<b> Absent</b>	0.172-	0.000
absent	62	47.7	108	78.8	0.295	0.503	
					-	-	

**Table 8:** Logistic regression predictive models

Variable	Nagelkerke R Square (R <sup>2</sup> )	Classification accuracy
Age + Defect size	0.168	66%
Age + Co-morbidity	0.155	63.8%
Defect size + Co-morbidity	0.225	65.7%
Age + Co-morbidity + Defect size	0.246	68.3%

### **3.4. Management and Treatment outcomes of Umbilical Hernias**

Of the 268 cases of umbilical hernias that were noted in the current study, 14.6% (39 cases) underwent emergent surgical management, 83.6% (224 cases) underwent elective surgical management while 1.9% (5 cases) were managed conservatively as shown below in *Figure 5*.



**Figure 5:** Management of Umbilical Hernias

Of the 268 cases of umbilical hernias studied, 98.1% (263 cases) underwent surgical management and were discharged with no further complications, 0.4% (1 case) developed a

hematoma and seroma while 1.1% (3 cases) had recurrence of the hernia. No post-operative wound infections and cosmetic complications such as granulomas and scarring were noted in the population of the current study.

## **CHAPTER 4: DISCUSSION**

Umbilical hernia is a common pathology among children more so in the black population (4,24). The natural history is that of a spontaneous closure of which majority happens by the age of 5 (14). Therefore delay in surgical closure has been the practice with complications such as incarceration and strangulation thought to be rare (34). This expectant management was based on literature mainly from the developed countries where access to healthcare and close monitoring is feasible (3,16).

Dissimilarities exist in literature between those encountered in developed countries and those reported in recent years by African authors (3,10,12). The trend being that of higher prevalence of incarceration at a younger age, coupled with poor access to healthcare making close observation not feasible in most African countries (20,38).

Some African authors, feel perhaps it is time to reexamine the current recommendation of expectant management in an African child, however most agree that more research is necessary to determine the actual prevalence of incarceration and to identify which patients are at greatest risk of incarceration (11,12,20,37). The aim of this study is therefore to determine the prevalence and risk factors for incarceration in children managed for umbilical hernias at Kenyatta National Hospital. The risk factors assessed in this study were age, gender, defect size, nutritional status and comorbidities. The results of this study will contribute to better understanding of the disease process and formulation of local practice guidelines in the management of pediatric umbilical hernias.

We conducted a 7 year retrospective study on all children managed for umbilical hernias whose records were available. A total of 268 cases [147 (54.9%) male, 121 (45.1%) females] were recorded in the data collection. The mean age was 2.87 ranging from 1 month to 13 years. 131 (48.9%) were incarcerated while 137 (51.1%) were non-incarcerated. Among the risk factors assessed, incarceration was commonly observed in those below 2 year of age (60%), medium defect size (0.5-1.5cm) and those with comorbidities chronic cough being the most common, with significances of 0.002, 0.00, and 0.00 respectively. There was no significant association between incarceration and gender and nutritional status. It was noted that a combination of age below 2 years, medium defect size and chronic cough was mostly associated with incarceration, [ $R^2 = 0.246, 68.3\%$ ].

In our series of 268 patients managed for umbilical hernia, almost half (48.5%) were incarcerated. The above results differs from what was reported by Mestel AL in his series of 1,500 cases who found complication rate of about 0.07% (34). A survey of literature by Papagrigoriadis suggests that the incidence of incarceration is approximately one in every 1,500 umbilical hernias (2).

Our results is comparable to studies from Africa. In Nigeria Chirdan et al reported 44.2% incarceration rates (11) and in Senegal Fall et al reported 15% (12). Mawera et al from Zimbabwe in his series, incarceration was found in 37.5% (24). The high prevalence of incarceration in our series could be attributed to the fact that, since this was a hospital-based prevalence, children with complications are more likely to come to the hospital, while many cases of asymptomatic umbilical hernias may not come to the hospital. Our institution also being the biggest tertiary hospital in the region may as well be receiving referrals of mainly complicated hernias rather than all hernias.

It is not clear as why some umbilical hernias incarcerate. Ngom et al reported that the main factors contributing to the incarceration of umbilical hernia were age and size of the umbilical defect (20). There are wide variations in the literature concerning the peak age of incarceration. Ireland et al. from Australia found a mean age of incarceration of 5 years (10) while Zendejas et al. from the United States reported a mean age of 4.7 (3). This was at variance with our report that indicate younger age of incarceration. Incarceration was highest in those below 2 years of age (60%) and almost all happened in those below 6 years (98.5%) with a mean age of incarceration of 20 months with extremes of 4 months to 13 years. Our findings compares favorably to those reported by Harouna et al. in Niger (38) and Fall et al in Senegal who reported a mean age of 14 months (12). The mean age of incarceration in the study by Ngom et al. was 10 months (20). In a 3 year retrospective study in Burkina Faso over two third of those with incarcerations were under 5 (37). 67% of cases with incarcerations in the study by Ameh et al. in Nigeria were under 4 years of age with 33% of them below 2 years (13).

Incarceration was more commonly observed in males (56%). Male dominance recorded in this study is consistent with the reports from other studies (12,13,20), though in contrast to the reports of others that recorded female dominance (44). The reason for this gender difference is not known.

In concurrence with Lassaletta et al. (39) who found that incarceration and strangulation was twice as common in medium-sized defects (diameters of 0.5– 1.5 cm) compared to small (< 0.5 cm) or larger (> 1.5 cm) diameter defects we found incarceration commonly occurred (67.2%) in the

presence of a medium sized (0.5 - 1.5 cm) defect with a mean defect size of  $1.41 \pm 0.87182$  cm. In the study by Okada et al. 52% of patients with incarceration had medium sized fascial defect, 24% had small sized defect and 24% had large size defect (36). 80% of children with incarcerations in the Ngom et al. study had a defect size less than 1.5 cm (20). In contrast Ameh et al. reported that complications occurred in umbilical hernias in which the diameter defects were  $> 1.5$  cm (33). The median diameter for acute incarceration in the study by Chirdan et.al was 2.0 cm (11). It could be that defects smaller than 0.5 cm are too small to contain bowel while larger defects have wider necks, making incarceration unlikely.

Nutritional status was not a significant contributing factor to incarceration in our study. Bandre et al. had attributed malnutrition to promoting developments of respiratory infections causing excessive/chronic cough. 57% of patients with incarceration in their study had a history of malnutrition and 56% of those had respiratory infections (37).

In our study, when present, incarceration commonly occurred in the presence of co-morbidities (52.3%), most common being excessive/chronic cough (35.5%). Bandre et al reported some aspects of seasonal variability where high incarceration rates are observed in cold seasons when respiratory tract infections are relatively common (37). In a series of 35 patients with strangulated hernia reported by Ngom et al. Sixty-five percent had rhinitis, asthma or pneumonia (42).

This increase in incarceration could be explained by an increase in abdominal pressure during attacks of cough which forcefully propels bowel loops through a narrow hernia neck. The loop continues to protrude and distend, and its increased volume makes it difficult and consequently impossible for reinsertion into the abdominal cavity. This promotes incarceration and strangulation.

90% of the patients who presented with incarceration had reduction achieved in the emergency department and surgery was scheduled on the next available elective list. 10% required emergency surgery with one patient having bowel gangrene requiring bowel resection and anastomosis. One case of spontaneous perforation was reported in this study. There was no difference in postoperative complications between the incarcerated and non-incarcerated group.

## STUDY LIMITATION

Being a retrospective, the study is dependent on the accuracy of data and clinical acumen recorded in the patients records by other clinicians other than the investigator. There was no standardization on how the defect size was measured. In some it was measured by use of ultrasound and in others by clinicians during clinical examination and/or intraoperatively.

## CONCLUSION AND RECOMMENDATION

In conclusion, our study indicates that incarceration of umbilical hernia in children is more frequent in our environment than generally thought. A positive association between incarceration and younger age group, medium defect size as well as presence of comorbidities such as chronic cough were observed. These are the factors which if present in a child with umbilical hernia are likely to present with incarceration. The high rate of incarceration in our series questions the conservative therapy recommended by most of the western authors for umbilical hernia in children. In our environment and similar environments where a process of active observation may not be feasible due to poor access to healthcare, elective repair of umbilical hernia at the time of diagnosis is recommended. We also recommend a population-based prospective study and not just hospital statistics to possibly deduce the true incidence of incarceration and the likely risk factors for incarceration.

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**ANNEXES**

**ANNEX 1: DATA COLLECTION TOOL**

**STUDY TITLE: PREVALENCE AND RISK FACTORS FOR INCARCERATION IN CHILDREN MANAGED FOR UMBILICAL HERNIAS AT KENYATTA NATIONAL HOSPITAL**

**Date**.....

**Time**.....

**Serial number**.....

- 1. Age in years.....
- 2. Birth Weight (kg).....
- 3. Height (cm).....
- 4. Admission weight (kg).....
- 5. Ring defect size (cm).....

6. Gender      Male     

   Female     

7. Presentation      Incarcerated     

   Not incarcerated     

8. Presence of comorbidity

   Chronic cough     

   Ascites

Chronic Constipation   
Bladder outlet obstruction   
Others.....

9. Incarceration

Simple

Spontaneous reduction

Reduction by taxis

Reduction at surgery

Complex

Bowel obstruction

Bowel gangrene

Perforation

Evisceration

10. Surgical/operative management

Emergency

Elective

11. Treatment outcome

Discharged with no complications

Surgical site infection

Cosmetic complication (granulation tissue and scare formation)

Hematoma and seroma formation

Recurrence

Death