Small colon impaction outbreak and associated risk factors in horses at the Onderstepoort Veterinary Academic Hospital, South Africa in 2021.

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Summary

During the period June - July 2021, the Onderstepoort Equine Clinic (OPEC) of the Faculty of Veterinary Sciences, University of Pretoria experienced a dramatic increase in the incidence of diffuse faecal impactions of the small colon. Diffuse faecal small colon impaction (SCI) is typically diagnosed in 1.3–3% of all horses admitted to referral hospitals for signs of abdominal pain. Miniature horses, Arabians and mares have been identified as being at risk for developing SCI.

The primary objectives were to describe the distribution, diagnosis, treatment, and outcomes of colic cases in 2021, with a specific focus on SCI cases. Additionally, the study aimed to identify risk factors associated with SCI development and evaluate the prognosis for medically and surgically treated horses.

Medical records of the University of Pretoria's, Onderstepoort Veterinary Teaching Hospital, Equine Clinic were reviewed to identify all horses presenting with colic in 2021. Horses in which SCI was diagnosed by either rectal palpation, exploratory laparotomy, or necropsy were included in the second part of the study. For comparison purposes, the information from horses in which large colon impaction had been diagnosed was collected and included in the third part of the study. Owner questionnaires were compiled to collect data to assess possible risk factors for SCI.

The study population consisted of 182 colic cases and sex, age and breed was similar to other referral practices. Apart from an abnormal amount of SCI seen in the current study (13%), the distribution of colic diagnosis were similar to most other large studies. Large colon impactions made up 26% (47/182) of colic admissions, followed by SCI (13%, 24/182), RDD (9%, 16/182), SII (8%, 15/182), EGUS (7%, 12/182) and LC volvulus (6%, 10/182). Horses were treated medically (65%, 118/182), surgically (32%, 58/182) or were euthanised before receiving treatment (3%, 6/182). Of the surgically treated cases, one case (1%) died during anaesthetic recovery. The majority of the treated horses were discharged (85%, 150/176).

Small colon impaction was diagnosed in 23 horses (13%, 23/182), which was significantly higher ($p<0.05$) than reported previously at the same institution (3%) as well as at other referral centres worldwide (1.3–2.5%). Clinical findings were non-specific but included a loose stool or diarrhoea on admission (48%,11/23) and colic signs in all cases. A SCI was diagnosed via rectal palpation 83% (19/23) of cases. Immediate surgical treatment was performed in 30% (7/23) of cases. This was due to severe colic signs in 2/7 patients or the clinical impression that the SCI palpable rectally was severe and extensive in 5/7 cases. In the remaining cases medical management was initiated although

surgical intervention was later pursued in 43% (10/23) of cases due to unrelenting colic signs (4/10) or the clinical perception that medical management was failing to resolve the impaction timeously (6/10). Thus 74% (17/23) cases were treated surgically via a ventral midline exploratory laparotomy. Medical management alone was implemented in 26% of SCI cases (6/23). The short term outcome was good (survive to discharge) in 87% (20/23) of horses. Three horses (13%, 3/23) were euthanised due to financial constraints (9%, 2/23) or GIT perforation (3%, 1/24). Survival to discharge in horses treated surgically was 94% (16/17) while the survival to discharge was poorer in patients treated medically (67%, 4/6).

Univariate analysis revealed that stallions were at an increased risk to develop SCI compared to “all other colic” diagnoses (OR 4.17, 95% CI 1.11-15.6, P=0.034). Friesians were more likely to develop SCI compared to “all other colic” (OR 7.00, 95% CI 1.73-28.3, P<0.001). Draft breed horses were more likely to develop SCI compared to compared to “all other colic” (OR 8.20, 95% CI 3.13-21.5, P<0.001) and compared to LCI (OR 32.7, 95% CI 3.76-285). An increased risk for horses to develop SCI in winter was identified compared to all other colic diagnoses (OR 43.2, 95% CI 9.59-195, P<0.001) and compared to LCI (OR 124, 95% CI 12.8-1195).

Conclusion

This study revealed a concerning outbreak of SCI and identified possible risk factors. Stallions, draft breed horses and Friesians are at an increased risk of developing SCI compared to other colic types. Season (winter) is also a risk factor for SCI compared to LCI and other colic types. Horse owners and veterinarians should be alerted to the increased possibility of SCI when evaluating colic in these horses, especially during winter months when the prevalence of SCI seems to increase, or when colic signs are accompanied by previously reported risk factors such as fever, leukopenia and diarrhoea. The outcome for surgically treated SCI is favourable.

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Abstract

Background

During June-July 2021, the Onderstepoort Equine Clinic experienced an increase in diffuse faecal small colon impactions (SCI). Typically, SCI is diagnosed in 1.3–3% of horses admitted to referral centres for colic.

Objectives

This study aimed to describe the distribution, diagnosis, treatment, and outcomes of colic cases in 2021, focusing on SCI and to identify risk factors for SCI compared to large colon impactions (LCI).

Method

Medical records from the Onderstepoort Veterinary Teaching Hospital were reviewed to identify colic cases in 2021 and the population distribution, diagnosis, treatment, and outcome recorded. Cases of SCI were identified and compared to LCI. Owner questionnaires assessed potential SCI risk factors.

Results

Colic cases(182), comprised mainly LCI(26%), large colon displacements(20%), and SCI(13%). Treatments included medical(65%), surgical(32%), or euthanasia(3%). Most horses(85%) were discharged. SCI was diagnosed in 13% of cases, higher than previously reported rates. Immediate surgical treatment was performed in 30% of cases. In the remaining cases medical management was initiated although surgical intervention was later pursued in 43% of cases. Short-term survival was 87%, with surgical cases showing higher survival (94%) than medical (67%).

Stallions were at risk to develop SCI compared to “all colic” diagnoses (OR 4.17). Friesians were more likely to develop SCI compared to “all colic” (OR 7.00). Draft breed horses were more likely to develop SCI compared to compared to “all colic” (OR 8.20) and compared to LCI (OR 32.7). The study identified a risk for horses to develop SCI in winter compared to “all colic” (OR 43.2) and compared to LCI (OR 124).

Conclusion

A SCI outbreak occurred in 2021, with increased risks in stallions, Friesians, and draft breeds, particularly in winter. Horse owners and veterinarians should be alerted to this, especially in at-risk groups during winter. Outcomes are favourable for SCI especially when treated surgically.

Key words:

Small Colon Impaction (SCI), colic, risk factors, treatment, outcome

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List of abbreviations

BPM	Beats per minute
CRT	Capillary refill time
EFE	Epiploic foramen entrapment
EVJ	Equine Veterinary Journal
EGUS	Equine gastric ulcer syndrome
GIT	Gastrointestinal tract
LC	Large colon
LCD	Large colon displacement
LCI	Large colon impaction
LCV	Large colon volvulus
LDD	Left dorsal displacement of the large colon
NSAIDs	Nonsteroidal Anti-Inflammatory Drugs
NSE	Nephrosplenic entrapment
OPEC	Onderstepoort Equine Clinic
OVAH	Onderstepoort Veterinary Academic Hospital
PFI	Pelvic flexure impaction
RDD	Right dorsal displacement of the large colon
SCI	Small colon impaction
SD	Standard deviation
SI	Small intestine
SII	Small intestinal impaction
UVIS	Universal Veterinary Information System

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1. Introduction

Background

During the period June - July 2021, the Onderstepoort Equine Clinic (OPEC) of the Faculty of Veterinary Sciences, University of Pretoria experienced a dramatic increase in the incidence of diffuse faecal impactions of the small colon. Small colon impactions (SCI) usually make up a small percentage (3%) of colic admissions to OPEC as shown by Voight (2009). In 2021, SCI were diagnosed in 13% of colic admissions. There were also anecdotal reports indicating that other veterinarians throughout the country experienced a significant rise in these cases during the same period. This unexpected surge in SCI raised concerns about a potential outbreak, prompting this investigation into the associated risk factors at the Onderstepoort Veterinary Academic Hospital and beyond.

Problem statement

To the author's knowledge, no small colon outbreaks have been reported worldwide. No studies have been published investigating the risk factors and clinical progression of SCI outbreaks in South Africa.

Research question, hypotheses and objective

The study comprised three components. The research question, hypotheses and objective of each component can be seen in table 1.1 below.

Table 1.1: The research components and corresponding study question, hypotheses and objective of the current study looking into a small colon impaction (SCI) outbreak at the Onderstepoort Equine Clinic (OPEC) in 2021.

Three components of the study:	**Study question**	**Objective**	**Hypothesis**
1. A description of the colic cases over 2021	1. What was the distribution of signalment, diagnosis, treatment and outcome of horses presenting to OPEC for colic in 2021 compared to other hospitals and previously reported at the same center?	1. Describe the signalment, diagnosis, treatment, and outcome of horses presented to OPEC for colic in 2021 using medical records. 2. Describe the incidence of SCI to assess for an increase in SCI incidence at the OPEC in June - July 2021using an epidemic curve.	1. OPEC has a similar breed distribution to other large referral hospitals. 2. An increased number of diffuse faecal SCI occurred in June-July compared to the rest of 2021 and previously reported numbers.
2. A clinical case series of SCI Jun-Jul 2021	1. What was the distribution of signalment, treatment and outcome of horses presenting to OPEC for small colon impaction (SCI) colic in 2021? 2. What is the outcome of medical and surgical treatment for diffuse SCI?	1. Describe the presentation (signalment and clinical presentation), treatment, complications, and outcome in horses with diffuse SCI using medical records. 2. Describe the short-term outcome (survival to discharge) of surgically treated diffuse faecal SCI compared to medically treated cases.	1. Horses with diffuse faecal SCI that presented with abdominal distension were more likely to require surgical intervention. 2. Medical and surgical treatment of diffuse SCI carry a good prognosis and survival rates with minimal risk of complications.
3. A risk factor study of SCI	1. What were the risk factors for diffuse faecal SCI compared to large colon impactions (LCI) and “other” colic diagnoses in horses in South Africa?	1. Using owner questionnaires and medical records describe risk factors for horses developing diffuse faecal SCI compared to LCI and “other” colic diagnoses.	1. Compared to LCI and “other” colic diagnoses; risk factors for diffuse faecal SCI in South Africa include season and breed.

Benefits arising from the study

The purposes of the study reported here, were to identify factors associated with the development of SCI in horses, identify factors associated with the selection of medical versus surgical treatment of SCI in horses, and to determine the prognosis for affected horses following medical or surgical management.

The research study will form part of the fulfilment for an MMedVet (Surgery Equine) degree in the Department of Companion Animal Clinical Studies in the Faculty of Veterinary Science, University of Pretoria.

2. Literature review

Colic in horses

Colic in horses refers to abdominal discomfort and pain.[1] It is a collection of clinical and behavioural signs rather than a specific diagnosis and can arise from both gastrointestinal and non-gastrointestinal conditions.[1] Abdominal pain related to the gastrointestinal tract (GIT) can be caused by various factors such as intestinal distension caused by fluid, gas, or ingesta; tension on the mesentery; ischemia or infarction or mucosal ulceration.[1,2] Colic signs that are not related to the GIT typically originate from the reproductive or urinary tracts, the peritoneum, the liver or the kidneys. Making a specific diagnosis is not always possible in horses with colic

Diseases causing colic leads to significant morbidity and financial losses.[1–5] The incidence of colic in the general equine population is 3.5-11.1% per year.[5–8] Colic case fatality is reported to be as high as 11% of all cases.[2] Despite the high prevalence and fatality, veterinary assistance is only pursued in 54.8% of cases.[6] The remaining cases either resolve spontaneously or are treated medically by lay persons.[7] Colic episodes recur in up to 34.5% of horses that have previously shown signs of colic.[5,6,8–12] Colic is the most common out of hours emergency in horses both in South Africa and world-wide.[3,6,13,14]

Colic has been extensively researched. Studies have investigated the occurrence of colic events both in the general equine population and within specific breeds.[1,13] Some studies have specifically examined particular pathologies associated with colic while others report on the incidence, identification of risk factors, outcomes, prognostication, recurrence, and economic costs associated with colic episodes.[1,3,5–7,10,12,13,15–25]

Risk factors for developing colic

Colic has been reported in all breeds, with the breed distribution varying according to the population dynamics. Breeds that are commonly represented in large colic referral studies are Thoroughbreds, Quarter horses, Warmbloods, and Arabians.[3,13,26,27]

The majority of studies have not identified a specific sex predilection for colic.[5,6,10,12,18,28] Some studies do however indicate that geldings are overrepresented when compared to the normal hospital population.[27]

Colic can occur at any age and has been reported from birth to 37 years of age.[5,6,10,12,18,28] Advanced age, classified as older than 20 years of age, has been associated with an increase in colic incidence.[22] No specific age predilection exists for the majority of diseases which cause colic, while others are more common in specific age groups. Strangulating lipomas are more common in older horses while small intestinal intussusceptions are more common in neonates and small intestinal obstruction due to ascarid impactions are common in yearlings.[1,27,29,30]

In various equine populations, an increase in colic incidence has been reported during specific months of the year.[5,6,31] However, the relationship between season and colic remains unclear and poorly understood.[31] Cyclical seasonal patterns have been identified for simple colic, epiploic foramen entrapment (EFE), equine grass sickness (EGS), large colon displacement/torsion and large colon impaction colic.[1,13,31] While no evidence of a cyclical pattern was identified in other studies or colic types such as cases of pedunculated lipoma.[10,17,31,32]

Other risk factors that have been identified are increased concentrate feeding[6], hours stabled per day, reduced time at pasture, changes in management (feed, travel), previous colic episode, temperament and behavioural vices like crib biting/windsucking.[5,6,10,12,18,19,22,33]

Treatment

While the majority of colic cases in horses are mild to moderate and can be resolved with simple medical treatment, approximately 23% of cases are more critical, necessitating intensive medical or surgical treatment, euthanasia, or resulting in death.[3,7,23] Approximately 11% of horses suffering from colic will die or be euthenased.[7,13,24,34]

Of horses admitted to referral centres for colic, 4% are euthanised or die (3%) prior to intervention or treatment, 49-55% can be treated medically, and 45-50.9% require surgical intervention.[7,12–14,26–28]

The medical treatment for most types of impaction colic is similar. The goal of medical treatment is to maintain the horse's hydration status, stimulate gastrointestinal motility, soften the impaction using osmotic laxatives or lubricants and to control pain.[28,35–38] Prompt and aggressive administration of enteral and intravenous fluids to over hydrate the horse causes secretion of fluid into the intestine in order to hydrate and soften the mass of ingesta.[38] Enteral fluids have the added benefit of stimulating the gastro-colic reflex.[28,35,38]

Outcome

Multiple studies have examined the factors that influence colic survival after both medical and surgical treatment.[11,16,24,26,34,35,39–42] Factors that have been identified include the horse's background, age, duration of colic, severity of colic symptoms on arrival, physical examination findings, haematological findings, peritoneal fluid analysis, diagnosis, surgical procedure performed, and surgery duration. [11,16,24,26,34,35,39–42]

The recurrence of colic in the general equine population is reported to be as high as 34.5%.[5,6]

One horse in every 200 dies of colic each year making the overall mortality for colic in horses 0.5% per year.[8] Many horses suffering from colic either die (3%) or are euthanised (4%) prior to receiving any treatment.[7,13] This might be due to late intervention, financial constraints, advanced clinical disease or poor prognosis. Colic and colic-related death increases steadily with age and more steeply after 16 years of age.[4]

Overall short term survival (to discharge) for colic patients is good (70.3-93.6%).[13,24,26,27] However, a significant proportion of the horses die or are subjected to euthanasia prior to discharge, both after exploratory laparotomy and during medical management.[7,13,24,34] The most common reasons for death/euthanasia in the post-operative period after a single laparotomy are persistent pain/colic and post operative ileus.[26] Approximately 73-88% of horses survive exploratory laparotomy.[13,26,27] Some horses die or are euthanised postoperatively and the short-term survival (to discharge) for horses undergoing surgical intervention for colic is 59.6-89.8%.[13,24,26,41–43] While short-term survival (to discharge) for horses undergoing medical treatment for colic is better at 92.9-93.6%.[11,13,27,44] This may be because surgically treated cases most likely represents horses with more severe disease and a more compromised clinical state. Survival to one year after discharge ranges from 27-87% depending on the cause of colic.[1,24,26,40,42,45]

Repeat laparotomy prior to discharge from the hospital (i.e. early (acute) relaparotomy) after surgery for colic is required in 3-13% of cases.[13,25,39] Repeat laparotomy significantly reduces the likelihood of survival to discharge from 59.6-89.8% to 50.0%.[39]

Six months post operatively, 68% of horses are able to resume their intended use while 54% can be expected to perform at their pre-operative level.[25] At one year post operatively, 76% of horses are able to resume their intended use while 66% will be performing at or above their pre-operative level.[25] Animals that suffered from a previous exploratory laparotomy, stall rest for an orthopaedic condition, a non-strangulating lesion type, an incisional hernia, diarrhoea, or laminitis were less likely to return to

use or performance. [25] The majority of horses, 81-90%, are able to resume their expected performance levels after undergoing colic surgery. [11,25,40,46]

Complications

Incisional site infection occurs in 17.5-42.2% of horses undergoing exploratory celiotomy while incisional hernias are recorded in 6.0-7.4% of cases.[40,41,46–57] Other commonly reported complications during hospitalisation include colic/pain (28.2%), post operative ileus (13.7%), severe endotoxaemic shock (12.3%), jugular thrombophlebitis (7.5%), septic peritonitis (3.1%) and colitis/diarrhoea (2.2%) and laminitis (0.4%).[25,40,41]

Comparative studies in South Africa

Many studies have been published worldwide evaluating the distribution of horses presented to referral hospitals for colic. [17,19,23,33] One such study has been performed at Onderstepoort Veterinary Academic Hospital and evaluated the most common causes of gastrointestinal colic in 935 horses admitted over a 10-year study period from 1998-2007.[13]

The causes of medical colic in horses were primarily impactions (39%) which affected the large colon (32%), small colon (3%), stomach (2%), caecum (1%) and small intestine (1%); tympany (7%); and large colon displacement (6%). A total of 331 horses (36%) underwent exploratory laparotomy due to large colon displacement (29%), and small intestinal strangulating lesions (18%).[13] Impactions were reported in 75 horses (22%) during exploratory laparotomy and affected the large colon (13%), small colon (4%), small intestine (4%), caecum (1%) and stomach (<1%).[13] Horse mortality was 3%, while 4% were euthanized before medical intervention.[13] Overall, medical intervention was successful in 93% of cases, while surgical intervention was successful in 67% of cases.[13] In conclusion, 55% of equine admissions responded well to medical intervention, and the recovery rate for horses receiving both medical and surgical intervention was similar to that reported in other studies.[13]

One study in South Africa reported data from an impaction colic outbreak that affected the large colon and caecum and was attributed to *Datura spp* hay contamination.[58] To the author's knowledge, no studies have been published investigating the risk factors, management and outcome of SCI outbreaks in South Africa.

Small colon impactions

Introduction / Background

The small (descending) colon originates from the transverse colon and continues as the rectum at the pelvic inlet.[36] It is 2.5-4m long and relatively mobile within the abdominal cavity. It lies left of the mesenteric root, usually occupying the left dorsal abdominal quadrant.[36]

Small colon lesions can be classified as either strangulating or non-strangulating.[1,59,60] Non-strangulating lesions are obstructions and can be located extra-luminal, intra-mural or intra-luminal.[30,36,59,61,62] Intra-luminal obstructions are referred to as impactions and can be either focal or diffuse.[32,35,63,64] This study will focus only on diffuse faecal impactions of the small colon and thus the other categories are not discussed.

Pathophysiology of diffuse faecal small colon impactions

The primary function in the small colon is to absorb water and form faecal balls.[65] Any factor which increase intestinal transit time will result in excessive dehydration of the luminal contents and may result in diffuse faecal SCI.[1,37,38,58,63,65] Extraluminal or intramural obstructions may physically prevent flow of ingesta and will also result in impactions.[30,36,59,62] Once an impaction forms, it will propagate orally and aboral to become diffuse.[37,38]

Incidence

Diffuse faecal SCI was diagnosed in 1.3–3.0% of all horses admitted for signs of abdominal pain in recent reviews.[13,15,35,36,59,63,66,67] Diffuse faecal SCI is the most common pathological condition of the small colon in adult horses and accounts for 34-78% of all cases of small colon disease.[32,36,60,66,68,69] An exception are regions such as California, where there is a high incidence of enterolithiasis with these as a cause in up to 35% of small colon obstructions.[35,36,63]

Predisposing factors

Many predisposing factors of SCI have been described including environmental and management factors, age, breed, sex and congenital disorders.[15,16,35,36,67,69]

Lack of water, poor dentition, poor-quality hay, parasite damage and inactivity are risk factors for the development of diffuse faecal SCI.[15,16,35,36] Horses older than 15 years, miniature horses, ponies, mares and Arabians were at an increased risk in several studies, but age, breed, and sex were not significant risk factors in other reports.[15,16,19,32,36,63,66,68]

There has been a reported increase in the incidence of SCI in cooler parts of the year (winter / late autumn).[16,35] This has been attributed to inadequate water consumption or change in feed quality as horses transition from pasture to hay.[16,63] Other studies have found no association with season or temperature.[16,31] Horses kept on pasture all year were found to be at reduced risk of developing SCI compared to horses that are stabled year-round.[19]

Horses that have a history of abdominal surgery are five times more likely to suffer a SCI.[19] A retrospective case series of 44 horses with SCI suggested that diarrhoea was a risk factor for development of SCI.[16] Colitis might predispose horses to SCI and SCI might also predispose horses to colitis.[16,63,70]

Typical clinical signs and findings

The clinical signs of SCI are variable and can resemble those seen in many other types of colic.[36,60,67,69] Horses with SCI often present with anorexia, dull mental status, and signs of mild abdominal pain with decreased or no faecal output.[15,16,32] Small colon impaction causes secondary gas distention in the large colon and caecum, which contributes to clinical signs of abdominal pain.[35,36,59,63,67,69]

Nasogastric reflux is present in 38% of cases, most likely due to marked to severe colonic distension by the time of presentation.[16,32,35,36,63,67] Diarrhoea on admission is a common finding in horses with SCI and is accompanied by fever in 34% of SCI affected patients.[16,68,70] Horses with SCI were 10.8 times as likely to have diarrhoea at the time of initial examination as were horses with large colon impaction.[16,70] Colitis might be suspected when diarrhoea and fever are present, which can delay appropriate treatment.[70]

Due to the anatomic position of the small colon in the distal portion of the gastrointestinal tract, clinical signs of abdominal disease and deterioration in clinical and haematological and serum biochemistry parameters can be slow.[32,36,60,63,67,69] Time from onset of colic signs to admission for diffuse faecal SCI cases is variable (13.0-43.2 hours).[28,39,41,42,45] Unlike other gastrointestinal tract disorders requiring surgical intervention, SCI is often slow to progress and not associated with signs of unrelenting pain or high heart rates initially.[16,32,35,60] Horses suffering from SCI are therefore often presented later than horses suffering from large colon impactions.[35,60] Signs will progress to moderate-severe abdominal pain and distention, decreased to no faecal production, tenesmus, decreased borborygmi and severe tympany.[18,32,36,69]

Clinical parameters are non-specific and usually normal, but can progress to include congested mucous membranes, a moderately elevated packed cell volume and a mildly elevated heart rate.[35,36]

A left shift leukopenia is commonly found in horses with a diffuse faecal SCI while serum biochemical and peritoneal fluid values are typically within normal limits.[35,36]

Diagnosis of small colon impactions

Rectal palpation is an accurate, cost-effective, readily available method of diagnosis for SCI.[16,35,66,69] Diffuse SCI are palpable as a solid 'sausage-like' tube of ingesta within a section of intestine near the pelvic inlet that often has a pathognomonic palpable antimesenteric band.[35,36] The rectal mucosa can be oedematous or rough and rectal examination often reveals bloody or serosanguinous fluid on faeces or the rectal sleeve. [35,36,67] It is not always possible to palpate SCI due to severe gas distension or the size of the patient.[32,36] Therefore, many diagnoses are only made during an exploratory celiotomy.[16,60]

Transrectal ultrasound can also be used for diagnosis; however, there is limited information available concerning the appearance of a small colon containing an obstruction on ultrasound.[35,36]

Transabdominal ultrasound is a sensitive diagnostic test for differentiating simple from strangulating obstructions of the small intestine but is not as helpful when evaluating SCI.[36] Gas accumulation in the colon often precludes effective evaluation of the small colon.[69] When SCI is visible on ultrasound, findings include a distended, amotile small colon with a thickened wall (>8 mm) and a lumen filled with hyperechoic ingesta.[35] Transabdominal ultrasound might be useful in horses that are too small for rectal palpation.[35]

Radiography can also be used to identify SCI. However, due to severe abdominal gas distention, the sensitivity of this modality is low.[35,69]

Treatment of small colon impactions

The location and extent of the impaction affects both appropriate treatment selection and prognosis.[20] Medical treatment is usually implemented first unless horses show signs of acute and severe pain.[67] Horses treated medically have a better long-term survival rate according to one study.[36] Large colon impactions are more likely to resolve with medical treatment alone whereas small colon and caecal impactions are more likely to require surgical intervention. [20,36]

Medical treatment

The medical management of SCI is similar to impactions of the small intestine and large colon.[28,37] A gravitational enema with or without epidural anaesthesia can also be attempted in the standing sedated horse to treat SCI.[35] Nonsteroidal anti-inflammatory drugs (NSAIDs) can be considered to control pain

and address pyrexia which is often present in SCI cases.[35] The presence of leukopenia and pyrexia in SCI cases may also warrant antimicrobial therapy. [35]

The decision to perform surgery is largely based on the failure of medical management to resolve the impaction, the inability to control pain, the clinical deterioration of the patient, or a clinical impression that the impaction is severe.[14,28,32,35,38,68,71] This can be indicated by increased abdominal distention, a deterioration in cardiovascular status of the patient or an increase in nucleated cell count and total proteins in the peritoneal fluid, as this indicates early loss of intestinal viability.[35,63,66,67] Horses with abdominal distension at the time of admission are five times more likely to require surgical treatment.[16,36] The time from the onset of colic signs to surgery of diffuse faecal SCI can vary from 5-72h.[67] Previous studies report 52% of SCI being resolved medically while 44-48% of horses required surgery.[16,35,63]

Surgical treatment

Ventral midline laparotomy under general anaesthesia is considered the standard of care for horses with abdominal pain requiring surgical treatment.[32,35,36] However, a recent review suggested that standing flank laparotomy with or without the aid of a high enema, is a viable alternative to ventral laparotomy for ponies and horses with either focal SCI or extensive SCI.[68,69] Standing flank laparotomies are more cost effective, require less people, have shorter surgery and hospitalisation times and avoid the risk of general anaesthesia.[35,68] A ventral midline laparotomy might still be required if the standing flank laparotomy fails to resolve the impaction.[69] A para-inguinal laparotomy approach has also been described for resolution of lesions in the distal small colon.[69]

Diffuse faecal SCI are reduced through a combination of intraluminal lavage (high enema with lukewarm fluids) and gentle transmural massage.[35,68] Should intraluminal lavage and extraluminal massage fail to resolve the SCI, a small colon enterotomy is recommended on the antimesenteric teniae.[35]

A complete examination of the large intestine is recommended before closure as impaction, displacement or volvulus can occur secondary to gas distention proximal to the SCI in some horses.[35] A pelvic flexure enterotomy is indicated when the large intestine is full of ingesta or impacted to prevent recurrence of impaction in the inflamed and oedematous small colon.[35,67,69]

Outcome and Prognosis

Small colon impactions have a good long-term prognosis after both medical and surgical treatment.[16,35,60,71] In cases where severe impactions or strangulations cause vascular compromise and resections are required the long-term survival is reduced from 8.4 years to 2.8 years. [60,71]

Substantial variation in the outcomes following medical and surgical interventions for SCI were found. Reported short-term survival (to discharge) after medical management ranges from 72-100% while survival after surgical treatment ranges from 47-95%.[16,32,35,60,63,71] Reported long-term survival decreases from 81% at one year to 73% at two years after discharge.[60]

Surgical cases of SCI are hospitalised for longer than large colon impaction cases, with a mean hospital stay of 7-9 days.[16] Small colon impactions require a longer period of time for the reintroduction of hay compared to large colon impactions (10 days vs 2.6 days) .[16] Feeding a complete pelleted diet for several weeks can help prevent re-impaction.[36,61]

Complications

Small colon post-operative complications are common (41%).[32,60] This risk increases if sections of the gut are devitalised and require resection, or if manipulation of the bowel causes trauma.[36]

Post-operative complications include incisional infections, ischaemic reperfusion injury, jugular thrombophlebitis or swelling at catheter site.[26,32,35] Fever, diarrhoea and laminitis are also common complications and might be caused by increased absorption of toxins through the inflamed intestinal wall. [26,32,35,60] Re-impaction after surgical intervention is a risk in both small[40] and large colon impactions.[15,28,35] Patients where the large colon was not evacuated are more likely to develop post-operative pain.[35]

Horses treated surgically are more likely to have a positive culture for *Salmonella spp*, which may be due to the use of perioperative broad-spectrum antibiotics that alter gastrointestinal flora.[35,60,71]

3. Materials and methods

Study design

The first part of the current study followed an observational study design based on the evaluation of records from which an epidemic curve was generated to identify the presence of an unusual amount of diffuse SCI during June-July 2021. The second part of the study was a retrospective case series to describe the presentation, treatment, and outcome for horses with diffuse SCI. The third part of the study involved a cross-sectional study to identify risk factors associated with the development of diffuse faecal SCI compared to LCI in horses in South Africa.

Study procedures

Medical records of the University of Pretoria's, Onderstepoort Veterinary Teaching Hospital, Equine Clinic were reviewed to identify all horses presenting with colic in 2021. Keywords used during the search included colic, impaction, rectal palpation. Horses were excluded if abdominal pain was not the primary presenting complaint.

From the patients above, horses in which SCI was diagnosed by either rectal palpation, exploratory laparotomy, or necropsy were included in the second part of the study. Horses were excluded if SCI was not the primary diagnosis or if the horse had been admitted because of primary colitis.

For comparison purposes, the information from horses in which large colon impaction had been diagnosed by means of palpation per rectum, exploratory laparotomy, or necropsy was collected and included in the third part of the study.

Owner questionnaires in the form of an online Google Forms survey were compiled to assess the association between possible risk factors and SCI. Owners of colic horses identified in the search were contacted via email and requested to fill in the questionnaire. Telephonic interviews were carried out by the primary investigator (EH) where any information was unclear or missing after completion of the online questionnaire.

Observational/analytical procedures

Data collected from the owner questionnaire is included in Appendix A. Signalment data included age, breed, sex, date of birth, pregnancy status, parity, use and exercise regime. General history included ownership duration, travel history and both routine medical care such as worming and vaccination and dental care as well as prior medical (especially colic) history. Environmental data included GPS

location and residential province. Husbandry data included stabling and pasture duration, water source and delivery, pasture type and access and exposure to toxic plants. Feed information included concentrate and roughage source, amount and type. Data collected regarding the colic episode in question included duration of colic signs prior to veterinary examination, treatment and referral and the reason for referral. The presence of pyrexia, diarrhoea and blood on the rectal sleeve was also recorded. Outcome data included time since discharge, complications after discharge and return to use.

Data extracted from the medical records (Appendix B) was extracted from hospital records. Presentation data included physical exam parameters, severity of abdominal distension and pain, rectal palpation findings, transcutaneous abdominal ultrasound findings, abdominocentesis findings, nasogastric intubation findings and laboratory reports (haematological and blood chemistry). The history and presence of pyrexia, diarrhoea and blood on the rectal sleeve was also recorded. Treatment pursued (medical, surgical or euthanasia) and the reason was recorded. Surgical findings were recorded and included weather a pelvic flexure enterotomy was performed, severity of SCI, surgery duration and surgery outcome. Hospitalisation data included time to refeeding (short and long stem) and the presence of complications. Lastly short term survival (to discharge) and final bill (Rands) was recorded.

Data analysis

All data obtained was entered into a Microsoft Excel spread sheet.

Descriptive statistics:

- An epidemic curve was generated to describe the distribution of colic cases during 2021.
- Continuous data were assessed for normality using histograms, descriptive statistics and the Shapiro-Wilk / Shapiro-Francia test.
- Mean and SD were calculated for normally distributed quantitative data.
- Median and range values were calculated for non-normally distributed quantitative data.
- Frequency, counts, percentages and 95% confidence intervals were reported for categorical data.

Comparison of quantitative data among diagnosis categories were performed using one-way ANOVA or Kruskal-Wallis tests depending upon the distributional form of the data. Categorial risk factors were evaluated using multivariable logistic regression. Risk factors for SCI compared to LCI were identified by fitting univariate and multivariable logistic regression models for the estimation of odds ratios and

95% confidence Intervals. Statistical analysis was performed using commercial software (IBM SPSS Statistics Version 28, International Business Machines Corp., Armonk, NY, USA) and results were interpreted at the 5% level of significance. Global spatial clustering was assessed by performing the Cuzick-Edwards test for the first nearest neighbour through the manual application of the formula in Excel.

Study population

This is a retrospective study, and no experimental procedures were performed in animals.

Patient owners (according to the University of Pretoria's Onderstepoort Veterinary Academic Hospital database) were contacted via email or telephonically and invited to complete an online survey.

Staff, facilities, equipment, and supplies

Owner questionnaires to assess exposure to possible risk factors and outcome was designed and distributed and data analysed by the primary investigator (EH) and co-supervisor (GF).

The study was overseen by Dr Yolandi Smit (Supervisor) and Prof Geoff Fosgate (Co-supervisor). Office work was carried out at the Faculty of Veterinary Science.

Reporting

The research is reported in a dissertation as part of a MMedVet degree in the department of CACS (Companion Animal Clinical Studies) through the University of Pretoria's Veterinary Faculty.

Findings of this study are intended for submission to the Equine Veterinary Journal (EVJ) or similar academic journals for publication.

Deviations

No deviations from the protocol occurred.

Records

Data were captured in Microsoft Excel® spreadsheets, which will be kept on the primary investigator's computer and laptop and is backed up electronically. Electronic copies of the data were made available to the co-supervisor and supervisor. The data will be kept by the primary investigator and if no longer in the employ of the University of Pretoria will be handed over to the department.

Declaration of conflict of interest

None of the authors of this paper has a financial or personal relationship with other people or organisations that could inappropriately influence or bias the content of this paper.

Ethical considerations

Anonymity is the main ethical consideration during this retrospective case series and will be maintained by using only patient numbers to identify cases. All personal details of survey respondents were kept confidential and will not be published in any form. Participation in the survey was voluntary. The study was approved by the both the Faculty of Veterinary Sciences Research Ethics Committee and the Faculty of Humanities of the University of Pretoria (REC16-22).

4. Results

All colic cases seen in 2021 at OPEC

Study population

Initial case search yielded 193 cases presented for abdominal pain to OPEC. Eleven cases (6%, 11/193) were excluded as six cases (3%, 6/193) were duplicate admissions, three cases (2%, 3/193) had incomplete client information, two cases (1%, 2/193) were not related to colic/abdominal pain and the primary complaint was entered incorrectly. A final study population of 182 cases was available for study.

Age of horses at presentation was normally distributed and ranged from three weeks to 27 years (mean =10.3yo, SD = 5.5y). The age of five patients was not recorded.

The most common breeds of the study population consisted of Thoroughbreds (37%, 68/182), Warmbloods (26%, 47/182), followed by Friesians (12%, 21/182) (Figure 4.1).

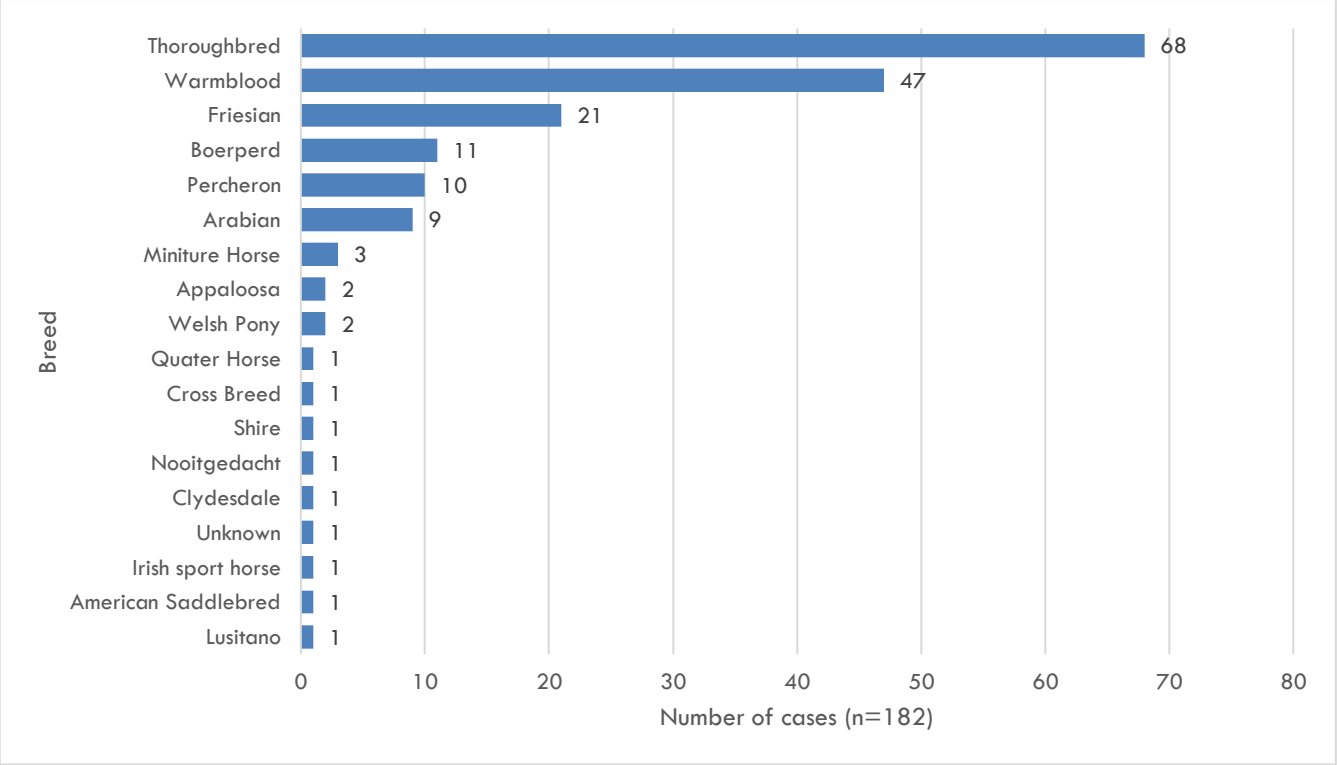
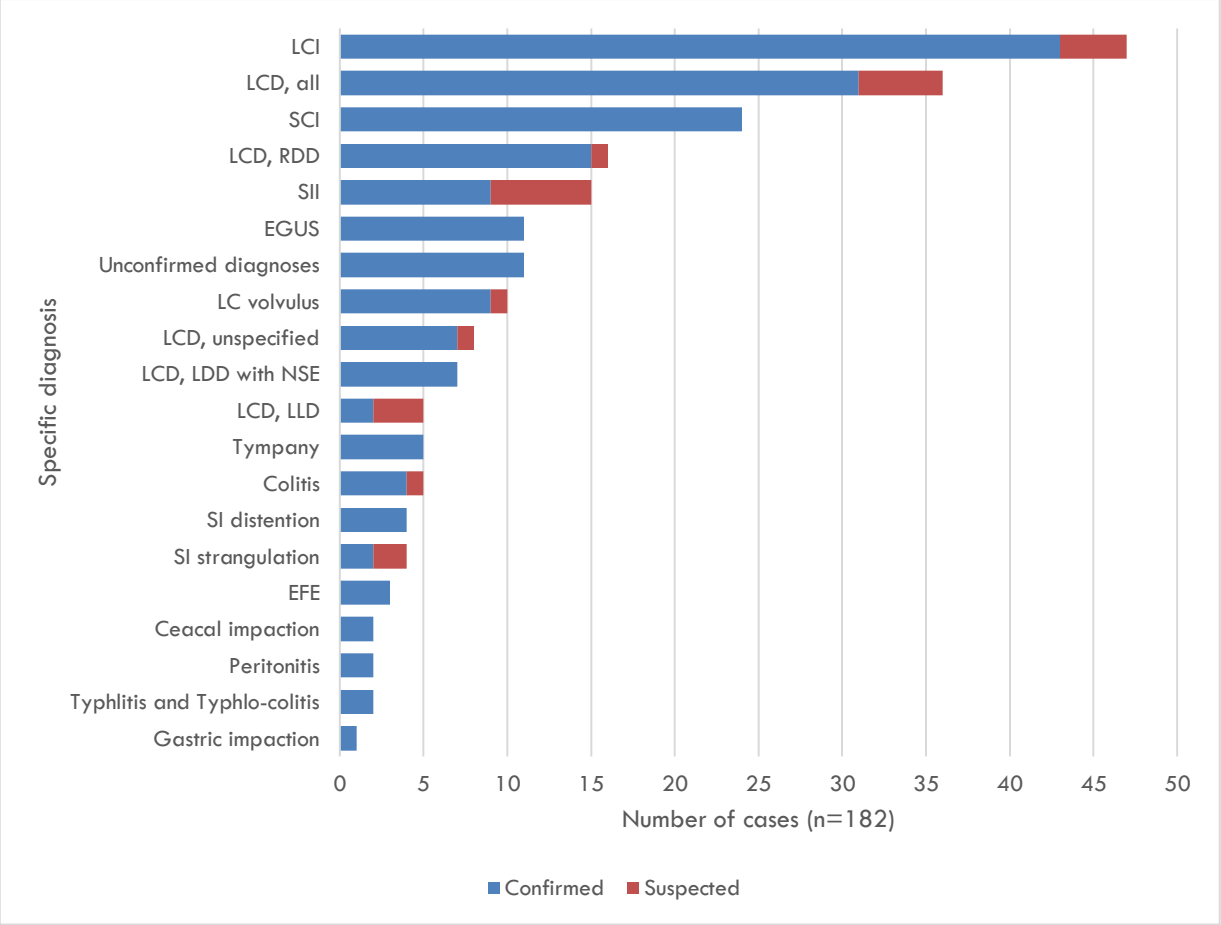


Figure 4.1 Breed distribution of horses admitted to the Onderstepoort Veterinary Academic Hospital (OVAH) for signs of acute abdominal pain during 2021 (n=182).

The majority of patients were male (55%, 100/182). Geldings represented 46% (84/182) while stallions represented 9% (16/182). Mares represented 44% (80/182) and the sex of two patients was not recorded.

Diagnosis or cause of colic

Large colon impactions made up 26% (47/182) of colic admissions, followed by SCI (13%, 24/182), RDD (9%, 16/182), SII (8%, 15/182), EGUS (7%, 12/182) and LC volvulus (6%, 10/182) (Table 4.1; Figure 4.2).



LCI: large colon impaction, SCI: small colon impaction, LCD: large colon displacement, RDD: right dorsal displacement, SII: small intestinal impaction, EGUS: equine gastric ulcer syndrome, LC: large colon, SI: small intestine, LDD: left dorsal displacement, NSE: nephrosplenic entrapment, EFE: epiploic foramen entrapment.

Figure 4.2 Diagnosis in horses admitted to the Onderstepoort Veterinary Academic Hospital (OVAH) for signs of acute abdominal pain during 2021 (n=182).

Table 4.1: Diagnosis in horses admitted to the Onderstepoort Veterinary Academic Hospital (OVAH) for signs of acute abdominal pain (n=182) during 2021.

Diagnosis	**Confirmed (n)**	**Suspected (n)**	**Total (n)**	**Total (%)**
Large colon impaction	43	4	47	26
Large colon displacement, all	31	5	36	19.8
- *Right dorsal displacement*	*(15)*	*(1)*	*(16)*	*(8.8)*
- *Unspecified large colon displacement*	*(7)*	*(1)*	*(8)*	*(4.4)*
- *Nephrosplenic entrapment*	*(7)*	*(0)*	*(7)*	*(3.8)*
- *Left dorsal displacement only*	*(2)*	*(3)*	*(5)*	*(2.7)*
Small colon impaction	24	0	24	13.2
Small intestinal impaction	9	6	15	8.2
Equine gastric ulcer syndrome only	11	0	11	6.0
Unconfirmed diagnoses	11	0	11	6.0
Large colon volvulus	9	1	10	5.5
Tympany only	5	0	5	2.7
Colitis	4	1	5	2.7
Small intestinal distention / ileus	4	0	4	2.2
Small intestinal strangulation	5	2	7	3.8
- *Epiploic foramen entrapment*	*(3)*	*(0)*	*(3)*	*(1.6)*
Caecal impaction	2	0	2	1.1
Peritonitis	2	0	2	1.1
Typhlitis and typhlo-colitis	2	0	2	1.1
Gastric impaction	1	0	1	0.5

Almost a third (32%, 52/182) of colic cases had more than one gastrointestinal diagnosis made either during exploratory laparotomy, rectal palpation, or gastroscopy.

Thoroughbreds (38% of colic cases in total) made up 70% of large colon displacements, Warmbloods (26% of colic cases in total) represented 56% of large colon volvulus cases and Friesians (12% of colic cases in total) contributed 38% of SCI cases (Figure 4.3).

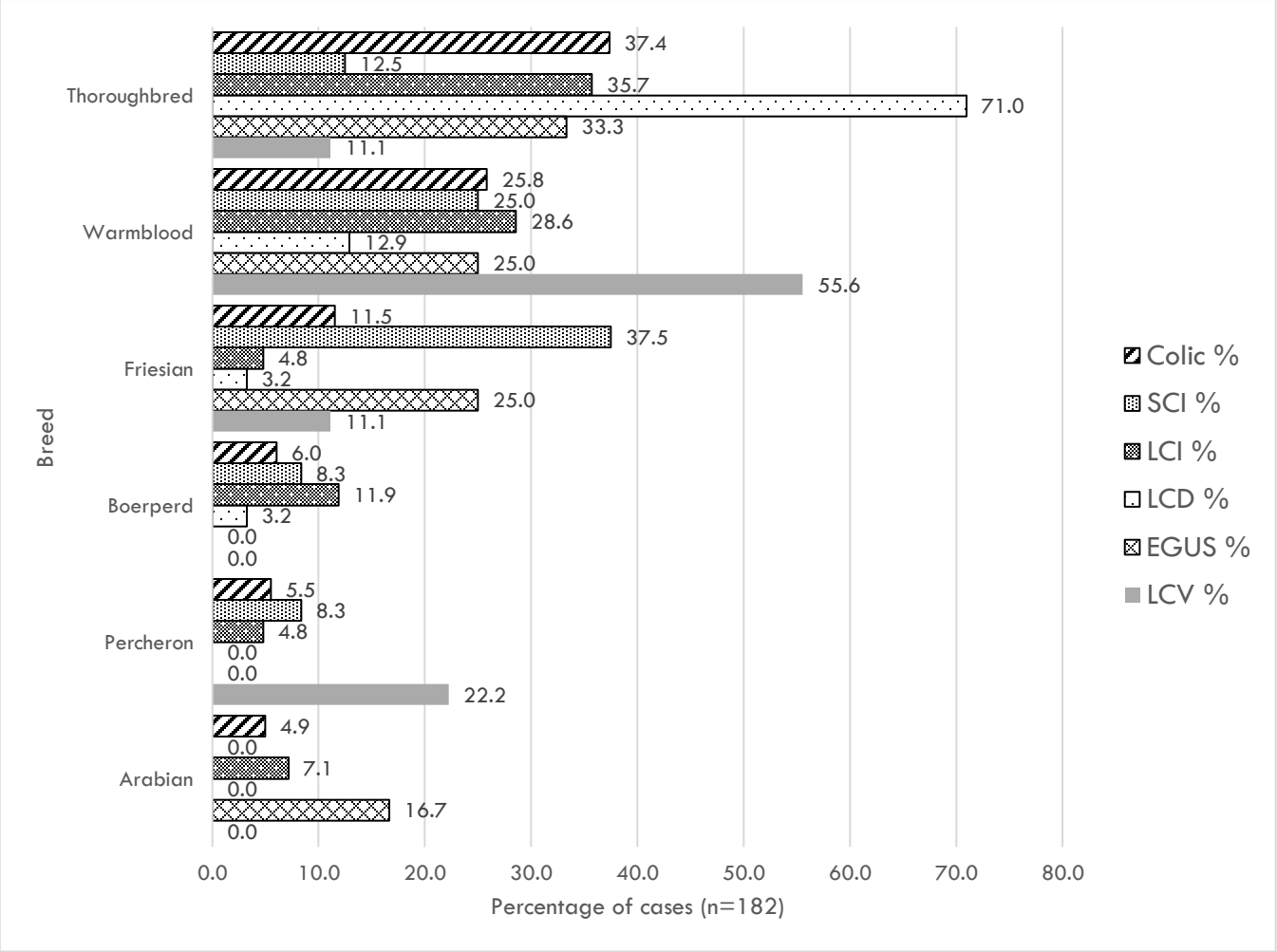


Figure 4.3 Breed distribution of colic (diagonal black lines) in general vs other diagnoses in the six most common breeds admitted to the Onderstepoort Veterinary Academic Hospital (OVAH) for signs of acute abdominal pain during 2021 (n=182). LCI: large colon impaction (white dots), SCI: small colon impaction(small dense black dots), LCD: large colon displacement (small sparce black dots), LCV: large colon volvulus(solid grey), EGUS: equine gastric ulcer syndrome (black cross hatch).

Epidemic curves

The temporal distribution of cases, as represented by the epidemic curve, revealed a significant overrepresentation of SCI in June and July 2021, suggesting a potential seasonal or environmental influence.

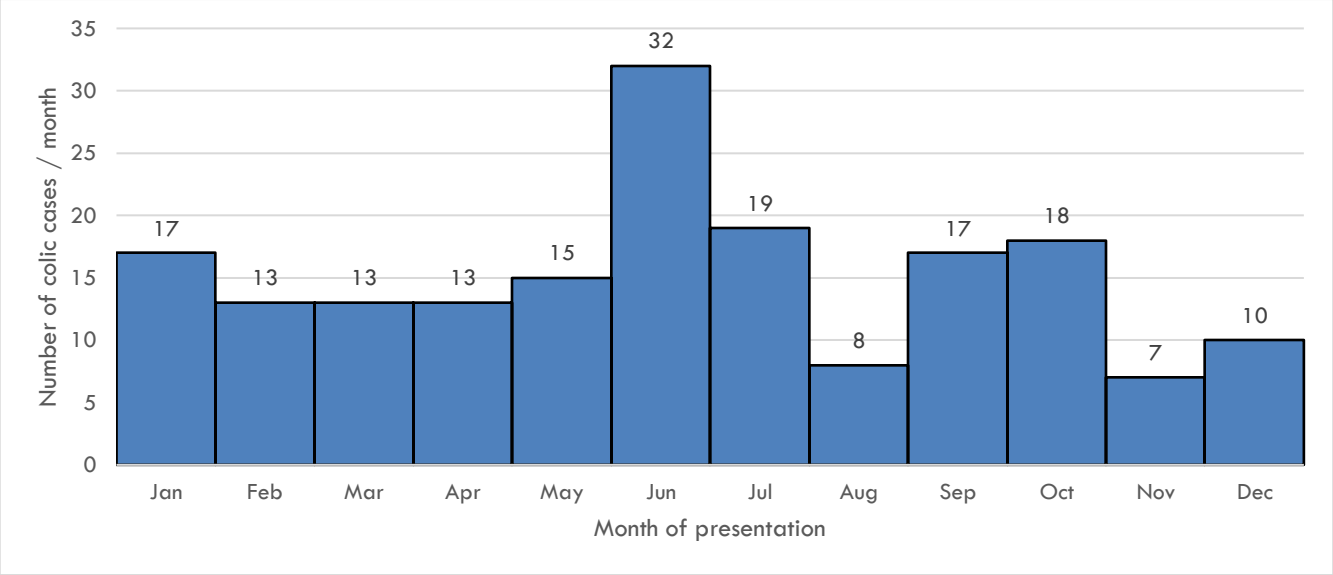


Figure 4.4 Colic case distribution by month of presentation to the Onderstepoort Veterinary Academic Hospital (OVAH) for signs of acute abdominal pain during 2021 (n=182).

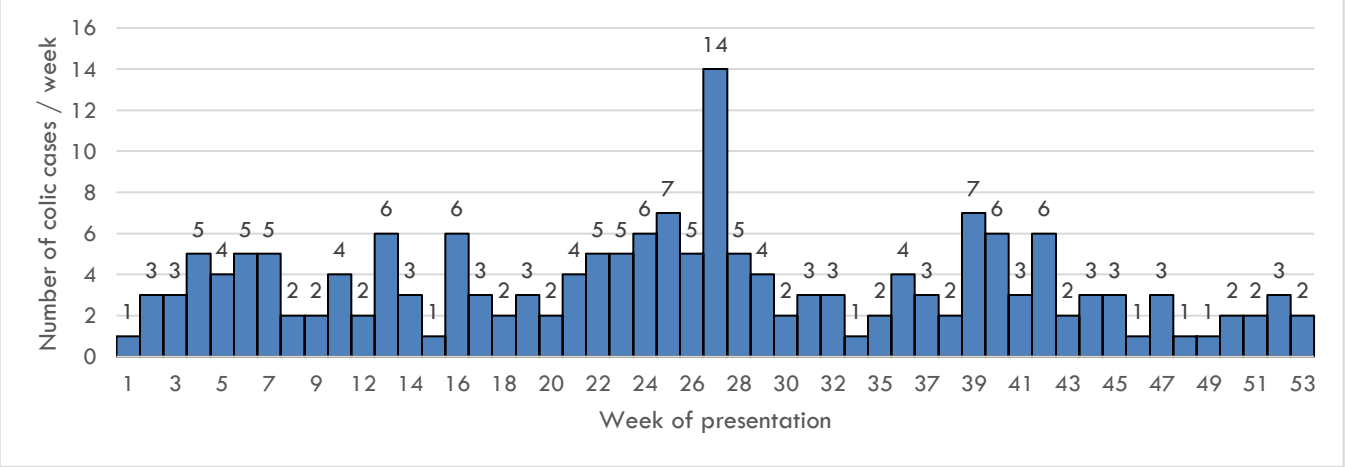


Figure 4.5 Colic case distribution by week of presentation to the Onderstepoort Veterinary Academic Hospital (OVAH) for signs of acute abdominal pain during 2021 (n=182).

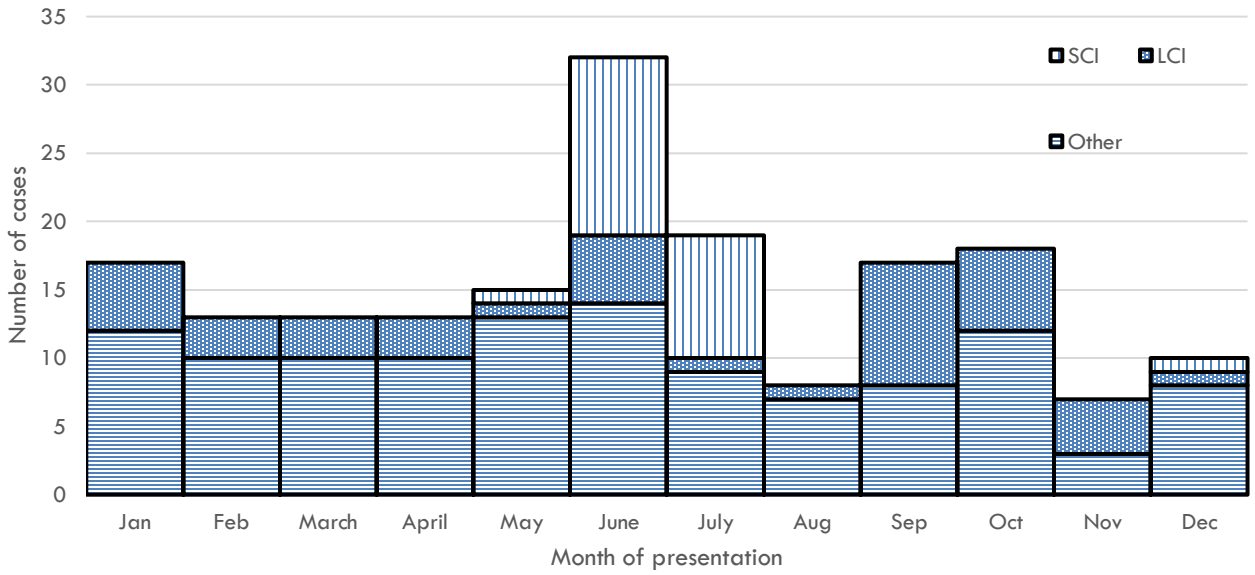


Figure 4.6 Horses presented to the Onderstepoort Veterinary Academic Hospital (OVAH) for signs of acute abdominal pain during 2021 and were diagnosed with either small colon impactions (SCI, vertical lines), large colon impactions (LCI, white dots) or "other" colic types (horizontal lines).

Treatment and outcome

During 2021, 182 horses presented to OPEC for acute abdominal pain, 3% (6/182) were euthanised before receiving treatment, 65% (118/182) were treated medically and 32%(58/182) were treated surgically. Of the surgically treated cases, one case (1%) died during anaesthetic recovery. The majority of the treated horses were discharged (85%, 150/176) (Table 4.2).

Table 4.2: Treatment pursued vs outcome of horses presented to the Onderstepoort Veterinary Academic Hospital (OVAH) for signs of acute abdominal pain during 2021 (n=176).

Count of Outcome	**Treatment**		
Outcome	**Medical**	**Surgical**	**Total**
Discharged	105 (89%)	45 (77%)	150 (85%)
Euthanised	13 (11%)	12 (21%)	25 (14%)
Died	0 (0%)	1 (2%)	1 (1%)
Total	**118 (67%)**	**58 (33%)**	**176**

Small colon impactions

Study population

During 2021, 24 cases of SCI were diagnosed at OPEC. Most (96%, 23/24) presented within a two-month period (May 24th-July 25th, 2021). One case presented outside of this time in December 2021 and was not included in further outbreak analysis. Age of horse at presentation was normally distributed (Shapiro-Wilk p-value = 0.15883258 (W = 0.9395)) and ranged from 2-16 (Mean = 8.5 years, SD = 4.1). The most common breeds were Friesians (35%, 8/23) and Warmbloods (26%, 6/23) (Table 4.3). Draft breeds were affected in 48% (11/23) of the SCI cases. The majority of the patients were male (65%, 15/23) with geldings representing 48% (11/23) and stallions 17% (4/23). Mares represented 35% (8/23) of the cases.

Table 4.3: Breed distribution of small colon impaction cases presented to Onderstepoort Veterinary Academic Hospital (OVAH) in 2021.

Breed	**SCI (n)**	**SCI (%)**
Friesian	8	35
Warmblood	6	26
Thoroughbred	3	13
Boerperd	2	9
Percheron	2	9
Cross Breed	1	4
Shire	1	4
Total	**23**	**100**

History

Of the 23 horses diagnosed with SCI; 26% (6/32) were not seen by a referring veterinarian and were brought directly to OPEC by the owner; 30% (7/32) were seen and diagnosed with SCI by a referring veterinarian but referred prior to any treatment; 44% (10/32) were diagnosed with SCI by the referring veterinarian and treated on the farm but were referred when the colic did not resolve.

Only one case (4%) had a history of pyrexia prior to presentation while 26% (6/32) had a history of diarrhoea prior to presentation.

Admission

Clinical exam findings on presentation varied and no patients were pyrexic on presentation. Temperature data were normally distributed, ranged from 37.1-38.3°C (mean = 37.85°C, SD = 0.33). Tachycardia was defined as HR>48 beats per minute (bpm) and was present in 44% (10/23) cases.

Heart rate ranged from 28-88bpm (mean = 53.4bpm, SD = 15.2). Tachypnoea was defined as a respiratory rate above 20bpm and was present in 35% (8/23) of cases. Respiratory rate ranged from 8-44bpm (mean = 21.1bpm, SD = 8).

On presentation, most patients had normal pink moist and glistening mucous membranes (70%, 16/23) with a capillary refill time (CRT) of <2s (61%, 14/23). Four patients (17%) had tacky dry mucous membranes, two (9%) had congested mucous membranes and one patient (4%) already had cyanotic mucous membranes. Six patients (26%) had a CRT of 2-3 seconds and only three patients (13%) had a CRT of ≥ 3s.

Most patients (83%, 19/23) had reduced or absent gastrointestinal sounds on abdominal auscultation and digital pulses were non-bounding in all the patients where it was recorded (20/20).

A loose stool or diarrhoea was recorded in 48% (11/23) of cases on admission. Colic signs at admission were recorded in all 23 cases with 26% (6/23) being mild, 57% (13/23) being moderate and 18% (4/23) of horses presenting with severe abdominal pain. The degree or presence of abdominal distension was not recorded in 12 cases. Of the remaining 11 cases, 27% (3/11) had no abdominal distension, 36% (4/11) had mild, and 27% (3/11) had moderate distension. Severe abdominal distension was recorded in only one case (8%).

Rectal palpation was performed in all patients (23/23) of which a SCI was palpable rectally in 83% (19/23) of cases. Thorough rectal palpation was precluded by severe gas distension in two patients (9%) and advanced pregnancy in one. Severe small intestinal distension was palpable in one patient. After rectal palpation blood was present on the examiners glove in two cases (9%).

Transcutaneous abdominal ultrasonography was performed in 96% (22/23) of cases and was unremarkable in 46% (10/22) of cases. Ultrasonography revealed fluid in the colon (1/22), a thickened colonic wall (2/22), peritoneal effusion (2/22) and hypomotile distended small intestine (5/22). Thorough abdominal ultrasound was precluded by severe gas distension in one patient and advanced pregnancy in another.

Abdominocentesis was performed in 78% (18/23) cases, but fluid was only obtained in 13 cases (Table 4.4).

Table 4.4: Abdominocentesis results in small colon impaction colic cases (n=13/23)

n	Macroscopic appearance	Protein (g/dL)	Lactate (mmol/L)
1	Clear, straw coloured	"normal"	"normal"
2	Clear, straw coloured	"normal"	0.5
3	Clear, straw coloured	NIR	0.5
4	Clear, straw coloured	5	0.5
5	Clear, straw coloured	10	2.6
6	Clear, straw coloured	NIR	2.3
7	Turbid, straw coloured	16	11.4
8	Turbid, straw coloured	12	0.5
9	Green to dark yellow	56	7
10	NIR	NIR	0.8
11	NIR	12	2
12	NIR	NIR	NIR
13	NIR	48	9

NIR = No information recorded, “normal” = only recorded as “normal” with no numeric value listed

A nasogastric tube was passed in all 23 cases and yielded less than 2.5 litres in 91% (21/23) of cases. The remaining two cases had 7L and 9L of nasogastric reflux.

Packed cell volume and total serum protein was assessed in all 23 cases. Packed cell volume was not normally distributed and ranged from 30–54% (median = 35%, interquartile range = 34-43%). Total serum protein was normally distributed and ranged from 40-80g/dL (mean = 66.3g/dL, SD = 9).

Haematology was performed in 91% (21/23) of cases and total white cell count (WCC) recorded in 95% (20/21) of cases. Leukopenia was defined as a total white cell count less than $4.7x10^9$ cells/L and 55% (11/20) horses fit this criteria. The total white cell count was not normally distributed and ranged from 1.73-7.2x10^9 cells/L (median 4.41x10^9 cells/L, IQR =

2.92-5.65x10^9 cells).

Venous blood gas analysis was performed in 96% (22/23) of cases and the systemic lactate recoded in 21 cases. Hyperlactatemia was defined as systemic lactate above 2mmol/L and 29% (6/21) cases fit this criteria. Systemic lactate was not normally distributed and ranged from 0.5-7.06mmol/L (median 1.68mmol/L, IQR 1.17-3.26mmol/L).

Treatment and reason

Immediate surgical treatment was performed in 30% (7/23) of cases. This was due to severe colic signs in 2/7 patients or the clinical impression that the SCI palpable rectally was severe and extensive in 5/7 cases. In the remaining 70% (16/23) cases medical management was initiated although surgical intervention was pursued in 63% (10/16) of cases due to unrelenting colic signs (4/10) or the clinical

perception that medical management was failing to resolve the impaction timeously (6/10). Thus 74% (17/23) cases were treated surgically via a ventral midline exploratory laparotomy. Medical management alone was implemented in 26% of cases overall (6/23).

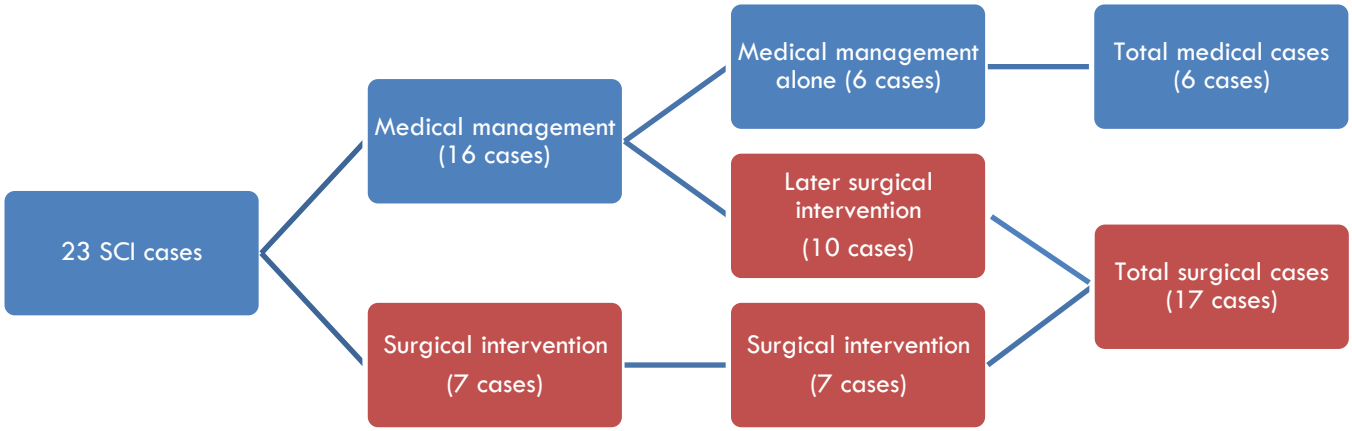


Figure 4.7 Treatment pursued (medical vs surgical) in 23 small colon impaction (SCI) cases presented to Onderstepoort Equine Clinic (OPEC) in 2021 (n=23)

Surgical findings

Small colon impactions were present in all cases (17/17) that underwent exploratory laparotomy and was judged as moderate (71%, 12/17) or severe (24%, 4/17) in the majority of cases. The extent of SCI was not recorded in one case. Other pathology encountered included large colon impaction (24%, 4/17), small intestinal impaction (6%, 1/17), severe large colon tympany (6%, 1/17), transverse colon impaction (6%, 1/17) and small intestinal enteritis (6%, 1/17). No abnormalities of the stomach or caecum were recorded. The SCI was resolved by enema and extraluminal massage in all cases. No small colon enterotomies were performed. A pelvic flexure enterotomy was performed in 88% (15/17) of cases. The remaining two cases that did not undergo a pelvic flexure enterotomy both underwent a second surgery 24-36 hours after the first due to recurrence of impaction of the small colon.

Anaesthetic and surgery time was available for 10/17 cases. Anaesthetic time ranged from 135-210 minutes (mean = 173min, SD 30.5) while surgery time was 105-155minutes (mean = 133min, SD = 26).

Hospitalisation

The duration of hospitalisation(days) was normally distributed and ranged from 1-22 days (mean = 11.1 days, SD = 6.0). Routine biosecurity sampling was performed on all 23 cases and failed to yield any indication of Salmonella spp. in any of the samples.

As two (2/23) patients were euthanised, time to SCI resolution and refeeding was recorded in 21/23 cases. Overall time(hours) to resolution of the SCI (from admission) was not normally distributed, ranged from 2-72h (median = 24h, inter quartile range = 16h) and this varied between treatment options (Table 4.5).

Table 4.5: Time to resolution of SCI in patients treated medically vs surgically

Treatment pursued	**N**	**Range**	**Median**	**IQR**
Overall	23	2-72h	24h	10-36h
Surgical treatment *Immediate* *After medical therapy failed*	17 *7* *10*	2-72h *2-12h* *12-72h*	24h *2h* *24h*	4-24h *2-6.5h* *24-24h*
Medical treatment *Alone* *Euthanised after medical therapy failed*	6 *4* *2*	24-72h *24-72h* *48h*	48h *48h* *48h*	48-48h *42-54h* *48-48h*

The time to refeeding (hours) after SCI resolution was recorded for 20/23 cases for both long and short stem feed. Time to short stem refeeding (hours) was not normally distributed and ranged from 2-168h (median = 30h, IQR=24-72h). Time to long stem refeeding (days) was not normally distributed and ranged from 1-8d (median = 3d, IQR=3-5d).

Complications

Colic signs (8/23 = 35%), nasogastric reflux (8/23 = 35%), incisional site infection (5/17 = 30%) and thrombophlebitis (6/23 = 26%) were the most common complications seen in hospital (Table 4.6).

Table 4.6: Complications encountered during hospitalisation of SCI colic cases (n=23) treated at the Onderstepoort Equine Clinic (OPEC) in 2021.

Complication	**Total**	**Mild**	**Moderate**	**Severe**
Nasogastric reflux	8 (35%)	1 (4%)	3 (13%)	4 (17%)
Colic signs	8 (35%)	2 (9%)	4 (17%)	2 (9%)
Incisional site infection (n=17)	5 (29%)	1 (6%)	4 (24%)	0
Thrombophlebitis	6 (26%)	3 (13%)	3 (13%)	0
Re-impaction	3 (13%)	1 (4%)	2 (9%)	0
Diarrhoea	1 (4%)	1 (4%)	0	0
Pneumonia	1 (4%)	1 (4%)	0	0
Total		10 (43%)	16 (70%)	6 (26%)

Outcome

The overall short term outcome was good (survive to discharge) in 87% (20/23) of horses. Three horses (13%, 3/23) were euthanised due to financial constraints (9%, 2/23) or GIT perforation (3%, 1/24). Survival to discharge in horses treated surgically was 94% (16/17) while the survival to discharge was poorer in patients treated medically (67%, 4/6).

Small colon risk factor analysis

Data collection was stopped after 16 weeks, by which time 62/182 (34%) of owners had successfully completed the questionnaire.

Risk factors for colic horses associated with an increased odds of being diagnosed with SCI were breed (draft breeds, OR 8.20, 95% CI 3.13-21.5, P<0.001 and Friesian, OR 7.00, 95% CI 1.73-28.3, P = 0.006), sex (stallion, OR 4.17, 95% CI 1.11-15.6, P = 0.034) and season (winter, OR 43.2, 95% CI 9.59-195, P<0.001) in the univariate analysis (Table 4.7). Only breed (Friesian, OR 8.87, 95% CI 1.97-39.9, P = 0.004), and season (winter, OR 43.8, 95% CI 9.04-212, P<0.001) remained significant in the multivariable model (Table 4.8).

When compared to LCI only, breed (draft breeds, OR 32.7, 95% CI 3.76-285, P = 0.002) and season (winter, OR 124, 95% CI 12.8-1195, P<0.001) remained as significant risk factors for SCI in the univariate analysis (Table 4.9). Additional factors identified were yard size (small number of horses, P=0.036) and horses presenting from the greater Pretoria (P=0.038) (Table 4.10).

Sample size was not sufficient to evaluate questionnaire data relative to LCI only. None of the draft horses had LCI so it was not possible to analyse breed as a predictor. The only significant predictor was originating from the region of western Pretoria and thus further modelling was not possible.

Within owners that completed a questionnaire, draft breeds (OR 5.24, 95% CI 1.25-21.9, P=0.023) were at an increased risk (Table 4.11). This also identified the number of horses at a yard as a risk factor (<14 horses, OR 12.9, 95% CI 1.43-117, P=0.023). Horses fed less than one kilogram of concentrate feeding were also at risk for the development of SCI (OR 10.6, 95% CI 1.06-107, P=0.045). Friesians (OR 52.5, 95% CI 3.39-814, p=0.005), <24 horses on the premises (OR 10.7, 95% CI 1.15-100, p=0.037) and feeding less than one kilogram of concentrates (OR 7.15, 95% CI 1.19-42.9, p=0.031) remained significant risk factors for the development of SCI within the multivariable model (Table 4.12).

Horses were from four provinces in South Africa. Gauteng (53/62), North West (5/62), Limpopo (2/62) and Mpumalanga (2/62) (Figure 4.8). There was significant global spatial clustering of SCI cases to the greater Pretoria area, based on a Cuzick-Edwards Z-score of 2.79, P = 0.005 whereas there was no significant spatial clustering for LCI case with a Z-score of 1.00 and P = 0.316.

Table 4.7: Univariate associations between small colon impactions (n=24) compared to all other colic diagnoses (n=138) presenting to a single referral equine clinic during 2021.

Variable	Level	Parameter estimate (β)	Odds ratio (95% CI)	P value (Wald)
Sex				0.092
	Stallion	**1.427**	**4.17 (1.11, 15.6)**	**0.034**
	Gelding	0.208	1.23 (0.46, 3.27)	0.676
	Mare	Referent		
Age (years)				0.350
	≤ 5	1.492	4.44 (0.87, 22.8)	0.074
	6 – 10	1.003	2.73 (0.54, 13.7)	0.224
	11 – 15	1.034	2.81 (0.53, 15.0)	0.227
	≥ 16	Referent		
Breed				0.002
	Thoroughbred	-0.944	0.39 (0.08, 1.86)	0.237
	Warmblood	0.074	1.08 (0.28, 4.18)	0.915
	Friesian	**1.946**	**7.00 (1.73, 28.3)**	**0.006**
	Boerperd	0.560	1.75 (0.27, 11.4)	0.558
	Other breed	Referent		
	Draft breed	**2.104**	**8.20 (3.13, 21.5)**	**<0.001**
	Other breed	Referent		
Season				<0.001
	Spring/Summer	Referent		
	Autumn	0.762	2.14 (0.13, 35.3)	0.594
	Winter	**4.076**	**58.9 (7.58, 458)**	**<0.001**
	Winter	**3.766**	**43.2 (9.59, 195)**	**<0.001**
	Other season	Referent		

CI = confidence interval

Table 4.8: Multivariable associations between small colon impactions (n=24) compared to all other colic diagnoses (n=138) presenting to a single referral equine clinic during 2021.

Variable	Level	Parameter estimate (β)	Odds ratio (95% CI)	P value (Wald)
Breed				
	Friesian	2.182	8.87 (1.97, 39.9)	0.004
	Other breed	Referent		
Season				
	Winter	3.780	43.8 (9.04, 212)	<0.001
	Other season	Referent		

CI = confidence interval

Table 4.9: Univariate associations between small colon impactions (n=21) compared to large colon impactions (n=37) presenting to a single referral equine clinic during 2021.

Variable	Level	Parameter estimate (β)	Odds ratio (95% CI)	P value (Wald)
Sex				0.396
	Stallion	0.677	1.97 (0.36, 10.8)	0.436
	Gelding	0.783	2.19 (0.68, 7.04)	0.190
	Mare	Referent		
Age (years)				0.941
	≤ 5	0.405	1.50 (0.22, 10.3)	0.680
	6 – 10	0.598	1.82 (0.28, 11.9)	0.532
	11 – 15	0.446	1.56 (0.22, 11.4)	0.659
	≥ 16	Referent		
Breed				0.798
	Thoroughbred	-0.981	0.38 (0.07, 2.16)	0.272
	Warmblood	-0.134	0.88 (0.18, 4.21)	0.868
	Friesian	21.783	Undefined (large)	0.999
	Boerperd	-0.827	0.44 (0.04, 5.40)	0.519
	Other breed	Referent		
	Draft breed	**3.488**	**32.7 (3.76, 285)**	**0.002**
	Other breed	Referent		
Season				<0.001
	Spring/Summer	Referent		
	Autumn	1.312	3.71 (0.21, 67.1)	0.374
	Winter	**4.816**	**124 (12.8, 1195)**	**<0.001**
	Winter	**4.362**	**78.4 (13.1, 469)**	**<0.001**
	Other season	Referent		

CI = confidence interval. No multivariable model fit these data.

Table 4.10: Descriptive statistics and comparison among treatment groups for small colon impaction (n=11), large colon impaction (n=17), and other colic diagnoses (n=34) treated at a single referral practice during 2021, in which the owners completed a risk factor questionnaire (Aug-Nov 2022).

	Small colon impaction		Large colon impaction		Other diagnosis		
Variable	**n**	**PE (range)***	**n**	**PE (range)***	**n**	**PE (range)***	**P value†**
Winter presentation	11	1.0[a] (0.76, 1.0)	2	0.12[b] (0.02, 0.34)	8	0.24[b] (0.12, 0.40)	**<0.001**
Sex							
Mare	3	0.27 (0.07, 0.58)	9	0.53 (0.30, 0.75)	11	0.32 (0.18, 0.49)	0.271
Gelding	6	0.54 (0.26, 0.81)	6	0.35 (0.16, 0.60)	21	0.62 (0.45, 0.77)	0.202
Stallion	2	0.18 (0.03, 0.48)	2	0.12 (0.02, 0.34)	2	0.06 (0.01, 0.18)	0.350
Breed							
Thoroughbred	1	0.09 (0.00, 0.37)	7	0.41 (0.20, 0.65)	15	0.44 (0.28, 0.61)	0.104
Warmblood	3	0.27 (0.07, 0.58)	6	0.35 (0.16, 0.60)	8	0.24 (0.12, 0.40)	0.984
Friesian	4	0.36[a] (0.13, 0.66)	0	0[b] (0, 0.16)	2	0.06[a,b] (0.01, 0.18)	**0.008**
Age (yrs.)	11	9.6 (1.8, 17.0)	17	10.0 (4.0, 19.3)	34	9.8 (0.6, 21.4)	0.630
Ownership (yrs.)	11	1 (0.01, 13)	17	4 (0.5, 17)	34	2.5 (0.03, 22)	0.603
Number of horses	11	12[a] (5, 29)	17	15[a,b] (3, 70)	34	29[b] (3, 130)	**0.036**
Horse use							
Jumping	3	0.27 (0.07, 0.58)	10	0.59 (0.35, 0.80)	11	0.32 (0.18, 0.49	0.130
Pleasure	4	0.36 (0.13, 0.66)	5	0.29 (0.12, 0.54)	10	0.29 (0.16, 0.46)	0.902
Dressage	6	0.54 (0.26, 0.81)	6	0.35 (0.16, 0.60)	9	0.26 (0.14, 0.43)	0.229
Prophylactic dental care							
Every 6 months	3	0.27 (0.07, 0.58)	9	0.53 (0.30, 0.75)	17	0.50 (0.34, 0.66)	0.353
Once per year	4	0.36 (0.13, 0.66)	7	0.41 (0.20, 0.65)	11	0.32 (0.18, 0.49	0.823
Other/unknown	4	0.36 (0.13, 0.66)	1	0.06 (0.00, 0.26)	6	0.18 (0.07, 0.33)	0.113
Time stabled per day							
≤ 8 hours	1	0.09 (0.00, 0.37)	3	0.18 (0.05, 0.41)	3	0.09 (0.02, 0.22)	0.999
> 8 hours	10	0.91 (0.63, 100)	14	0.82 (0.59, 0.95)	31	0.91 (0.78, 0.98)	0.999
Exclusively water in buckets	10	0.91 (0.63, 100)	9	0.53 (0.30, 0.75)	20	0.59 (0.42, 0.74)	0.097
Municipal water source	3	0.27 (0.07, 0.58)	5	0.29 (0.12, 0.54)	8	0.24 (0.12, 0.40)	0.999
Toxic plants observed	3	0.27 (0.07, 0.58)	4	0.24 (0.08, 0.48)	9	0.26 (0.14, 0.43)	0.999
Veterinarian examined (hr.)	4	2 (2, 5)	11	1 (1, 24)	23	1 (1, 12)	0.081
Hospital admitted (hr.)	10	5.5 (1, 24)	17	3 (2, 4)	34	3 (1, 16)	0.325
Presenting in greater Pretoria	11	1.0 (0.76, 1.0)	11	0.65 (0.40, 0.84)	20	0.59 (0.42, 0.74)	**0.038**

PE = point estimate; proportion for categorical data and median for quantitative data.

*Presented as the median (range) for quantitative data and the proportion (95% confidence interval) for categorical data.

†Based on Kruskal-Wallis tests for quantitative data and chi-square tests for categorical data (or Fisher exact tests when small sample sizes comparing small colon impactions to all other diagnoses). Point estimates without superscripts in common are significantly different (P<0.05) based on post-hoc pairwise comparisons incorporating Bonferroni correction of P values.

Table 4.11: Univariate associations between small colon impactions (n=11) compared to all other colic diagnoses (n=51) presenting to a single referral equine clinic during 2021 with owners completing an online questionnaire during 2022.

Variable	Level	Parameter estimate (β)	Odds ratio (95% CI)	P value (Wald)
Sex				0.527
	Stallion	1.204	3.33 (0.41, 26.9)	0.258
	Gelding	0.393	1.48 (0.33, 6.65)	0.608
	Mare	Referent		
Age (years)				0.687
	≤ 5	0.944	2.57 (0.34, 19.3)	0.359
	6 – 10	-0.105	0.90 (0.13, 6.18)	0.915
	11 – 15	0.405	1.50 (0.21, 10.6)	0.685
	≥ 16	Referent		
Breed				0.034
	Friesian	2.079	8.00 (0.96, 66.5)	0.054
	Thoroughbred	-1.749	0.17 (0.02, 1.86)	0.148
	Warmblood	-0.154	0.86 (0.15, 5.06)	0.865
	Other breed	Referent		
	Draft breed	**1.656**	**5.24 (1.25, 21.9)**	**0.023**
	Other breed	Referent		
Ownership length				0.265
	< 1 year	0.629	1.88 (0.42, 8.44)	0.413
	1 – 4 years	-0.847	0.43 (0.07, 2.62)	0.359
	≥ 5 years	Referent		
Horse use				0.259
	Show jumping	0.639	1.90 (0.18, 20.4)	0.598
	Pleasure	0.944	2.57 (0.24, 28.1)	0.439
	Dressage	2.079	8.00 (0.73, 88.2)	0.090
	Other use	Referent		
Routine dental care				0.185
	Every 6 months	-1.600	0.20 (0.04, 1.12)	0.067
	Once a year	-0.944	0.39 (0.08, 2.00)	0.258
	Other/unknown	Referent		
Deworming schedule				0.600
	According to FEC	0.799	2.22 (0.19, 25.7)	0.523
	Every 3 – 6 months	-0.262	0.77 (0.07, 8.41)	0.830
	Every 7 – 12 months	-0.095	0.91 (0.07, 12.5)	0.943
	Other/unknown	Referent		
Exercise history				0.190
	2 – 4 times per week	1.232	3.43 (0.37, 31.6)	0.277
	4 – 7 times per week	-0.154	0.86 (0.07, 10.7)	0.905
	Other	Referent		

Number of horses				0.062
	<14	**2.559**	**12.9 (1.43, 117)**	**0.023**
	14 – 28	1.638	5.14 (0.49, 54.3)	0.173
	≥ 29	Referent		
Travel history	Yes	0.851	2.34 (0.57, 9.59)	0.237
	No/unknown	Referent		
Colic history	Yes	-0.705	0.49 (0.12, 2.08)	0.337
	No/unknown	Referent		
Lucerne feeding	Yes	0.143	1.15 (0.31, 4.27)	0.830
	No	Referent		
Teff feeding	Yes	0.047	1.05 (0.27, 4.07)	0.946
	No	Referent		
Eragrostis feeding	Yes	0.105	1.11 (0.26, 4.77)	0.887
	No	Referent		
Roughage source				0.996
	Commercial	-0.074	0.93 (0.16, 4.45)	0.935
	Independent supplier	0.080	1.08 (0.15, 7.96)	0.937
	Direct from farmer	-0.325	0.72 (0.10, 5.10)	0.744
	Home grown	0.080	1.08 (0.09, 13.5)	0.950
	Unknown	Referent		
Concentrate source	Commercial	-1.238	0.29 (0.06, 1.46)	0.133
	Other/none	Referent		
Concentrate supplier				0.105
	Supplier A (Royal)	1.601	4.96 (0.98, 25.0)	0.053
	Supplier B (Epol)	-0.190	0.83 (0.14, 4.77)	0.832
	Other supplier	Referent		
Concentrate amount				0.174
	0 – 1 kg	**2.363**	**10.6 (1.06, 107)**	**0.045**
	2 kg	0.961	2.62 (0.21, 32.1)	0.452
	3 kg	1.367	3.92 (0.37, 42.2)	0.259
	≥ 4 kg	Referent		
Time at pasture	< 8 hours	-0.036	0.96 (0.18, 5.24)	0.966
	≥ 8 hours	Referent		
Time stabled	< 8 hours	-0.288	0.75 (0.08, 6.94)	0.800
	≥ 8 hours	Referent		
Municipal water	Yes	0.092	1.10 (0.25, 4.76)	0.902
	No	Referent		
Water delivery	Buckets only	2.026	7.59 (0.90, 63.8)	0.062
	Other delivery	Referent		
Toxic plants (pasture)	Yes	0.092	1.10 (0.25, 4.76)	0.902
	No	Referent		

Northern Pretoria	Yes	0.334	1.40 (0.25, 7.86)	0.705
	No	Referent		
Eastern Pretoria	Yes	0.857	2.36 (0.50, 11.1)	0.278
	No	Referent		
Western Pretoria	Yes	0.875	2.40 (0.64, 9.00)	0.194
	No	Referent		

CI = confidence interval. FEC = faecal egg count.

Table 4.12: Multivariable associations between small colon impactions (n=11) compared to all other colic diagnoses (n=51) presenting to a single referral equine clinic during 2021 with owners completing an online questionnaire during 2022.

Variable	**Level**	**Parameter estimate (β)**	**Odds ratio (95% CI)**	**P value (Wald)**
Friesian breed	Yes	3.961	52.5 (3.39, 814)	0.005
	No	Referent		
<24 horses on premises	Yes	2.374	10.7 (1.15, 100)	0.037
	No	Referent		
Concentrate amount	0 – 1 kg	1.968	7.15 (1.19, 42.9)	0.031
	More	Referent		

CI = confidence interval. Hosmer-Lemeshow $\chi 2 = 2.714$, df = 4, P = 0.607

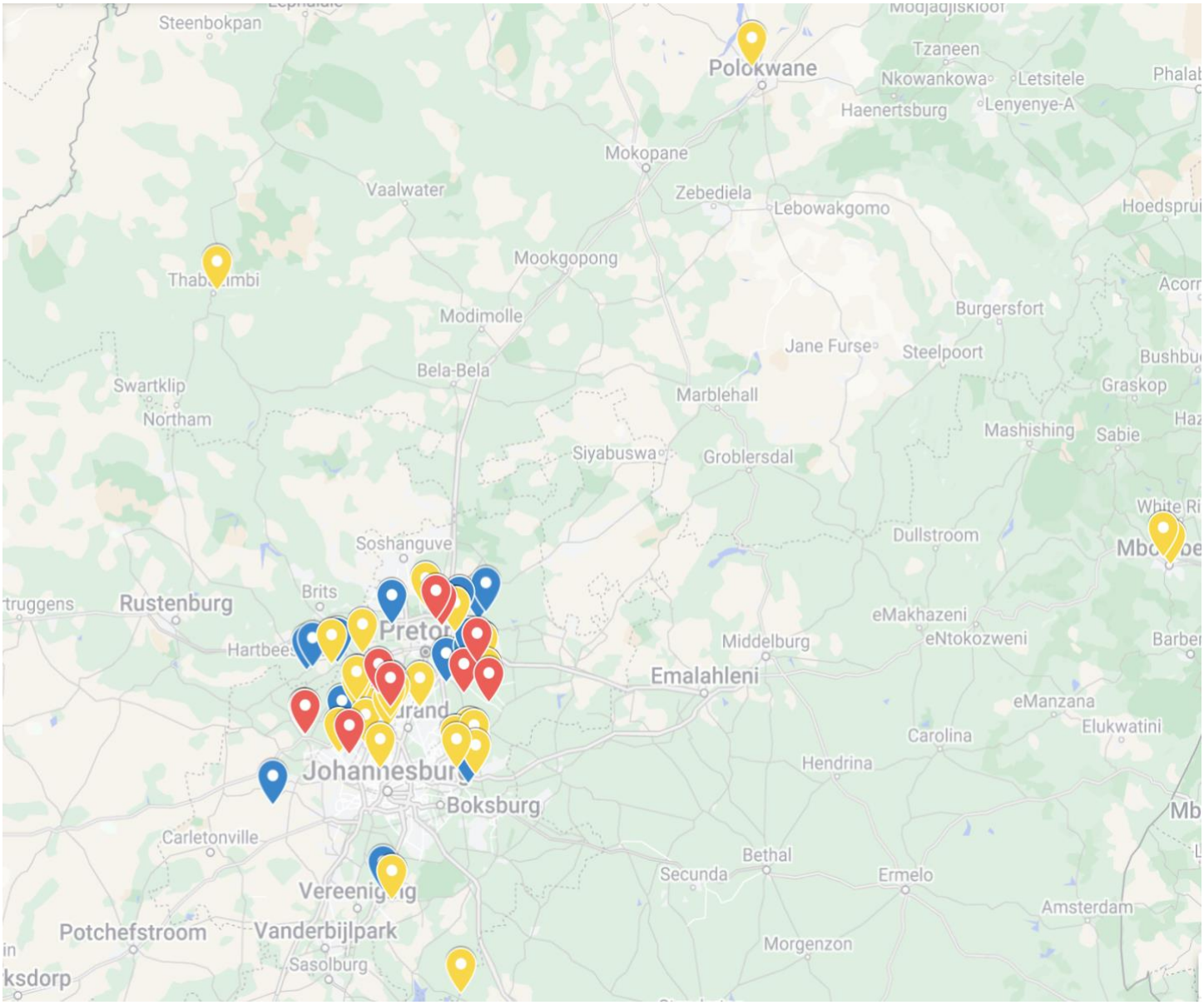


Figure 4.8 Distribution map of colic cases including small colon impactions (n=11, red), large colon impactions (n=17, blue) and "other" (n=34, yellow) presenting to Onderstepoort Equine Clinic in which the owners completed a risk factor questionnaire (Aug-Nov 2022) (n = 62).

5. Discussion

In this thesis, the authors attempt to address a concerning situation that emerged in the Onderstepoort Equine Clinic (OPEC) in 2021. A significant rise in diffuse faecal small colon impaction (SCI) cases during June and July 2021 prompted the need for an investigation into this outbreak. Remarkably, no previous SCI outbreaks have been reported globally, and there is a lack of studies on risk factors and clinical progression of SCI. This research aimed to answer critical questions regarding the distribution, diagnosis, treatment, and outcomes of colic cases in 2021, focusing on SCI cases in particular. Additionally, the study aimed to identify risk factors associated with the development of SCI and to evaluate the prognosis for horses treated medically or surgically.

All colic cases in 2021

This retrospective study presents an analysis of the colic cases in horses presented to an academic referral hospital in South Africa in 2021. Similar to that reported in other large studies, age had a wide range and male and female horses equally affected by colic.[3–5,7,13,27]

The most common breeds admitted to OPEC for colic were Thoroughbreds (37%), Warmbloods (26%) and Friesians (12%). Thoroughbreds and Warmbloods are often amongst the top breeds reported in previous studies including two at the same institution.[7,13,14,27] These findings support the hypothesis that OPEC has a similar breed distribution to other large referral hospitals. Friesians usually represent a smaller part of the colic population (<7.6%) in most studies.[7,13,14,29] In the 2009 studies at the same institution, Friesians made up <5% of the general case population and <6% of the colic population.[13,14]

Apart from an abnormal amount of SCI seen in the current study (13%), the distribution of colic diagnosis were similar to most other large studies.[7,13,14,27,29] This finding supports the hypothesis that an increased number of diffuse faecal SCI occurred in June-July compared to the rest of 2021 and previously reported numbers. Large colon impaction colic is diagnosed in 20.8-25% of horses admitted to referral hospitals which is similar to the 26% reported here.[13,20,27,28,37,38] Large colon displacements were diagnosed in 20% of cases, being slightly higher than previous reports (13-16.5%).[13,20,27] The breed distribution for specific colic causes varied, with different breeds being more susceptible to certain colic diagnoses. Thoroughbreds were more commonly affected by large intestinal impactions and Warmbloods by large intestinal displacements although these were not statistically significant. Interestingly, almost one-third of colic cases had more than one gastrointestinal diagnosis in the current study, highlighting the complexity of equine colic.

Reportedly, about a quarter (23%) of all colic cases require admission to hospital for more intensive medical therapy or surgery.[7,23] Of these cases that are seen at referral hospitals, 45-50.9% require surgical intervention. [7,14,23,27] In 2021, 65% of cases referred to OPEC for colic were treated medically while only 32% required surgical intervention. Although not statistically significant ($p>0.05$), this is less than previously reported at the same institution (36% and 43.8%) in 2009.[13] The observed difference may be due to improved medical management of intensive colic cases, shifts in the demographics or severity of cases within the patient population over time or personal preference of the attending veterinarian favouring more conservative therapy. In the current study, 3% of cases died or were euthanised prior to medical intervention. This is similar to figures previously reported in the same hospital (3-4%) over a ten-year period.[13]

The overall short-term survival for colic cases in 2021 was good (85%) which is not statistically significant ($p>0.05$), than results from a study by Voight (2009) at the same institution (79%) despite major advancements in diagnostic techniques, surgical procedures, and post-operative care in the past 15 years.[13] The short term survival of medically treated horses (89%) was higher than that of surgically treated horses (78%). This is in line with studies from referral centres that reported survival rates of 92.9-93.6% and 59.6-89.8% for medical and surgical treatment of colic respectively.[11,13,24–27,34] Horses treated for colic medically may experience better short-term survival due to the avoidance of surgical risks, anaesthesia complications and post-operative complications, but also because horses with more severe lesions are more likely to be systemically compromised by the time surgical intervention is required.

Small colon impactions

The study population (n=182) included 23 cases of SCI diagnosed at OPEC in 2021, with the majority of cases (96%) presenting within a two-month period between May and July 2021. This represented 13% (95% CI 6.9-16) of colic admissions, which was significantly higher ($p<0.05$) than reported previously at the same institution (3%) as well as at other referral centres worldwide (1.3–2.5%).[13,15,35,63,67]

Sex distribution resembled the general colic population at OPEC and other SCI studies. Although stallions comprised 17% of SCI cases, compared to 9% of all colic cases, demonstrating a notable risk (OR 4.17, 95% CI 1.11-15.6, P=0.034) according to univariate analyses, this significance did not withstand multivariable models. One previous study has identified mares as being at risk for SCI, while others have failed to identify sex as a risk factor.[16,63,66]

The age distribution of these cases was relatively similar to other study populations, with a mean age of 8.5 years (SD = 8.5y). This was younger than the mean age of the colic population at OPEC in 2021 (10.3y, SD = 5.5y).

Draft breeds comprised 48% of the SCI cases with Friesians (12% of colic cases in total) contributing 38% of SCI cases. From this it appears that Friesians are over represented in the SCI colic group. Friesians were more likely to develop SCI compared to all other colic (OR 7.00, 95% CI 1.73-28.3, P<0.001). Draft breed horses were more likely to develop SCI compared to compared to all other colic (OR 8.20, 95% CI 3.13-21.5, P<0.001) and compared to LCI (OR 32.7, 95% CI 3.76-285). This supports the hypothesis that breed is a risk factor for SCI.

To the author's knowledge this is the first study to identify Friesians as having an increased risk for a specific cause of colic (SCI). The correlation might be related to variations in how Friesians are managed, heightened attention to colic by those responsible for managing Friesians, or a genetic inclination toward gastrointestinal disorders in this breed or an unidentified confounder. Dart (1992) found that Arabians, ponies, and American miniature horses were predisposed to small colon disease.[66] A later study by Edwards (2010) also indicated that Arabians might be over represented in SCI cases, but this was not statistically significant.[67] No Arabians presented with SCI impactions during the current study, although they typically make up 9-10% of the referral population of OPEC.[13,14]

An increased risk for horses to develop SCI in winter was identified compared to all other colic diagnoses (OR 43.2, 95% CI 9.59-195, P<0.001) and compared to LCI (OR 124, 95% CI 12.8-1195) using univariate and multivariate associations. This supports the hypothesis that season (winter) is a risk factor for SCI. The temporal distribution of cases, as represented by the epidemic curve, revealed an overrepresentation of SCI in June and July 2021, suggesting a potential seasonal or environmental influence. Unfortunately this study failed to identify any such factor. Cyclical seasonal patterns have been identified for some colic types including impactions.[1,5,13,31] Many mechanisms have been proposed to explain the seasonality of impaction colic. Cold weather may reduce water intake and result in dryer intestinal content. In winter, pasture grass may be sparse or of lower quality, leading horse owners to rely more on hay for their horses' diets. Changes in diet or quality of forage can affect digestion and increase the risk of impactions. Reduced physical activity, such as prolonged stabling in winter or reduced pasture activity, may also negatively influence gastrointestinal transit time, increasing the risk of impactions. The relationship between season and colic is still poorly understood, some suggest that horses experience more impaction colic in summer due to factors such as dehydration

from increased sweating, consumption of dry or dusty forage, limited access to water during hot weather, and changes in grazing patterns or diet quality.[31]

Although only 26% of cases in the current study had a history of diarrhoea prior to presentation, a retrospective case series of 44 horses with SCI suggest that diarrhoea might be a risk factor for development of SCI.[16] The presence of diarrhoea, fever, leukopenia, and an irritated rectal mucosa indicates that colitis might predispose certain horses to SCI, potentially due to disruptions in motility.[35,70] In the current study, only one case had a history of pyrexia prior to presentation but 48% had a loose stool or diarrhoea and 55% were leukopenic on admission. This underscores the importance of considering the possibility of SCI in horses exhibiting clinical signs such fever, diarrhoea, and a decrease in white blood cell count, especially when they do not display typical signs of colic or colitis. [70]

Clinical examination, abdominal ultrasonography, nasogastric intubation and abdominocentesis on admission were non-specific. Apart from leukopenia observed in 55% of SCI cases, haematology and blood gas analysis was unremarkable. Small colon impactions tend to present with non-specific clinical signs, and the progression of haematological and biochemical parameters deterioration is gradual due to the distal location in the gastrointestinal tract.[32,35,36,63,66,67,69,71] Similar to Frederico (2006), transrectal palpation was as the most effective diagnostic tool for identifying horses suffering from diffuse faecal SCI in our study, with a diagnostic success rate of 80% and 83% respectively.[16] The remaining cases were diagnosed during exploratory laparotomy of necropsy.

The majority (74%) of cases that underwent surgical treatment, primarily due to unrelenting colic signs. This is higher than most other reports (44-52.3%).[16,63] Similar to other studies, SCI treated surgically were resolved by high enema and extraluminal massage, with no small colon enterotomies performed.[35,63,67]

Routine biosecurity sampling (faecal culture) was performed on all 23 cases and failed to yield any indication of *Salmonella spp.* in any of the samples. Salmonella has been associated with SCI previously especially when treated surgically.[35,67] A positive Salmonella faecal culture has been reported in up to 43% of SCI cases.[63] This may be related to perioperative antibiotic use or the role *Salmonella spp.* play in the development of colitis in adult horses.

As reported previously, and in line with the hypothesis, the outcome for diffuse faecal SCI in the current study was good.[16,26,35,60,63] Most horses survived to discharge (87%), with a higher survival in surgically treated cases (94%). Mair and Smith (2005) also documented a good short-term survival, reporting a

100% short-term survival rate in cases of surgically treated SCI.[26] The short-term survival for medically treated horses was poorer (67%). This is lower than the survival reported for all colic cases at OPEC in 2021 (89%) and other studies investigating SCI cases.[16,35,60,63,67] This might be due to the small sample size (only six cases), inflating the influence of financial constraints in two cases.

Frequently encountered complications arising from the medical or surgical treatment of SCI include jugular thrombophlebitis, fever, laminitis, peritonitis, and recurrent impaction.[35,60,63,67] Re-impaction occurred in three cases in the current study, two of which did not undergo a pelvic flexure enterotomy during the first laparotomy and required repeat laparotomy. Horses undergoing surgical intervention are also susceptible to additional complications such as incisional infection, incisional hernia, and intestinal adhesions.[35] The most common complications encountered in the current study were recurrent colic (35%), nasogastric reflux (35%), thrombophlebitis (26%) and incisional infection (29%).

As anticipated, the expenses incurred for horses receiving medical treatment were less than those for horses undergoing surgical treatment, aligning with findings from prior research.[3,4,41,72]

When compared solely to large colon impactions (LCIs), draft breeds and winter season remained as risk factors in univariate associations. Additionally, a comparison of descriptive statistics further emphasized the influence of winter presentation and Friesian breed on SCI, with yard size (fewer number of horses managed) and horses from the greater Pretoria region emerging as additional risk factors. The examination of SCI against all other colic diagnoses revealed that draft breeds continued to pose an increased risk in univariate associations. Multivariate analysis further identified Friesians, premises with fewer than 24 horses, and feeding less than one kilogram of concentrates as significant risk factors for SCI. The increased risk in horses kept in smaller yards may reflect limited access to pasture or forage, reduced space for horses to move around freely and less strict management resulting in irregular feeding schedules or inappropriate diets. In smaller yards, there may be fewer staff or resources available for monitoring horses. Overall, while smaller yards can offer some benefits such as more individualized care, they also present challenges that can increase the risk of colic in horses. Although increased concentrate feeding has previously been identified as a risk factor for colic, the increased risk of horses receiving less than one kilogram of concentrate per day identified in the current study, may rather be a reflection the increased influence of roughage in the diet.

Geographically, horses affected by SCI were distributed across four provinces in South Africa, with Gauteng exhibiting a higher prevalence. The spatial analysis unveiled significant clustering of SCI cases, underscoring the potential regional factors influencing the outbreak, while no such clustering

was observed for large colon impactions. This could be attributed to unmeasured localized environmental factors influencing SCI, such as grazing elements or vegetation types, which may vary within specific geographic areas. Additionally, population density and distribution could play a role, with certain areas having higher equine populations or concentrations of certain equestrian activities. Conversely, large colon impactions might be influenced by more factors making specific localized factors less relevant, resulting in a lack of spatial clustering.

Considering these risk factors it is difficult to suggest measures to prevent SCI outbreaks as breed, season and sex are consistent. Management practices such as amount of concentrates and yard size could however be addressed to prevent future outbreaks.

Limitations

This is an appropriate topic for a retrospective study because the incidence of diffuse faecal SCI is usually low (1.9–2.5% of patients presenting for colic[13,15,35]) and to the author's knowledge no outbreaks of this condition have been reported. As with any retrospective study, the investigator depends on the availability and accuracy of the medical records and owner's recall.

Retrospective studies with small sample sizes have inherent limitations that can impact the generalizability and robustness of their findings. The most prominent concern is the reduced statistical power, which makes it challenging to detect subtle or less common associations, potentially leading to false negatives. Additionally, the small sample size can limit the ability to control for confounding variables adequately, potentially introducing bias into the results. The findings could also lack external validity, as they might not be representative of the broader population. Furthermore, retrospective studies heavily rely on existing data, which can be incomplete or subject to recall bias. As a result, while retrospective studies can provide valuable insights, their findings should be interpreted with caution and ideally validated through larger, prospective research to ensure their reliability and applicability to a wider population. A low response for a medical survey might indicate a potential challenge in engaging participants, raising concerns about the representativeness of the gathered data and the need for strategies to enhance survey participation. A case series is subject to selection bias because the investigator self-selects the cases.

Data collection for the risk factor analysis study spanned 16 weeks, during which 34% (62/182) of horse owners successfully completed the questionnaire, exceeding expectations. Response proportions for surveys in healthcare settings vary and fall within the range of 20-26% in equine research.[73]

The analysis of questionnaire data against large colon impactions faced limitations due to insufficient sample size, preventing the evaluation of certain predictors.

Conclusion

This study of colic cases at the Onderstepoort Equine Clinic in 2021 yielded valuable insights into specific aspects of equine colic, with a particular focus on SCI. This study revealed a concerning outbreak of SCI and identified possible risk factors. Despite some limitations, the study showed that stallions, draft breeds, especially Friesians, are at a higher risk for developing diffuse faecal SCI. Horse owners and veterinarians should be alerted to the increased possibility of SCI when evaluating colic in these breeds, especially during winter months when the prevalence of SCI seems to increase, or when colic signs are accompanied by previously reported risk factors such as fever, leukopenia and diarrhoea. The short-term survival for SCI cases was however favourable, and carries a good prognosis.

6. References

1. Hackett ES. Specific Causes of Colic. *Practical Guide to Equine Colic*. 2013;(May):204-229. doi:10.1002/9781118704783.ch17
2. Ludwig E, Hobbs K, McKinney-Aguirre C, Gonzalez L. Biomarkers of Intestinal Injury in Colic. *Animals*. 2023;13(2). doi:10.3390/ani13020227
3. Barker I, Freeman SL. Assessment of costs and insurance policies for referral treatment of equine colic. *Veterinary Record*. 2019;185(16):508. doi:10.1136/vr.105415
4. Egenvall A, Penell J, Bonnett BN, Blix J, Pringle J. Demographics and costs of colic in Swedish horses. *J Vet Intern Med*. 2008;22(4):1029-1037. doi:10.1111/j.1939-1676.2008.0136.x
5. Tinker M, White N, Lessard P, et al. Prospective study of equine colic incidence and mortality. *Equine Vet J*. 1997;29(6):448-453. doi:10.1111/j.2042-3306.1997.tb03157.x
6. Escalona EE, Okell CN, Archer DC. Prevalence of and risk factors for colic in horses that display crib-biting behaviour. *BMC Vet Res*. 2014;10. doi:10.1186/1746-6148-10-S1-S3
7. Curtis L, Burford JH, Thomas JSM, et al. Prospective study of the primary evaluation of 1016 horses with clinical signs of abdominal pain by veterinary practitioners, and the differentiation of critical and non-critical cases. *Acta Vet Scand*. 2015;57(1). doi:10.1186/s13028-015-0160-9
8. Tannahill V, Cardwell J, Witte T. Colic in the British military working horse population: A retrospective analysis. *Veterinary Record*. 2019;184(1):1-7. doi:10.1136/vr.104956
9. Cohen N. Epidemiology of colic. *Vet Clin North Am Equine Pract*. 1997;13(2):191-201. doi:10.1016/S0749-0739(17)30236-5
10. White NA. Prevalence, Demographics, and Risk Factors for Colic. In: *AAEP Focus on Colic, Quebec City*. ; 2005:1-12. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.487.2292&rep=rep1&type=pdf
11. van der Linden M, Laffont C, van Oldruitenborgh-Oosterbaan M. Prognosis in Equine Medical and Surgical Colic. *J Vet Intern Med*. 2003;17(3):343-348. doi:10.1111/j.1939-1676.2003.tb02459.x

12. Fikri F, Hendrawan D, Wicaksono AP, et al. Incidence, risk factors, and therapeutic management of equine colic in Lamongan, Indonesia. *Vet World*. 2023;16(7):1408-1414. doi:10.14202/vetworld.2023.1408-1414

13. Voigt A, Saulez M, Donnellan C, Gummow B. Causes of gastrointestinal colic at an equine referral hospital in South Africa (1998-2007). *J S Afr Vet Assoc*. 2009;80(3):192-198. doi:10.4102/jsava.v80i3.201

14. Viljoen A, Saulez M, Donnellan C, Bester L, Gummow B. After-hours equine emergency admissions at a university referral hospital (1998-2007): Causes and interventions. *J S Afr Vet Assoc*. 2009;80(3):169-173. doi:10.4102/jsava.v80i3.196

15. Abutarbush S, Carmalt J, Shoemaker R. Causes of gastrointestinal colic in horses in western Canada: 604 cases (1992 to 2002). *Canadian Veterinary Journal*. 2005;46(9):800-805.

16. Frederico L, Jones S, Blikslager A. *Predisposing Factors for Small Colon Impaction in Horses and Outcome of Medical and Surgical Treatment: 44 Cases (1999-2004)*. Vol 229.; 2006.

17. Goncalves S, Julliand V, Leblond A. Risk factors associated with colic in horses. *Vet Res*. 2002;33:641-652. doi:10.1051/vetres

18. Hillyer MH, Taylor FGR, Proudman CJ, Edwards GB, Smith JE, French NP. Case control study to identify risk factors for simple colonic obstruction and distension colic in horses. *Equine Vet J*. 2002;34(5):455-463. doi:10.2746/042516402776117746

19. Kaya G, Sommerfeld-Stur I, Iben C. Risk factors of colic in horses in Austria. *J Anim Physiol Anim Nutr (Berl)*. 2009;93(3):339-349. doi:10.1111/j.1439-0396.2008.00874.x

20. Sawesi O, Milad A. Risk Factors Associated with Impaction Colic in Horses at North Western Area of Libya. *Journal of Veterinary Advances*. 2015;5(8):1064. doi:10.5455/jva.20150810014434

21. Reeves MJ, Salman MD, Smith G. Risk factors for equine acute abdominal disease (colic) : Results from a multi-center case-control study. *Prev Vet Med*. 1996;26(3-4):285-301. doi:10.1016/0167-5877(95)00551-X

22. Malamed R, Berger J, Bain MJ, Kass P, Spier SJ. Retrospective evaluation of crib-biting and windsuckingbehaviours and owner-perceived behavioural traits as riskfactors for colic in horses. *Equine Vet J*. 2010;42(8):686-692. doi:10.1111/j.2042-3306.2010.00096.x

23. Kaneene J, Miller R, Ross R, Gallagher K, Marteniuk J, Rook J. Risk factors for colic in the Michigan (USA) equine population. *Prev Vet Med*. 1997;30(1):23-36. doi:10.1016/S0167-5877(96)01102-6

24. Arndt S, Kilcoyne I, Vaughan B, Dechant J. Clinical and diagnostic findings, treatment, and short- and long-term survival in horses with peritonitis: 72 cases (2007-2017). *Veterinary Surgery*. 2021;50(2):323-335. doi:10.1111/vsu.13564

25. Davis W, Fogle C, Gerard M, Levine J, Blikslager A. Return to use and performance following exploratory celiotomy for colic in horses: 195 cases (2003–2010). *Equine Vet J*. 2013;45(2):224-228. doi:10.1111/J.2042-3306.2012.00615.X

26. Mair TS, Smith LJ. Survival and complication rates in 300 horses undergoing surgical treatment of colic. Part 1: Short-term survival following a single laparotomy. In: *Equine Veterinary Journal*. Vol 37. British Equine Veterinary Association; 2005:296-302. doi:10.2746/0425164054529409

27. Freeman DE DE. Fifty years of colic surgery. *Equine Vet J*. 2018;50(4):423-435. doi:10.1111/evj.12817

28. White NA, Dabareiner RM. Treatment of impaction colics. *Vet Clin North Am Equine Pract*. 1997;13(2):243-259. doi:10.1016/s0749-0739(17)30239-0

29. Haddad R, Corraretti G, Simon O, Mair T, Sutton G, Kelmer G. Small intestinal intussusception in horses: Multicentre retrospective report on 26 cases (2009-2020). *Equine Vet Educ*. 2022;34(12):e563-e569. doi:10.1111/eve.13604

30. Riley E, Martindale A, Maran B, et al. Small colon lipomatosis resulting in refractory small colon impaction in a Tennessee Walking Horse. *Equine Vet Educ*. 2007;19(9):484-487. doi:10.2746/095777307X236301

31. Archer D, Pinchbeck G, Proudman C, Clough H. Is equine colic seasonal? Novel application of a model based approach. *BMC Vet Res*. 2006;2. doi:10.1186/1746-6148-2-27

32. Oreff GL, Tatz AJ, Dahan R, Raz T, Kelmer G. Surgical management of foreign body obstruction of the small and large colons in 29 equids (2004–2016). *Equine Vet Educ*. 2020;32(8):424-430. doi:10.1111/eve.13036

33. Kilcoyne I, Magdesian KG, Guerra M, Dechant JE, Spier SJ, Kass PH. Prevalence of and risk factors associated with Salmonella shedding among equids presented to a veterinary teaching hospital for colic (2013–2018). *Equine Vet J*. 2023;55(3):446-455. doi:10.1111/evj.13864

34. Long A. Clinical insights: Clinicopathological parameters for diagnosing and predicting outcome of horses with colic. *Equine Vet J*. 2022;54(6):1005-1010. doi:10.1111/evj.13871

35. Hanson R, Schumacher J. Diagnosis, management and prognosis of small colon impactions. *Equine Vet Educ*. 2021;33(1):47-56. doi:10.1111/eve.13119

36. Schumacher J, Mair TS. Small colon obstructions in the mature horse. *Equine Vet Educ*. 2002;14(1):19-28. doi:10.1111/j.2042-3292.2002.tb00132.x

37. Waite K. Impaction colic in horses. *Michigan State University Extension*. Published online 2015:3-6.

38. Plummer AE. Impactions of the Small and Large Intestines. *Veterinary Clinics of North America - Equine Practice*. 2009;25(2):317-327. doi:10.1016/j.cveq.2009.04.002

39. Mair TS, Smith LJ. Survival and complication rates in 300 horses undergoing surgical treatment of colic. Part 4: Early (acute) relaparotomy. In: *Equine Veterinary Journal*. Vol 37. British Equine Veterinary Association; 2005:315-318. doi:10.2746/0425164054529454

40. Mair TS, Smith LJ. Survival and complication rates in 300 horses undergoing surgical treatment of colic. Part 3: Long-term complications and survival. In: *Equine Veterinary Journal*. Vol 37. British Equine Veterinary Association; 2005:310-314. doi:10.2746/0425164054529445

41. Mair TS, Smith LJ. Survival and complication rates in 300 horses undergoing surgical treatment of colic. Part 2: Short-term complications. In: *Equine Veterinary Journal*. Vol 37. British Equine Veterinary Association; 2005:303-309. doi:10.2746/0425164054529364

42. Rudnick MJ, Denagamage TN, Freeman DE. Effects of age, disease and anastomosis on short- and long-term survival after surgical correction of small intestinal strangulating diseases in 89 horses. *Equine Vet J*. 2022;54(6):1031-1038. doi:10.1111/evj.13558

43. Bishop RC, Gutierrez-Nibeyro SD, Stewart MC, McCoy AM. Performance of predictive models of survival in horses undergoing emergency exploratory laparotomy for colic. *Veterinary Surgery*. 2022;51(6):891-902. doi:10.1111/vsu.13839

44. Southwood LL. Medical versus Surgical Treatment of the Horse with Colic. In: *Practical Guide to Equine Colic*. John Wiley & Sons, Inc.; 2013:164-172. doi:10.1002/9781118704783.ch15

45. Hillberry E, Panizzi L, Lang HM, MacKay A, Barber SM. Long-Term Follow-Up Information of a Three-Tract Arthrodesis Technique for Treatment of Carpometacarpal Osteoarthritis. *J Equine Vet Sci*. 2015;35(9):773-778. doi:10.1016/j.jevs.2015.07.007

46. Wiemer P, Bergman H, van der Veen H, Pruissen L. Koliekchirurgie bij het paard: een retrospectief onderzoek van 272 patiënten. *Tijdschr Diergeneeskd*. 2002;127(22):682-686.

47. Freeman D, Rötting A, Inoue O. Abdominal closure and complications. *Clinical Techniques in Equine Practice*. 2002;1(3):174-187. doi:10.1053/ctep.2002.35575

48. Gandini M, Cerullo A, Giusto G. Scoping review: Occurrence and definitions of postoperative complications in equine colic surgery. *Equine Vet J*. 2023;55(4):563-572. doi:10.1111/evj.13881

49. Hill JA, Tyma JF, Hayes GM, Radcliffe R, Fubini SL. Higher body mass index may increase the risk for the development of incisional complications in horses following emergency ventral midline celiotomy. *Equine Vet J*. 2020;52(6):799-804. doi:10.1111/evj.13242

50. Martinez-Lopez J, Brown JA, Werre SR. Incisional complications after skin closure with n-butyl cyanoacrylate or stainless-steel skin staples in horses undergoing colic surgery. *Veterinary Surgery*. 2021;50(1):186-195. doi:10.1111/vsu.13534

51. Scharner D, Gittel C, Winter K, et al. Comparison of incisional complications between skin closures using a simple continuous or intradermal pattern: A pilot study in horses undergoing ventral median celiotomy. *PeerJ*. 2018;2018(11). doi:10.7717/peerj.5772

52. Durward-Akhurst SA, Mair TS, Boston R, Dunkel B. A comparison of two antimicrobial regimens on the prevalence of incisional infections after colic surgery. *Veterinary Record*. 2013;172(11):287. doi:10.1136/vr.101186

53. Hann M, Timofte D, Isgren CM, Archer DC. Bacterial translocation in horses with colic and the potential association with surgical site infection: A pilot study. *Veterinary Record*. 2020;187(2). doi:10.1136/vr.105788

54. Isgren C, Salem S, Townsend N, Timofte D, Maddox T, Archer D. Sequential bacterial sampling of the midline incision in horses undergoing exploratory laparotomy. *Equine Vet J*. 2019;51(1):38-44. doi:10.1111/evj.12958

55. Isgren CM, Salem SE, Archer DC, Worsman FCF, Townsend NB. Risk factors for surgical site infection following laparotomy: Effect of season and perioperative variables and reporting of bacterial isolates in 287 horses. *Equine Vet J*. 2017;49(1):39-44. doi:10.1111/evj.12564

56. Gustafsson K, Tatz AJ, Slavin RA, et al. Intra-incisional medical grade honey decreases the prevalence of incisional infection in horses undergoing colic surgery: a prospective randomised controlled study. *Equine Vet J*. 2020;(November 2020):1-7. doi:10.1111/evj.13407

57. Moustafa A, Elmetwally M, EL-Khodery S, Hamed M, Gomaa N, Rizk MA. Abdominal Hernia in Equine: Animal Level Risk Factors and Repair Using Polypropylene Mesh. *J Equine Vet Sci*. 2022;111. doi:10.1016/j.jevs.2022.103889

58. Naudé TW, Gerber R, Smith RJ, Botha CJ. Datura contamination of hay as the suspected cause of an extensive outbreak of impaction colic in horses. *J S Afr Vet Assoc*. 2005;76(2):107-112. doi:10.4102/jsava.v76i2.407

59. Edwards G. Diseases and surgery of the small colon. *Vet Clin North Am Equine Pract*. 1997;13(2):359-375. doi:10.1016/S0749-0739(17)30245-6

60. De Bont M, Proudman C, Archer D. Surgical lesions of the small colon and post operative survival in a UK hospital population. *Equine Vet J*. 2013;45(4):460-464. doi:10.1111/evj.12005

61. Prange T. Small colon obstructions in foals. *Equine Vet Educ*. 2013;25(6):293-296. doi:10.1111/eve.12040

62. Haven ML, Rottman JB, Bowman KF. Leiomyoma of the Small Colon in a Horse. *Veterinary Surgery*. 1991;20(5):320-322. doi:10.1111/j.1532-950X.1991.tb01275.x

63. Rhoads WS, Barton MH, Parks AH. Small Colon Impactions in Horses : 84 Cases (1986 – 1996). *AAEP Proceedings*. 1997;43:1996-1997.

64. Gay CC, Speirs VC, Christie BA, Smyth B, Parry B. Foreign Body Obstruction of the Small Colon in Six Horses. *Equine Vet J*. 1979;11(1):60-63. doi:10.1111/j.2042-3306.1979.tb01302.x

65. Blikslager A, White N, Moore J, Mair T, eds. *The Equine Acute Abdomen*. Third edit. John Wiley & Sons, Inc.; 2017. doi:10.1002/9781119063254

66. Dart AJ, Snyder JR, Pascoe JR, Farver TB, Galuppo LD. Abnormal conditions of the equine descending (small) colon: 102 cases (1979-1989). *J Am Vet Med Assoc*. 1992;200(7):971-978.

67. Edwards GB. A review of 38 cases of small colon obstruction in the horse. *Equine Vet J*. 2010;24(S13):42-50. doi:10.1111/j.2042-3306.1992.tb04788.x

68. Herbert E, Lopes M, Kelmer G. Standing flank laparotomy for the treatment of small colon impactions in 15 ponies and one horse. *Equine Vet Educ*. 2021;33(2):e51-e56. doi:10.1111/eve.13154

69. Klohnen A. Secondary approaches to the abdominal cavity for horses with signs of colic may be key to successful resolution of an either very proximal or very distal small colon obstruction. *Equine Vet Educ*. 2013;25(9):447-450. doi:10.1111/eve.12045

70. Blikslager A. The paradox of diarrhoeal disease and small colon obstruction. *Equine Vet Educ*. 2016;28(8):424-425. doi:10.1111/eve.12504

71. Prange T, Holcombe SJ, Brown JA, et al. Resection and anastomosis of the descending colon in 43 horses. *Veterinary Surgery*. 2010;39(6):748-753. doi:10.1111/j.1532-950x.2010.00700.x

72. Lopes MAFM, Hardy J, Farnsworth K, et al. Standing flank laparotomy for colic: 37 cases. *Equine Vet J*. 54(5):934-945. doi:10.1111/evj.13511

73. Christley RM. Questionnaire survey response rates in equine research. *Equine Vet J*. 2016;48(2):138-139. doi:10.1111/evj.12552

7. Appendices

Appendix A: Data collected from owner questionnaire

Small colon impaction owner questionnaire

Thank you for taking time to contribute to research at the University of Pretoria (EH to add "UP Informed consent notice")

* Required

1. Email *

2. Horse's full name *

3. Horse's date of birth *

Example: January 7, 2019

4. Breed *

5. Use *

e.g. Show jumping, pleasure, dressage

6. Sex *

Mark only one oval.

- Mare
- Stallion
- Gelding

7. Pregnancy status *

Mark only one oval.

- Not-pregnant
- Pregnant
- Not applicable

8. Did your horse undergo regular dental examination and maintenance prior to the colic episode in question? *

Mark only one oval.

- Every 6 months
- Once per year
- Irregular / sporadic dental intervention when I think they need it
- My horse has never undergone dental work
- Other:

9. Did your horse undergo regular deworming prior to the colic episode in question? *

Mark only one oval.

- Every 6 months
- Once per year
- Irregular / sporadic deworming when I think they need it
- My horse has never been dewormed
- Dewormed according to fecal egg count
- Other:

10. Exercise: How often do you usually ride your horse *

Mark only one oval.

- <2 times per week
- 2-4 times per week
- 4-6 times per week
- Every day
- Whenever I have time
- Other:

11. Do you recall giving your horse rest prior to the colic episode in question? *

Mark only one oval.

- Yes, my horse rested
- No, I do not think so
- I do not remember
- Other:

12. Did your horse travel off the farm in the 2 weeks prior to the colic episode in question? *

Mark only one oval.

- Yes, my horse traveled
- No, I do not think so
- I do not remember
- Other:

13. Prior to the colic episode in question, has your horse ever suffered from colic? *

Check all that apply.

- Yes, mild and was treated on the farm
- Yes, had to be admitted to hospital to be treated medically
- Yes, had to be admitted to hospital and undergo surgery
- My horse has never suffered from a colic episode prior to this

Other:

14. Roughage type *

Check all that apply.

- Lucerne
- Teff
- Eragrostis
- Oathay
- Straw

Other:

15. Roughage amount *

Check all that apply.

- always availible
- only when stabled
- only when turned out

Other:

16. Roughage source *

Check all that apply.

- Home grown and baled
- Bought from commercial feed supplier (please name under "other" where possible)
- Bought from independent feed supplier (please name under "other" where possible)
- Bought straight from farmer (please name under "other" where possible)
- Not sure, the yard sources and supplies roughage

Other:

17. Concentrate feed source *

Check all that apply.

- [ ] Produced at home
- [ ] Mixed at home (raw material bought in) (please name under "other" where possible)
- [ ] Bought from commercial feed supplier (please name under "other" where possible)

Other: [ ] _____

18. Concentrate feed bought in *

Please list brand and type (e.g. Equi-Feeds Show Feed 12%)

19. Concentrate daily amount (kg per day) *

Mark only one oval.

1	2	3	4	5	6	7	8	9	10
◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

20. Time at pasture per day *

Mark only one oval.

- ◯ <4 hours
- ◯ 4-8 hours
- ◯ 8-12 hours
- ◯ >12 hours
- ◯ No pasture time
- ◯ Other: _____

21. Type of pasture and size of paddocks *

22. Have you ever noticed any weeds in the pasture *

Mark only one oval.

- ◯ Yes (Please list under "other")
- ◯ No
- ◯ Other: _____

23. Was the horse's pasture treated with herbicide / pesticide / fertilizer prior to the colic episode in question? *

Mark only one oval.

- ◯ Yes (Please list under "other")
- ◯ No
- ◯ Not sure
- ◯ Other: _____

24. Time stabled per day *

Mark only one oval.

- ◯ <4 hours
- ◯ 4-8 hours
- ◯ 8-12 hours
- ◯ >12 hours
- ◯ My horse lives out
- ◯ Other: _____

25. Duration of colic signs

Mark only one oval per row.

	My horse was seen by a veterinarian on the farm after ___hour(s)	After being seen by a veterinarian on the farm, my horse was admitted to hospital after ___hour(s)	My horse was not seen by a veterinarian on the farm and was taken straight to hospital after ___hour(s)
1h	◯	◯	◯
2h	◯	◯	◯
3h	◯	◯	◯
4h	◯	◯	◯
5h	◯	◯	◯
6h	◯	◯	◯
7h	◯	◯	◯
8h	◯	◯	◯
9h	◯	◯	◯
10h	◯	◯	◯
11h	◯	◯	◯
12h	◯	◯	◯
13h	◯	◯	◯
14h	◯	◯	◯
15h	◯	◯	◯
16h	◯	◯	◯
17h	◯	◯	◯
18h	◯	◯	◯
19h	◯	◯	◯
20h	◯	◯	◯
21h	◯	◯	◯
22h	◯	◯	◯
23h	◯	◯	◯
24h	◯	◯	◯
24-36h	◯	◯	◯
36-48h	◯	◯	◯
48-72h	◯	◯	◯

26. Do you recall any diarrhoea / loose stool prior to hospitalisation *

Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Maybe
- ◯ Other: _____

27. Do you recall any history of fever prior to admission *

Fever in this study is defined as a rectal temperature >38.5 degrees Celcius

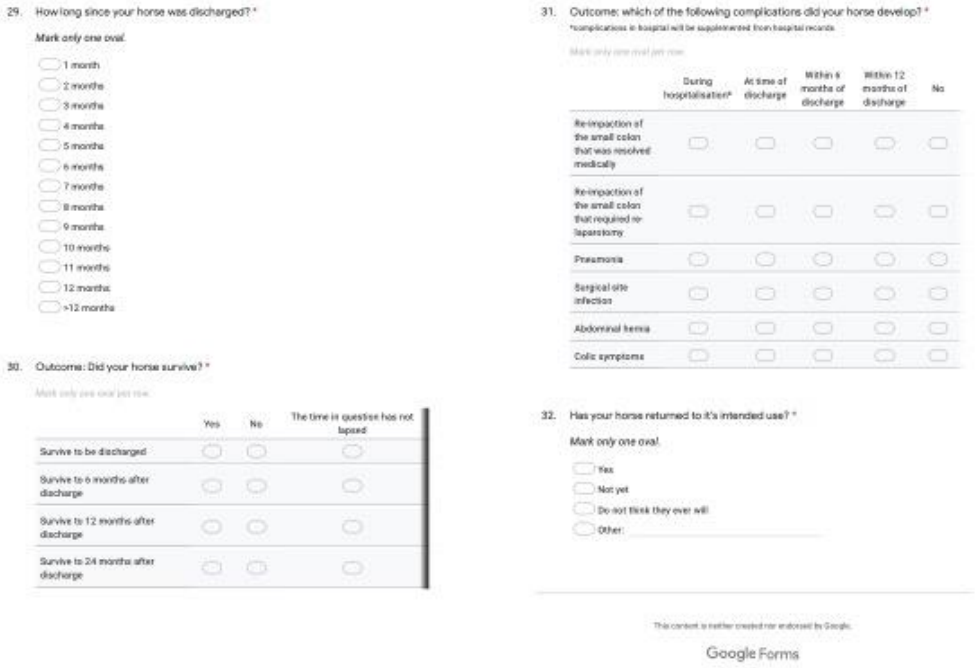
Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Other: _____

28. Do you recall any blood in your horse's stool or after the rectal examination was performed? *

Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Other: _____



29. How long since your horse was discharged? *

Mark only one oval.

- 1 month
- 2 months
- 3 months
- 4 months
- 5 months
- 6 months
- 7 months
- 8 months
- 9 months
- 10 months
- 11 months
- 12 months
- >12 months

30. Outcome: Did your horse survive? *

Mark only one oval per row.

	Yes	No	The time in question has not lapsed
Survive to be discharged			
Survive to 6 months after discharge			
Survive to 12 months after discharge			
Survive to 24 months after discharge			

31. Outcome: which of the following complications did your horse develop? *

*complications in hospital will be supplemented from hospital records

Mark only one oval per row.

	During hospitalisation*	At time of discharge	Within 6 months of discharge	Within 12 months of discharge	No
Re-impaction of the small colon that was resolved medically					
Re-impaction of the small colon that required re-laparotomy					
Pneumonia					
Surgical site infection					
Abdominal hernia					
Colic symptoms					

32. Has your horse returned to it's intended use? *

Mark only one oval.

- Yes
- Not yet
- Do not think they ever will
- Other:

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*Fever is defined as rectal temperature ≥ 38.5°C.

Appendix B: Data collected from hospital records

Small colon impaction in hospital questionnaire

* Required

1. Patient full name *

2. UVIS Patient number *

History

3. Patient referred by RDVM *

Mark only one oval.

- Yes, diagnosed and referred
- Yes, diagnosed and treated, then referred when colic did not resolve
- No, brought straight in
- Other: _____

4. History of pyrexia *

Mark only one oval.

- Yes
- No
- Other: _____

5. History of diarrhoea *

Mark only one oval.

- Yes
- No
- Other: _____

Admission

6. Physical exam: Temperature (°C) *

numerical value only

7. Physical exam: pulse (bpm) *

numerical value only

8. Physical exam: respiration (bpm) *

numerical value only

9. Physical exam: Mucous membranes *

Check all that apply.

- [ ] Pink, moist, glistening
- [ ] Dry
- [ ] Tachy
- [ ] Congested
- [ ] Other: _____

10. Physical exam: CRT *

Mark only one oval.

- <2s
- 2-3s
- >5s
- Other: _____

11. Physical exam: Gut sounds *

Mark only one oval.

- reduced
- normal
- increased
- Other: _____

12. Physical exam: Digital pulses *

Mark only one oval.

- Non-bounding
- Bounding
- Other: _____

13. Physical exam: Hoof temperature *

Mark only one oval.

- Cool
- Warm
- Other: _____

14. Loose stool *

Mark only one oval.

- No
- Yes

15. Abdominal pain *

Mark only one oval.

- None
- Mild
- Moderate
- Severe
- Other: _____

16. Abdominal distension *

Mark only one oval.

- None
- Mild
- Moderate
- Severe
- Other: _____

17. Rectal examination - findings *

Check all that apply.

- [ ] Rectal not possible due to severe gas distension
- [ ] Rectal not possible due to severe pain
- [ ] No significant finding on initial rectal
- [ ] Small colon impaction palpable
- [ ] Large colon impaction palpable
- [ ] Gas palpable rectally
- [ ] Small intestinal distension

Other: [ ] _____

18. Rectal examination - blood on rectal sleeve *

Mark only one oval.

- ◯ Yes, frank
- ◯ Yes, old
- ◯ No
- ◯ Other: _____

19. Ultrasound examination - findings *

Check all that apply.

- [ ] US precluded by severe gas distension
- [ ] US precluded by severe pain
- [ ] No significant finding on initial untrasound
- [ ] Small intestinal distension
- [ ] Small intestinal wall thickeing
- [ ] Large colon fluid filled
- [ ] Large colon wall thickened
- [ ] Free fluid in abdomen

Other: [ ] _____

20. Abdominocentesis performed *

Mark only one oval.

- ◯ Yes, fluid colected
- ◯ Yes, but no fluid obtained
- ◯ Not performed
- ◯ Other: _____

21. Abdominocentesis - macroscopically *

Check all that apply.

- [ ] Clear, straw coloured
- [ ] Turbid
- [ ] Serosanguinous
- [ ] Green

Other: [ ] _____

22. Abdominocentesis - Protein *

g/L (numeric value only)

_____

23. Abdominocentesis - lactate *

mmol/L (numeric value only)

_____

24. Nasogastric intubation performed *

Mark only one oval.

- ◯ Performed
- ◯ Not performed
- ◯ Other: _____

25. Nasogastric intubation volume of reflux obtained *

L (numeric value only)

_____

26. PCV *

% (numeric value only)

_____

27. TSP *

g/L (numeric value only)

_____

28. Heamatology *

Mark only one oval.

- ◯ CBC
- ◯ MBC
- ◯ Not performed
- ◯ Other: _____

29. WCC *

cells*9/L (numeric value only)

_____

30. VBG *

Mark only one oval.

- ◯ Performed
- ◯ Not performed
- ◯ Other: _____

31. VBG: Systemic lactate *

mmol/L (numeric value only)

_____

Treatment

32. Medical vs surgical treatment *

Mark only one oval.

- ◯ Medical management alone *Skip to question 40*
- ◯ Medical and later surgical treatment
- ◯ Immediate surgical treatment

Surgical intervention

33. Reason for surgical intervention *

Mark only one oval.

- ◯ Medical treatment failed to resolve impaction timeously
- ◯ Colic signs unrelenting despite medical treatment
- ◯ SCI palpable was severe / extensive
- ◯ Clinical deterioration of patient
- ◯ Other: _____

34. Surgical findings *

Check all that apply

	Normal	Tympany	Fluid filled	Impaction	Enterotomy
Stomach					
Small intestine					
Caecum					
Large colon					
Transverse colon					
Descending colon					

35. Other pathology encountered during surgery *

Lipomas / serositis / displacements

36. Pelvic flexure enterotomy performed *

Mark only one oval.

- yes
- no

37. Extent of SCI *

38. Duration of surgery *

Example: 4:03:32 (4 hours, 3 minutes, 32 seconds)

39. Duration of anaesthetic *

Example: 4:03:32 (4 hours, 3 minutes, 32 seconds)

Hospitalisation

40. Duration of hospitalisation *

days of hospitalisation (d)

41. Time to resolution of SCI *

*or time to surgery in surgical cases (e.g. 1d, 4h)

42. Time to refeeding (short stem) *

from time of resolution (e.g. 2d, 12h)

43. Time to refeeding (long stem) *

from time of resolution (e.g. 2d, 12h)

44. Complications in hospital *

Check all that apply

	No	Mild	Moderate	Severe
Thrombophlebitis				
Reimpaction				
Colic signs				
Incisional infection				
Diarrhoea				
Pyrexia				
Pneumonia				
Nasogastric reflux				

Outcome

45. Outcome *

Mark only one oval.

- Survive to discharge
- Euthenased (state reason under Other)
- Other:

Tachycardia was defined as a heart rate >60 beats/min at the time of initial examination

For horses treated medically, time of resolution of the impaction was defined as the time that the impaction could no longer be palpated per rectum.

For horses treated surgically, time of resolution of the impaction was defined as the time of surgery.

Short- term survival was defined as discharge from the hospital.

Long-term survival was defined as survival at least 1 year after treatment for SCI.

Horses were considered to have diarrhoea if they had > 2 bowel movements that were sufficiently liquid that most of the faecal material did not remain on the surface of the bedding once admitted to hospital.

Appendix C: Declaration of originality

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

UNIVERSITY OF PRETORIA

FACULTY OF VETERINARY SCIENCE

DECLARATION OF ORIGINALITY

This document must be signed and submitted with every essay, report, project, assignment, mini-dissertation, dissertation and/or thesis

Full names of student: Elza Hollenbach

Student number: 11290910

Declaration:

1. I understand what plagiarism is and am aware of the University's policy in this regard.
2. I declare that this dissertation (e.g. essay, report, project, assignment, mini-dissertation, dissertation, thesis, etc.) is my own original work. Where other people's work has been used (either from a printed source, Internet or any other source), this has been properly acknowledged and referenced in accordance with departmental requirements.
3. I have not used work previously produced by another student or any other person to hand in as my own.
4. I have not allowed, and will not allow, anyone to copy my work with the intention of passing it off as his or her own work.

Signature of student: E Hollenbach

Signature of supervisor:

Appendix D: Humanities ethics approval

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Humanities
Fakulteit Geesteswetenskappe
Lefapha la Bomotho

Humanities 100. Since 1919

6 July 2022

Dear Dr E Hollenbach

Project Title:	Small colon impaction outbreak in 23 horses in South Africa
Researcher:	Dr E Hollenbach
Supervisor(s):	Dr Y Smit
Department:	Companion Animal Clinical Studies
Reference number:	11290910 (REC016-22)
Degree:	Masters

I have pleasure in informing you that the above application was **approved** by the Research Ethics Committee on 30 June 2022. Please note that before research can commence all other approvals must have been received.

Please note that this approval is based on the assumption that the research will be carried out along the lines laid out in the proposal. Should the actual research depart significantly from the proposed research, it will be necessary to apply for a new research approval and ethical clearance.

We wish you success with the project.

Sincerely,

Prof Karen Harris
Chair: Research Ethics Committee
Faculty of Humanities
UNIVERSITY OF PRETORIA
e-mail: tracey.andrew@up.ac.za

Research Ethics Committee Members: Prof KL Harris (Chair); Mr A Bizos; Dr A-M de Beer; Dr A dos Santos; Dr P Gutura; Ms KT Govinder Andrew; Dr E Johnson; Dr D Krige; Prof D Maree; Mr A Mohamed; Dr I Noomé, Dr J Okeke; Dr C Puttergill; Prof D Reyburn; Prof M Soer; Prof E Taljard; Ms D Mokalapa

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Appendix E: Research ethics approval

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Veterinary Science
Research Ethics Committee 03 April 2024

LETTER OF APPROVAL

Ethics Reference No	**REC016-22**
Protocol Title	**Small colon impaction outbreak and associated risk factors in horses at the Onderstepoort Veterinary Academic Hospital, South Africa in 2021**
Principal Investigator	**Dr E Hollenbach**
Supervisors	**Prof GT Fosgate**
	Dr Y Smit

Dear Dr E Hollenbach,

We are pleased to inform you that your submission conforms to the requirements of the Faculty of Veterinary Sciences Research Ethics committee.

Please note the following about your ethics approval:

1. Please use your reference number (REC016-22) on any documents or correspondence with the Research Ethics Committee regarding your research.
2. Please note that the Research Ethics Committee may ask further questions, seek additional information, require further modification, monitor the conduct of your research, or suspend or withdraw ethics approval.
3. Please note that ethical approval is granted for the duration of the research as stipulated in the original application (for Post graduate studies e.g. Honours studies: 1 year, Masters studies: two years, and PhD studies: three years) and should be extended when the approval period lapses.
4. The digital archiving of data is a requirement of the University of Pretoria. The data should be accessible in the event of an enquiry or further analysis of the data.

Ethics approval is subject to the following:

1. The ethics approval is conditional on the research being conducted as stipulated by the details of all documents submitted to the Committee. In the event that a further need arises to change who the investigators are, the methods or any other aspect, such changes must be submitted as an Amendment for approval by the Committee.
2. Note: All FVS animal research applications for ethical clearance will be automatically rerouted to the Animal Ethics committee (AEC) once the applications meet the requirements for FVS ethical clearance. As such, all FVS REC applications for ethical clearance related to human health research will be automatically rerouted to the Health Sciences Research Ethics Committee, and all FVS applications involving a questionnaire will be automatically rerouted to the Humanities Research Ethics Committee. Also take note that, should the study involve questionnaires aimed at UP staff or students, permission must also be obtained from the relevant Dean and the UP Survey Committee. Research may not proceed until all approvals are granted.

We wish you the best with your research.

Yours sincerely

PROF M. OOSTHUIZEN
Chairperson: Research Ethics Committee

100 YEARS OF VETERINARY EDUCATION

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