ESTABLISHING THE INTERNATIONAL COLIC SURGERY AUDIT (INCISE)

Thesis submitted in accordance with the requirements of the University of Liverpool for the degree of Master of Philosophy

by

Matthew David Sebastian Cullen

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ABSTRACT

Clinical audit is a process used to measure standards of healthcare and implement changes that lead to quality improvement (QI). As an expensive procedure with relatively high rates of morbidity and mortality, emergency laparotomy to manage signs of abdominal pain in horses (colic surgery) is a discipline well-suited to clinical audit. The International Colic Surgery Audit (INCISE) was launched in January 2020, with the main objective to improve the quality of care and outcomes for equine patients undergoing colic surgery. Chapter Two of this thesis (INCISE-1) was an organisational audit that aimed to gather information about the current provision of colic surgery around the World, and to describe the processes, facilities and staffing in place at clinics offering this service. As the launch of INCISE coincided with the start of the COVID-19 pandemic, a secondary aim was to determine the effects of COVID-19 on provision of colic surgery at participating clinics. Chapter Three of this thesis (INCISE-2) aimed to describe key features and outcomes of horses undergoing colic surgery at contributing clinics that could be used to generate benchmarking data. All data were collected using a bespoke, electronic data collection platform via the INCISE website. Clinics accessed the website using a confidential password unique to each clinic, that provided users with access to their own clinic data only and the ability to automatically generate audit reports.

Sixty clinics from 24 countries submitted data to INCISE-1, consisting of 38 (63.3%) private clinics and 22 (36.7%) academic (university-based) clinics. Most clinics (96.7%) offered colic surgery 24 hours a day, 365 days a year. The median number of horses with colic admitted to contributing clinics in 2019 was 150 (range 14 – 600), and the median number of exploratory laparotomies performed in 2019 was 44 (range 3 – 130). Clinical staff composition and provision of out-of-hours patient care were highly variable between clinics. Protocol use was also highly variable and was less common than reported in human hospitals undertaking emergency laparotomy at all stages of care. Internal audit of colic surgeries was undertaken by 26.3% of clinics but only one clinic published this information externally. Morbidity and mortality rounds were undertaken by 56.1% of contributing clinics, though the frequency of rounds, format and staff attendance were highly variable.

Sixty-three clinics contributed data to INCISE-2, consisting of 39 (61.9%) private clinics and 24 (38.1%) academic clinics. Data for 4,027 horses presenting with signs of colic between January 2019 and December 2021 were analysed, of which 3,770 (93.6%) underwent emergency laparotomy. The most common surgical lesions were: pedunculated lipomas causing small intestinal strangulation (10.2%), right dorsal displacement of the large colon (9.8%) and large colon volvulus greater than or equal to 270º (9.6%). A total of 2,908 horses (77.1%) recovered from surgery and 2,271 were discharged from clinics (overall short-term survival of all horses undergoing emergency laparotomy 60.2%; short-term survival of horses that survived surgery and stood following general anaesthesia 78.1%) The most frequent postoperative morbidities from data entered onto the INCISE platform were: postoperative colic (25.7%), intra-abdominal haemorrhage (21.7%) and septic peritonitis (19.0%).

Work presented in this thesis has demonstrated that confidential collection of multicentre, international equine surgical audit data is possible. These data provide a snapshot of current standards of care for horses undergoing colic surgery and report key patient features and outcomes following this procedure at a broad range of clinic types located across the World. Multiple areas for QI have been identified in this thesis and ongoing data analysis is being undertaken to generate colic surgery benchmarks across a range of outcomes. It is hoped that the INCISE audit toolkit will continue to facilitate colic surgery audit by veterinary clinics, promote ongoing monitoring of standards of care and encourage measurement of the impact of future interventions aimed at improving colic surgery outcomes.

LIST OF ABBREVIATIONS

AAEP	**American Association of Equine Practitioners**
ACVS	**American College of Veterinary Surgeons**
BEVA	**British Equine Veterinary Association**
ECC	**Emergency and Critical Care**
ECVS	**European College of Veterinary Surgeons**
FLASH	**Fast Localised Abdominal Sonography of Horses**
INCISE	**International Colic Surgery Audit**
IQR	**Interquartile Range**
MACVSc	**Members of the Australian College of Veterinary Scientists**
M&M	**Morbidity and Mortality**
NELA	**National Emergency Laparotomy Audit**
NHS	**National Health Service**
OOH	**Out-Of-Hours**
PCV	**Packed Cell Volume**
QI	**Quality Improvement**
RCVS	**Royal College of Veterinary Surgeons**
ROW	**Rest of the World**
TP	**Total Protein**

CHAPTER ONE

LITERATURE REVIEW

Work presented in this chapter has been published during the writing of this thesis:

Cullen, M.D., Archer, D.C. and Mair, T.S. (2020) Clinical audit in equine practice, and the International Colic Surgery Audit. *Equine Veterinary Education*, 32, 172-174.

INTRODUCTION

Colic, the term used to describe clinical signs of abdominal pain, is one of the most important causes of mortality and morbidity in horses (Tinker *et al*, 1997; Traub-Dargatz *et al*, 2001). Further investigation of more complex colic cases is the most common reason for emergency referral of horses to equine hospitals (Southwood *et al*, 2009; Viljoen *et al*, 2009). While most cases of colic seen in ambulatory practice resolve with medical treatment or no treatment at all, some require surgical treatment or euthanasia (Proudman, 1992; Hillyer *et al*, 2001; Curtis *et al*, 2015). The proportion of horses with colic that undergo or require surgery ranges from 1.4 to 17.5% (Proudman, 1992; Kaneene *et al*, 1997; Tinker *et al*, 1997; Hudson *et al*, 2001; Mair, 2004; Archer and Proudman, 2006; Curtis *et al*, 2015), with variable estimates depending on the population studied.

Despite significant improvements in treatments and outcomes for horses undergoing colic surgery over the last five decades (Freeman, 2018a), morbidity and mortality rates remain relatively high (Mair, 2009; Salem *et* al, 2016). The associated financial costs are also high and the procedure requires a large input of staff and other resources, as shown in *Figure 1.1*. Morbidities and mortalities are influenced by the type of lesion and other patient factors, such as systemic status and the degree of intestinal compromise. However, the contribution of surgical performance and our treatment choices are undoubtedly significant. These can and should be scrutinised to enable further improvements in quality of care for horses with colic (Freeman, 2018a). The use of clinical audit, a tool by which patient care can be assessed and improved, has been suggested as one way to achieve this in the discipline of equine colic surgery (Mair and White, 2005).

WHAT IS CLINICAL AUDIT?

Surgical audit in human medicine can be traced back to the mid nineteenth century. Regarded as the founding father of modern abdominal surgery, Theodor Billroth began auditing surgical outcomes in the 1860s while working as the Director of the University of Zurich’s surgical clinic. Publishing of these outcomes, good and bad, led to open discussion about surgical techniques, morbidities and mortalities which, in turn, improved patient selection (Kazi and Peter, 2004). Even before this, in 1854, audit was used by Florence Nightingale to combat the poor conditions and high mortality she encountered while nursing troops at Selimiye Barracks during the Crimean War. By introducing new hygiene protocols and lobbying for improved facilities, Nightingale and her team of nurses greatly reduced the rates of nosocomial infections (Levy and Rockall, 2009). Nightingale was also a pioneer in the use of statistics and visual methods of data presentation, which she used to monitor these changes and demonstrate a reduction in mortality from 40% to 2%. This work continued post-Crimea, first with the preparation of a report into the healthcare and administrative failings of the War and continuing throughout Nightingale's life with constant efforts to improve hospitals and healthcare, always with a focus on the practical application of her findings (McDonald, 2010). Evaluating surgical outcomes to help identify areas for improvement is now a central tenet of human surgery (Holt *et al*, 2008) and is a fundamental duty of all surgeons. Indeed, analysis of clinical practice is an integral responsibility of all healthcare professionals (Wylie, 2015) and involvement in clinical audit can be considered a professional and ethical obligation (Kinn, 1997; Burgess, 2011).

Figure 1.1: The clinical team in an equine teaching hospital preparing a patient for colic surgery. The investigation up to this stage, surgical treatment and postoperative care require a large input of resources.

The word audit can encompass a variety of activities, particularly within the discipline of surgery where it has been used for a long time with different meanings (Williams, 1996). However, the understanding of audit in a surgical or medical context has evolved and is now commonly recognised as referring to the term 'clinical audit'. Clinical audit is a specific, cyclical process which is intended to improve quality of healthcare (Williams, 1996). Variable definitions of clinical audit exist (Rose *et al*, 2016a), but one of the most commonly used describes it as:

> "A quality improvement process that seeks to improve patient care and outcomes through systematic review of care against explicit criteria and the implementation of change. Put more simply, clinical audit is all about measuring the quality of care and services against agreed standards and making improvements where necessary" (National Institute for Clinical Excellence, 2002).

This definition highlights two important aspects of clinical audit, namely the need for established standards to which actual levels of performance can be compared, and the need to act on the findings and change future practice for the better. Just measuring outcomes does not justify the considerable resources required for data collection (Burgess, 2011). However, the cyclical process of clinical audit also demands the identification and implementation of changes which improve and maintain quality. This outcome makes clinical audit hugely beneficial to healthcare and a rewarding experience for those involved.

Slight differences in definitions and descriptions of the clinical audit process are evident throughout the veterinary and human medical literature (Morrell and Harvey, 1999; Rose *et al*, 2016a). Combined with the different types of audits that exist, this can cause confusion and difficulties for clinicians wanting to design and undertake a clinical audit (Waine and Brennan, 2015). A simple, consensus definition that is understood by all stakeholders and that is used across the veterinary profession may make the process easier and more accessible (Waine *et al*, 2018c). This has recently been attempted by a group who used a modified eDelphi method to generate veterinary-specific, consensus definitions of 14 quality improvement (QI) terms (Rooke *et al*, 2021). A 93.8% level of consensus was reached for the following definition of clinical audit:

> *"*The collection of data prospectively or retrospectively in health care settings to answer a specific question relating to the delivery of clinical care. The ultimate aim of clinical audit should be to improve the care delivered to patients and the service delivered, through a cycle of measuring, improving and monitoring*"* (Rooke *et al*, 2021).

As shown in *Figure 1.2*, clinical audit forms one part of clinical governance, a broader concept that encompasses a multi-faceted approach to accountability and quality improvement in healthcare (Scally and Donaldson, 1998; Levy and Rockall, 2009; Mair, 2009). In human medicine, clinical audit is widely employed as part of clinical governance activities to maintain and improve standards. For example, participation in clinical audit has been mandatory for doctors working within the National Health Service (NHS) in the United Kingdom (UK) since 2001, as laid out in 'The NHS Plan, a plan for investment, a plan for reform' (Department of Health, 2000). Clinical audit is also widely performed by health services in Australia (Retegan *et al*, 2013), across continental Europe and in the United States of America, where it is more commonly called chart audit (Burgess, 2011). Within the overall framework of clinical governance, clinical audit ensures adherence to standards or guidelines. These standards should, where possible, be informed by the best evidence available from clinical research, another of the 'pillars' of clinical governance.

Figure 1.2: The six pillars of clinical governance described by Levy and Rockall (2009). Slightly different pillars are described by different sources, with other headings including 'Patient/Client Involvement', 'Staffing/Staff Management' and 'Use of Information' (Viner, 2009).

Clinical audit and research are separate entities, with the main distinction being a difference in their primary objective (Williams, 1996). Research aims to generate new knowledge, ideally by asking a clearly defined research question, whereas clinical audit aims to assess whether actual clinical performance is meeting expected standards (Dunn, 2012; Wylie, 2015). Put simply, "research is concerned with discovering the right thing to do; audit with ensuring that it is done right" (Smith, 1992). The difference is not just pedantry; there are differing methodologies and ethical requirements that healthcare professionals need to be aware of (Wylie, 2015). There are also implications regarding the generalisability and influence of the results that should be considered when interpreting the conclusions of either process. However, clinical audit and research undoubtedly overlap and have complementary roles in clinical governance; each can be used to inform the other. Research can be used to establish agreed standards and guidelines to compare actual practice to. Similarly, in assessing what is actually being achieved, clinical audit stimulates discussion and can identify new questions that might be best investigated by clinical research.

Different types of clinical audit have been defined based on what part of healthcare the audit team would like to assess (Mosedale, 2020). In a seminal paper evaluating methods for assessing quality of healthcare, Avedis Donabedian suggested there were three inter-related aspects we should consider, namely structure, process and outcome (Donabedian, 1966). These have subsequently been used to categorise any item of healthcare that may be assessed by an audit, referred to as a criterion (Ashmore *et al*, 2011a). Clinical audits of structure criteria assess staffing, facilities and equipment to ensure that all resources required to deliver a specific service are in place. Process audits assess whether the actions and decisions undertaken by staff adhere to those recommended by guidelines or protocols. Outcome audits measure the results of a particular intervention to see if the desired standards are being met. Depending on the objective of the audit being performed, it is often appropriate to assess more than one criterion. However, audits that attempt to assess too many aspects of care may lose momentum and can be difficult to interpret (Ashmore *et al*, 2011a). Adopting a selective approach to audit criteria can produce a more focused audit report that pinpoints more exactly what changes are needed. In addition, selective audits tend to be more achievable and thus more likely to be completed (Ashmore *et al*, 2011a).

STAGES OF THE AUDIT CYCLE

Regardless of the type of clinical audit being performed, the same stages of the process should be used. These stages are illustrated in *Figure 1.3* and are very well-described by multiple educational articles aimed at veterinary professionals (Mosedale, 1998; Viner, 2009; Dunn, 2012; Waine and Brennan, 2015; Waine *et al*, 2018a,b; Rose and Pang, 2021). In addition, detailed descriptions and a highly pragmatic approach to the process can be found in textbooks aimed at human health care professionals (Morrell and Harvey, 1999; Burgess, 2011), which are just as relevant to veterinary surgeons wishing to undertake a clinical audit. The key stages that differentiate 'clinical audit' from just auditing clinical data are the selection of explicit criteria, implementation of change, and repeating the audit cycle. These steps instigate an 'ongoing upward spiral' of improvement that is a central principle of clinical audit (Viner, 2005).

Although there are important distinctions between clinical audit and research (Wylie, 2015), a notable similarity is the importance of good preparation to achieving intended outcomes for both processes (Hulley *et al*, 2007; Esposito and Canton, 2014). The preparation stage of a clinical audit is often the most time-consuming, as it involves selecting and researching a topic, assembling an audit team, setting standards and deciding what data to collect. This stage also involves training in clinical audit for those who have not undertaken the process before. The topic chosen should be relevant to the team involved and an area with scope for meaningful improvement or where a specific problem has been identified. Good topics are typically high volume, high risk or high cost (Benjamin, 2008). However, for those starting out in clinical audit, it may be more important to keep the topic simple and interesting to ensure engagement of the audit team (Waine *et al*, 2018a).

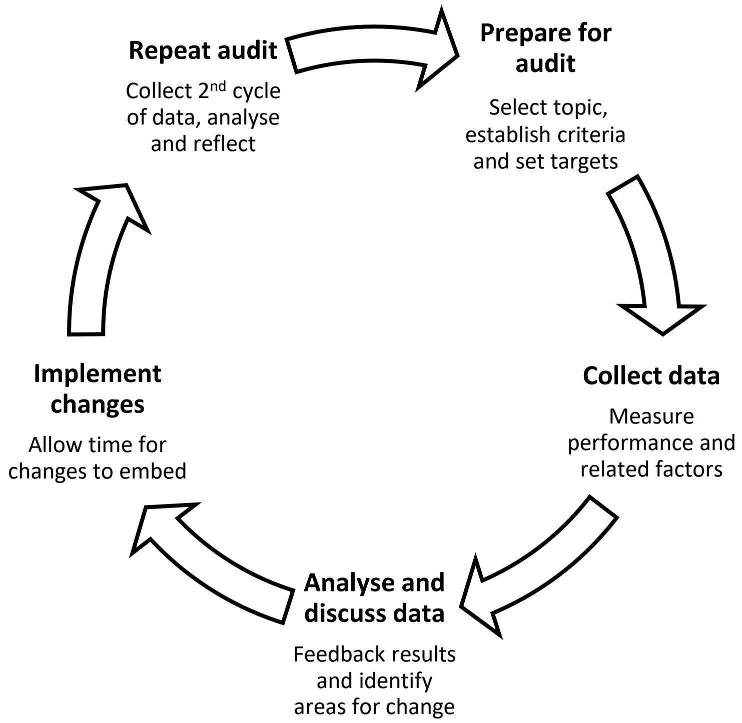


Figure 1.3: The stages of clinical audit, demonstrating the cyclical nature of the process.

The most effective clinical audits are typically led by clinical staff and benefit from multi-disciplinary representation (Morrell and Harvey, 1999). However, the audit team should represent all stakeholders involved in the topic being assessed, while also being as small as possible to increase efficiency of audit design and methodology (Ashmore *et al*, 2011a). In veterinary clinics this may include clinical staff of different types, administrative staff and animal owners. An audit lead should be nominated to oversee the process and ensure the findings are appropriately reported. This should be an individual with good knowledge of clinical audit and the ability to motivate and manage others (Ashmore *et al*, 2011a).

The audit team can then review the selected topic and decide how best to assess it. This involves defining the audit aim, objectives, criteria and standards. The aim should define the overall purpose of the audit, for example, to improve the diagnosis or treatment of a specific condition. Verbs such as 'improve', 'increase', 'enhance', 'ensure' and 'change' are often used in audit aims (Ashmore *et al*, 2011a). Crucially, the aim should be simple and realistic (Waine *et al*, 2018c). Objectives are more specific statements of how the aim will be achieved, which should be easily measurable. The audit objectives will inform the standards and criteria that are used. These terms have been variably defined by different sources, though broadly speaking they refer to the measurable statements that a clinical audit intends to investigate. A criterion is a definable and measurable item of healthcare that describes quality and which can be used to assess it, while a standard is the target level of care to be achieved, usually expressed as a percentage (Ashmore *et al*, 2011a; Esposito and Canton, 2014). Standards can also be stated as an amalgamation of a criterion and its target level of performance (Ashmore *et al*, 2011a). Standards should ideally be taken from the best available evidence in peer-reviewed literature or existing protocols or guidelines (Viner, 2009; Dunn, 2102). Alternative sources include expert consensus statements, scientific literature pertaining to similar topics, or the findings of audits performed at other centres (Esposito and Canton, 2014; Waine and Brennan, 2015). However, if these do not exist the audit team can set and agree on their own standard or use a standard obtained from running the first round of the audit (Waine and Brennan, 2015). Whatever the method chosen for setting standards, they should be optimised based on what is realistic for the criterion being assessed. Optimum standards usually lie between the minimum acceptable level of care and the ideal level possible if there are no constraints (Benjamin, 2008; Ashmore *et al*, 2011b).

Actual performance is then measured by collecting data regarding the chosen criteria. This should be as simple and efficient as possible, with no extraneous information gathered (Ashmore *et al*, 2011b). The focus should be on information that is directly relevant to the audit objectives. However, to identify changes that can be implemented to improve quality of care, it is also necessary to consider variables that may affect the standard being assessed (Waine *et al*, 2018b). Sources and methods of data collection for clinical audit require careful consideration by the audit team. A full review of factors affecting these considerations is beyond the scope of this thesis; instead, the reader is directed towards other excellent sources (Morrell and Harvey, 1999; Ashmore *et al*, 2011b; Waine *et al* 2018b). However, one important factor is the suitability or unsuitability of retrospective data collection, which is often limited by the properties and ease of use of computer software used for clinical record keeping (Rose *et al*, 2016a), and by the fact that some information of interest may not be routinely recorded.

Analysis of clinical audit data should be simple and aimed at determining whether or not the audit standards have been achieved and if not, why not. The findings can then be discussed by the audit team, so that they can carry out the crucial step of identifying changes that can be made to improve standards and formulate an action plan for their implementation. All stakeholders should be involved in approval of the final action plan (Waine *et al*, 2018b). Communication of the audit findings and recommended changes to all staff outside of the audit team is essential to achieve QI. Although this may be easiest using an e-mail or poster, passive methods like this are often ineffective at bringing about meaningful change (Bero *et al*, 1998). Recommendations should be given in both written and verbal formats and be given more than once (Ivers *et al*, 2012). Dedicated meetings to interactively disseminate the audit report increase assimilation of the findings. Furthermore, they allow staff to query parts they do not understand or believe in, which should identify potential barriers to change before they become an issue (Morrell and Harvey, 1999) and hopefully avoid misunderstandings.

Once changes have been implemented and an appropriate period has elapsed to allow them to be effective, the audit should be repeated. This will assess what effect the changes have had on quality of care. This stage is critical to complete the audit cycle, achieve QI and sustain this improvement

(Benjamin, 2008; Dunne *et al*, 2018). The findings of the re-audit should also be disseminated to all stakeholders. Repeating the audit cycle should maintain interest and remind people of the changes that have been agreed. Sustaining changes that have been implemented is important to ensure long-term QI (Morrell and Harvey, 1999). To facilitate this the audit team should develop structures and systems that integrate and monitor implemented changes (Benjamin, 2008). They can then reflect on the need for further audit cycles, either with adjusted standards, a change to the criteria being assessed, or an entirely new audit topic.

While the methodology and terminology involved can seem complex, in essence clinical audit is a process to ensure what should be done is being done (Smith, 1992). The well-defined stages of this process provide an excellent framework to achieve this and introduce the changes that drive quality improvement. However, over-prescriptive definitions and inconsistent terminology should not dissuade clinicians from embarking upon what should fundamentally be a simple process of improving the care provided to patients.

DOES CLINICAL AUDIT WORK?

Significant debate exists regarding the efficacy of clinical audit as a QI tool (Shortell *et* al, 1998; Boyle and Keep, 2018). In the field of human emergency medicine, clinical audit has had little effect on the promptness of administration of analgesia to children with severe pain, but has led to significant improvements in other areas, such as the proportion of adults with sepsis who receive antimicrobial treatment within one hour of admission (Boyle and Keep, 2018). Two studies of the effectiveness of clinical audit, or 'audits of audits,' have found that many are ineffective (John *et al*, 2004; Guryel *et al*, 2008). Too often, the audit cycle is not completed and changes to practice do not occur (Prasad and Reddy, 2004; Cai *et al*, 2009). Some doctors suggest that, although audit has become an effective tool to benchmark care between different units and provide quality assurance information to regulators, it is an expensive and ineffective way to achieve its primary aim of improving clinical care (Boyle and Keep, 2018). This may be a consequence of the pressures on the NHS at the time when clinical audit was being introduced. Following a widely publicised inquiry into standards of paediatric cardiac surgery at the Bristol Royal Infirmary, multiple failings in clinical governance were identified (Walshe and Offen, 2001). This came at a time when clinicians across the NHS were under ever increasing pressures to prove the effectiveness and efficiency of their services (Lord and Littlejohns, 1997). Therefore, it is plausible that the use of clinical audit to measure and regulate was emphasised over its role as a genuine tool to improve quality of care. It is also understandable if doctors in that environment were sceptical or suspicious of the motives for clinical audit at that time.

As with any process in medical care, it is right to critically appraise the effectiveness of clinical audit. Doing this thoroughly identifies multiple examples of published clinical audits that have led to improved quality of human healthcare in the UK (Chate *et al*, 2006; Husk, 2008) and internationally (Wagaarachchi *et al*, 2001; Kirby *et al*, 2008; Lai *et al*, 2009). Examples of proven benefits of clinical audits range from shorter reporting times in diagnostic imaging (Mackinnon *et al*, 2008) to shorter waiting times, reduced postoperative complications, earlier mobilisation, and shorter hospital stays for people undergoing surgical repair of hip fractures (Freeman *et al*, 2002; Patel *et al*, 2013). Two systematic reviews have found that clinical audit is effective in improving professional practice and healthcare outcomes (Ivers *et al*, 2012; Johnson and May, 2015). These effects are most likely to be substantial when the audit has clear targets and an action plan.

Examples of failed clinical audit have led to 'quality improvement' (QI) being proposed as a separate, superior process that takes a collective approach with improved engagement of clinical staff and emphasises targeted data collection and rapid interventions (Boyle and Keep, 2018). Alternatively, this could just be viewed as performing clinical audit properly as part of the wider framework of QI (Burgess, 2011; Hillman and Roueche, 2011). Amongst a move towards other methods of quality improvement in the first decade of the 21st century, clinical audit staff in the NHS were redistributed, leading to decreased support for clinicians and marginalisation of the process (Burgess, 2011). However, clinical audit remained mandatory throughout that period and the process has been revitalised, led by the Healthcare Quality Improvement Partnership (HQIP). Instead of rebranding or abandoning clinical audit, it has been simpler and more efficient to reinvigorate the process with a refined focus on its original intended purpose and its place within the wider concept of clinical governance. While the balance of opinion suggests clinical audit is an effective quality improvement tool, its effects on clinical practice are typically small to moderate and rely on the design and delivery of audit recommendations and feedback (Ivers *et al*, 2012). The limitations of what clinical audit can achieve should be remembered, particularly by any audit team at the planning stage of a new project. However, to dismiss it entirely due to the failure of poorly designed audits risks the loss of what is, when used correctly, a highly useful QI framework.

CLINICAL AUDIT IN VETERINARY MEDICINE

The adoption of clinical audit by the veterinary profession was first suggested more than two decades ago in an article that expounded the process with clinical examples and emphasised its potential benefits (Mosedale, 1998). Two years later a human consultant surgeon (Collier, 2000) and equine orthopaedic surgeon (McIlwraith, 2000) offered their perspectives of clinical audit in an editorial in Equine Veterinary Education, while also reflecting on several of the practical challenges faced in its application.

Readers were reminded of our responsibility to learn from our mistakes and encouraged to view audit not as a competitive or finger-pointing exercise, but rather as a means by which we should aspire towards excellence together. Dr McIlwraith concluded his article: ‘One needs to be careful not to be considered ‘elitist’, but it seems time to take up the gauntlet.’

There has been a steadily growing interest in veterinary clinical audit, reflected in the many review articles on the topic (Rayment, 2002: Viner, 2005; Viner, 2009; Mair, 2009; Dunn, 2012; Waine and Brennan, 2015; Wylie, 2015; Waine *et al*, 2018a,b; Rose and Pang, 2021). Although there is no statutory requirement for clinical audit in the veterinary profession, evidence of clinical governance is essential for all practices in the United Kingdom enrolled in the Royal College of Veterinary Surgeons Practice Standards Scheme (RCVS, 2022). Furthermore, clinical audit is specifically mentioned as an example of clinical governance activity for practices wishing to attain General Practice status and is mandatory for those wishing to achieve Veterinary Hospital status (RCVS, 2022). In addition to fulfilling these requirements, multiple other benefits of clinical audit in veterinary medicine have been described. These include evidence-based improvements in patient care, increased efficiency and profit, empowerment of all stakeholders involved in the audit process, and the continued professional development and increased job satisfaction of clinical staff (Viner, 2009; Dunn, 2012; Waine and Brennan, 2015). Furthermore, the quality assurance that clinical audit provides can improve public confidence in the profession and be used to evidence standards of care in cases of complaint or litigation (Dunn, 2012).

Despite more than two decades of the use of clinical audit in the veterinary field, there is a dearth of published examples and a systematic review found those that had been published commonly suffered from poor design and reporting (Rose *et al*, 2016a). Encouragingly, the number of published veterinary clinical audits has increased steadily since Rose and others published their findings, though the quality of design is still variable. Many examples outline the choice of topic for an audit and describe the first round of data collection, but do not set targets, implement change, or perform the re-audit stage (Spanton *et al*, 2020; Martin *et al*, 2022; Smith *et al*, 2022). Although not fulfilling the complete audit cycle, these studies provide valuable benchmarking data for clinics wishing to undertake their own clinical audits of the same topics, as well as identifying related factors of interest which future audits can target for change implementation. They also demonstrate that the data collection required for clinical audit is achievable in commercial veterinary practice. However, examples of the full audit cycle are few, particularly in the equine literature.

This lack of published examples is perhaps unsurprising. Clinical audits performed in practice are often seen as only relevant to that one centre. Colleagues conducting clinical audits may not perceive any wider interest in their experience or may be reluctant to publish their results due to commercial sensitivities, which may be more of a barrier in private veterinary practice than in human healthcare. Even in the NHS, where clinical audit is a mandatory process, the number of audits that are published as a percentage of those performed is very small. Furthermore, those that are published are frequently poorly described (Jones *et al*, 2016). The need for published clinical audits can be questioned. However, in the author's experience, reading a practical example of clinical audit can be far more informative than a review of the process, especially in understanding the logistical aspects and possible pitfalls of the process. There are many good examples in the human medical literature (Harmer and Davies, 1998; Polkinghorne *et al*, 2009; Patel *et al*, 2013; Vratsistas-Curto *et al*, 2017). There are also examples of well-reported, complete clinical audits in small animal practice (Dunn and Dunn, 2012; Rose *et al*, 2016b), including some that fulfil the full audit cycle but are reported as interventional studies (Hofmeister *et al*, 2014).

Until recently, the closest example of a clinical audit in equine veterinary practice could be considered the Confidential Enquiry of Perioperative Equine Fatalities (CEPEF) (Johnston *et al*, 1995, 2002, 2004). Although we do not yet have proof of their QI effects, the findings of CEPEF-1, -2 and -3 have been widely adopted at equine clinics around the world. CEPEF-4 is currently underway (Gozalo-Marcilla *et al*, 2020) and could be viewed as the first re-audit stage. Preliminary results indicate that current practice in equine anaesthesia has changed over the last 20 years and are suggestive of reduced mortality rates (Gozalo-Marcilla *et al*, 2021). The distinctions between research and clinical audit are important (Viner, 2009; Wylie, 2015) and CEPEF may not fulfil all stages of the clinical audit process. However, it shines as an excellent example of the possibilities for well-designed, international collaborations.

Two recent publications have documented single centre clinical audits in equine veterinary practice with only minor omissions. Although no standards were set for the criteria being assessed, a clinical audit of preoperative antimicrobial administration successfully introduced changes and improved antimicrobial recording in a Canadian equine teaching hospital (Ceriotti *et al*, 2021). Very clear criteria and standards were set in a British clinical audit of the management of pituitary pars intermedia dysfunction (Steel *et al*, 2022). However, although the findings and several recommendations for change were shared with the clinical team, no re-audit stage was performed. These examples have clear objectives and demonstrate the benefits of a well-designed audit plan for colleagues wishing to embark on the process of clinical audit.

Awareness of clinical audit amongst veterinary surgeons is undoubtedly increasing, as is the number of published examples. Therefore, it seems likely that the overall utilisation of clinical audit in veterinary practice is also increasing. Evidence of this is lacking, though a recent survey of over 300 vets working in farm animal practice revealed 48% of them had carried out a clinical audit (Waine *et al*, 2018c). Respondents were significantly more likely to have completed a clinical audit if they had received postgraduate training on the process, and vets were more likely to have received undergraduate training in clinical audit if they had graduated after 2010 (Waine *et al*, 2018c). Increased use of clinical audit in veterinary practice depends on an understanding of the process amongst veterinary staff and dedicated time to undertake it (Viner, 2009). Some authors also argue that it requires pre-existing, evidence-based standards or guidelines to audit against (Williams, 1996; Viner, 2009), which are few in the veterinary field relative to the large numbers in human medicine. Barriers to clinical audit in veterinary practice, such as a lack of evidence-based standards, are well-described (Waine *et al*, 2018a; Rose and Pang, 2021) and are discussed in the following section. Identifying these barriers and taking steps to negate them are important stages to facilitate successful audit.

OVERCOMING ORGANISATIONAL BARRIERS TO CLINICAL AUDIT AND OTHER POTENTIAL PITFALLS: A VETERINARY PERSPECTIVE

Clinical audit is a time-consuming process, a commodity which is often in short supply for staff in the veterinary sector. Lack of adequate time is the barrier to audit that is most frequently cited by doctors and vets alike (Johnston *et al*, 2000; Nettleton and Ireland, 2000; Benjamin, 2008; Mair and White, 2008; Waine *et al*, 2018c). This may be compounded by attempts to include too many audit criteria and by starting out with a poorly designed audit plan, both of which are easily avoided by careful planning and training during the preparation stage. It can also be helpful to produce a general template that may be adapted slightly to perform multiple different audits. Provided the audit design is optimised, the largest time savings can be made during data collection. Often, too much time is wasted due to inefficient data collection systems (Johnston *et al*, 2000) and fast, easy methods of data collection have been highlighted as important to success by vets involved in clinical audit (Waine *et al*, 2018c). Modern, easy-to-use medical record systems speed up retrospective data collection and prospective data entry. The NHS provides dedicated audit staff and resources to aid data collection, although a lack of these is often highlighted as a barrier within that organisation (Johnston *et al*, 2020). Almost every NHS hospital employs staff dedicated to assisting clinical staff with the design and conduct of clinical audits (Boyle and Keep, 2018). As corporatisation of the veterinary profession increases, these resources may become more widely available to veterinary surgeons. However, they remain financially impractical for many clinics. In the interim, clinicians may recruit administrative staff who may be more efficient at using practice management software. This has additional benefits of including administrative staff in the process, who are often an overlooked but important stakeholder in many clinical audit topics. Finally, an enthusiastic and organised audit lead can help minimise time wastage by ensuring that meetings arranged to monitor progress and reflect on findings are run as efficiently as possible.

Even with the best designed and most efficient clinical audit possible, the process still requires time. Junior doctors report that they have inadequate time for QI improvements around clinical commitments (Bagnall, 2012) and often feel such work is not valued by their clinical managers (Gilbert *et al*, 2012). It is crucial that veterinary practice managers provide staff with protected time for an audit project on a regular basis. This time should allow for staff members to work together where necessary and within 'office hours' (Cai *et al*, 2009), particularly when multidisciplinary involvement is required. Provision of protected time for clinical audit to veterinary professionals is more likely in a clinic that promotes a culture of evidence-based medicine. This in turn is more likely where team leaders have directly experienced the benefits that clinical audit provides. In the long-term this is achieved by providing prompt, balanced feedback once an audit has been analysed. However, it may also be achieved by presenting examples of successful audits from other clinics or the human field (Benjamin, 2008). Time not spent on clinical work can be seen as costly to veterinary clinics (Viner, 2005) so it can also be helpful to emphasise the financial benefits of clinical audit.

When those in management are persuaded of the benefits of clinical audit, this should be passed on to those they manage. Engagement of the staff charged with conducting an audit is essential. Furthermore, a positive attitude towards clinical audit amongst the wider team is needed for them to buy in to the audit findings, adhere to any recommended change and achieve quality improvement. Bray identified several methods that NHS managers can use to demonstrate genuine support for QI, which in turn can foster a workplace culture that allows effective engagement with clinical audits amongst junior doctors (Bray, 2017). Recommended steps included providing protected time and resources for clinical audit, encouraging junior colleagues to work in teams rather than attempt solo QI projects, providing specific QI training and integrating this training into leadership and career pathways (Bray, 2017). These are all steps that can be adopted by the veterinary profession.

If and when enthusiasm for clinical audit is generated, sustaining this for a prolonged period presents a further challenge (Rose *et al*, 2016a). This may be accomplished by scheduling regular clinical governance meetings to present findings and communicate any changes to practice. Good communication at all stages of the audit cycle is essential for successful clinical audit (Johnston *et al*, 2000). A clear understanding of the initial audit aim, followed by regular progress updates and sharing of results allows the audit team and other stakeholders to feel informed and involved in the process (Waine *et al*, 2018c). Clinical governance meetings can also be used to choose a new topic and team member to lead the next audit so that the workload is shared; in this way continual improvement becomes a part of the team ethos. In addition to the method of feedback, the design of the recommendations has been identified as a contributing factor in how well they are adhered to (Foy *et al*, 2002). The changes in the final action plan should be clear and accountable, consisting of unambiguous recommendations with set people given the task of monitoring adherence (Waine *et al*, 2018). To improve adherence the changes should also include measurable targets (Ivers *et al*, 2012), be as simple as possible and not require any changes in routine (Foy *et al*, 2002). Where complexity and changed routines are unavoidable, or even a key part of the recommendation, the changes should be accompanied by the resources to achieve them (Morrell and Harvey, 1999). For example, staff may need training in a new clinical technique, or a new piece of equipment may need to be purchased.

The lack of evidence-based, published standards in many areas of veterinary care has been highlighted as a barrier to effective clinical audit (McIlwraith, 2000; Mair and White, 2008; Wylie, 2015). Furthermore, the evidence from peer-reviewed literature that does exist within a single topic can be conflicting and there are relatively few systematic meta-analyses to provide clarity. To overcome this barrier an audit team can set their own standards based on what the team or expert opinion deems to be an acceptable level of clinical care. If this method is chosen, it is important that these are realistic and achievable to avoid demoralising team members. Alternatively, an initial audit or benchmarking exercise may be performed to establish the current standards and facilitate future rounds of clinical audit, as has been performed for clinical audit of equine castration complications (Hodgson and Pinchbeck, 2018) and for mortality in dogs undergoing general anaesthesia and sedation (Shoop-Worrall *et al*, 2022).

Re-audit ensures standards of care are improved rather than just measured. Failure to do this compromises a fundamental part of the audit cycle and is commonly cited as a reason for ineffective clinical audit (John *et al*, 2004; Kurup *et al*, 2007; Dunne *et al*, 2018). In one study only 27% of audits were completed and the crucial re-audit stage was performed in only 22% (John *et al*, 2004). Others have found re-audit rates as low as 5% in a human orthopaedics department (Kurup *et* al, 2007) and 18% in general surgical audits across multiple NHS trusts (Dunne *et al*, 2018). In one study the most frequent reason given for not performing a re-audit was the achievement of a desired publication or presentation before getting to the re-audit stage (Dunne *et al*, 2018), suggesting that this is a more important motivator than QI for carrying out clinical audits. This is in agreement with other research that found improvement of healthcare to be one of the least important reasons for junior doctors undertaking clinical audit, while the most important reasons were meeting the requirements of their annual competency progression assessments and scoring points for job applications (Kidd, 2015). If junior doctors are less likely to re-audit once they achieve a publication or meet their training requirements (Dunne *et al*, 2018), then the same may be true of vets who are undertaking an audit for similar reasons. In one study, the most common reason provided by vets for undertaking a clinical audit was to gather information on what happens in their practice (Waine *et al*, 2018c). Other reasons included meeting RCVS Practice Standards requirements, a response to a significant event and to meet RCVS Continuing Professional Development requirements.

Making the re-audit stage mandatory for junior doctors wishing to use a clinical audit for progression assessments or job applications would seem an easy way to improve the number of completed audit cycles. Another way to increase the rate of re-audits suggested in the NHS is to allocate junior doctors with a repeat cycle of a previously performed audit, rather than a new project (Kurup *et al*, 2007).

Hospital audit facilitators should track the completion of audit cycles and encourage clinical staff to complete the re-audit stage (Dunne *et al*, 2018). Finally, clinical departments should audit their own audits periodically to monitor the completion of re-audits and identify pitfalls in the cycle (Tabandeh and Thompson, 1995). However, these methods do not address the lack of engagement with the principal aim of clinical audit, namely QI. Furthermore, they are designed for the NHS, where clinical audit is frequently performed by junior doctors, in hospitals with a department dedicated to assisting clinical staff with audits. They may be less relevant to veterinary clinics, where reasons for failing to complete the audit cycle are likely to be similar to the previously identified reasons they may not perform clinical audit at all, such as lack of time and training. A focus on good training and ensuring the primary aim of a clinical audit is improvement, may be more effective methods of ensuring the audit cycle is completed. Additionally, this may be encouraged by initiatives that promote good audit methodology, such as the RCVS Knowledge QI awards (Doorly *et al*, 2020).

Most barriers to clinical audit can be overcome by providing training in audit design and methodology (Johnston *et al*, 2000). In a survey of farm animal veterinary surgeons in the United Kingdom, although 73% of respondents reported that they had heard of clinical audit, only 19% remembered receiving training on the subject at veterinary school and 22% recalled receiving postgraduate training in clinical audit (Waine *et al*, 2018c). Increased training at undergraduate level will improve general understanding of the clinical audit process and is also available in the form of free Continued Professional Development provided by the RCVS (Doorly *et al*, 2020). In addition to improving audit methodology, ensuring a better understanding of clinical audit tends to foster genuine belief in the process and a more supportive environment. These, in turn, promote humility amongst clinicians, healthy communication between colleagues, and the desire to take appropriate action following the results of a clinical audit, all of which are essential to achieve the improvements that the process is intended to bring about.

CLINICAL AUDIT IN COLIC SURGERY

Colic is a term used to describe the clinical signs of abdominal pain in horses. There are a large number of potential causes of colic, though the majority are disorders of the gastrointestinal tract (Traub-Dargatz *et al*, 2001; Curtis *et al*, 2015). These causes vary in severity from mild disorders requiring no veterinary treatment, to life-threatening pathologies that require intensive medical or surgical intervention. Soon after the inception of surgical treatment of horses with colic in the 1960s, veterinary surgeons undertaking the procedure began reporting their experiences and outcomes (Tennant *et al*, 1972; Tennant, 1975; Pearson *et al*, 1975). Colic surgery has since become a routine procedure in many developed countries and has been the focus of a large number of descriptive studies that provide important but limited information to colleagues around the world. When the discipline was in its infancy, most equine surgeons learnt from visits to other hospitals, senior colleagues, and by trial and error. Traditionally, many aspects of surgical treatment and postoperative management have relied predominantly on the experience and 'school of thought' of a specific surgeon or hospital, with a limited evidence base (Mair, 2002; Mair *et al*, 2007). Clinical experience is highly valuable in surgery and should not be ignored. However, it should also be integrated with the results of peer-reviewed investigative research in the practice of evidence-based medicine (Sackett *et al*, 1996).

As colic surgery has gained popularity and funding opportunities for veterinary research have increased, a large number of research studies have been conducted aimed at improving clinical outcomes, with an increasing focus on the importance of evidence-based surgery (Mair, 2002; Mair *et al*, 2007; Freeman, 2018a). The quality of this research varies but the field of colic has benefitted from collaborations between multiple centres and research groups more than most areas of equine veterinary science (Pinchbeck and Proudman, 2008). Many studies have focused on survival and complication rates following colic surgery. While most are limited to specific complications, or a specific surgical lesion, some research groups have investigated these outcomes on a larger scale (Pascoe *et al*, 1983; Proudman *et al*, 2002a,b; French *et al*, 2002; Mair and Smith, 2005a,b,c; Proudman *et al*, 2006; Christopherson *et* al, 2014; Wormstrand *et al*, 2014). Surgeons can use these studies to set benchmark targets for outcomes and process guidelines within their own clinics. However, no attempts have been made to standardise these across the equine surgical community in the same way as occurs in human surgery, or as has been attempted for the recognition and diagnosis of colic (Freeman and Curtis, 2015). Critical appraisal of the available evidence in its entirety may explain why. Different research groups investigating colic surgery outcomes commonly use different inclusion criteria, different categorisation of lesions and different definitions of complications. The conundrum of postoperative reflux and ileus is one example where such differences have been well highlighted (Merritt and Blikslager, 2008; Salem *et al*, 2016; Freeman, 2018b; Lisowski *et al*, 2018). These differences make direct comparison between studies challenging (Pinchbeck and Proudman, 2008; Gandini *et al*, 2022). Furthermore, different studies have found contradictory results regarding the correlation between outcomes and the possible contributing factors (Mair *et al*, 2007).

Mortality and morbidity after colic surgery continues to be a popular field of research (Gustafsson *et al*, 2021; Bishop *et al*, 2022; Dybkjær *et al*, 2022; Straticò *et al*, 2022). However, collaborations on projects and definitions are still the exception rather than the norm. Improved quality of care in colic surgery could be achieved more effectively and more quickly by improved study design, uniform definitions and more collaboration between clinics (Mair and White, 2005; Pinchbeck and Proudman, 2008). The same aim could be aided by the adoption of clinical governance activities by the global colic community (Freeman, 2018a). The creation of a database that might facilitate increased international collaboration and the use of clinical audit in equine colic surgery was first outlined in 2005 (Mair and

White, 2005). In an editorial introducing a special, colic-focused issue of the Equine Veterinary Journal, Mair and White suggested that clinical audit could be used to elucidate factors associated with negative outcomes and identify areas where surgeons and clinics could improve their own success rates. To facilitate this, they proposed the establishment of an international colic surgery audit achieved by:

1. "Systematic collection of an agreed minimum dataset at each contributing centre on a defined patient population.
2. Aggregation and validation of data.
3. Analysis and development of risk stratification models for outcome measures.
4. Regular feedback to contributing centres."

Although the authors predicted significant difficulties in setting up and maintaining such a database (Mair and White, 2005), it is easy to appreciate how useful this information would be to vets and horse owners when making decisions about their patients and animals. Generating an up-to-date, international dataset of colic surgery processes and outcomes would provide benchmarks for ongoing clinical audit. Additionally, changing trends within the specialty could be monitored and targets for quality improvement could be identified (Mair and White, 2005). Another proposed benefit of such a database is the huge potential it offers for high quality, collaborative, clinical epidemiological studies, provided the data are analysed responsibly and correctly (Pinchbeck and Proudman, 2008).

Clinical audit should be a continuous process of appraisal and improvement (Viner, 2005). As such, one important aim of an international colic surgery audit should be the establishment of a process and database that allow repeated assessment at regular intervals and, importantly, a community of veterinary surgeons willing to contribute. The potential benefits of such a project are well-documented (Mair, 2009; Freeman, 2018a) and a survey of equine surgeons indicated a high level of interest and willingness to contribute data (Mair and White, 2008). However, the same survey also identified significant concerns and potential barriers.

OVERCOMING BARRIERS TO AN INTERNATIONAL COLIC SURGERY AUDIT

In addition to the general difficulties staff face when undertaking the clinical audit process in practice, barriers to an international colic surgery audit include concerns regarding the establishment and management of an international database. The latter was investigated by Mair and White (2008) in their survey, though it should be noted that the results only represent views of diplomates of the American College of Veterinary Surgeons (ACVS) and European College of Veterinary Surgeons (ECVS). Further bias may have been introduced by the methods of the study, which held face-to-face interviews with 30 surgeons with a known interest in colic surgery and used a questionnaire to collect views from the wider community of specialist equine surgeons, with a 43.9% (43/98) response rate (Mair and White, 2008). Nevertheless, the study provided valuable insight to the opinions of a large proportion of equine surgeons, in particular with regards to concerns that needed to be addressed by those wishing to design and implement an international colic surgery database.

The most common problems cited by equine surgeons with regards to contributing to a colic surgery database were the time involved and practical aspects of data collection (Mair and White, 2008). Other concerns related to management and confidentiality of the database, comparison of results from different geographical regions and horse populations, legal issues associated with the database and the reliability of data entered by different sources (Mair and White, 2008). To address these concerns the data collected should be as simple as feasibly possible when considering such a multifactorial set of processes and outcomes. Management of the database should robustly adhere to strict ethical principles and the laws pertaining to data handling. These data must then be appraised and anonymised prior to analysis and presentation, to inspire confidence in those willing to contribute. Feedback to individual clinics must be useful, prompt, and facilitate rigorous clinical audit. Outcomes should be presented by geographical region and surgical lesion to provide the most useful benchmarks for clinical audit and prevent unfair comparisons. Finally, interpretation of the total dataset should be done with caution, accounting for the complex multitude of factors affecting disease processes and outcomes (Mair, 2009).

Although they represented only 4.1% of the surgeons surveyed by Mair and White, there will be surgeons who do not believe an international colic audit will be useful and do not want to contribute data. This may be due to scepticism that the audit will be useful in its main objective, in which case setting up the database and evidencing its benefits may persuade surgeons otherwise. However, it may also be rooted in a negative feeling towards being monitored or suspicions regarding the motives of the clinical audit process. Clinical audit is viewed by some as a process that decreases clinical judgement and ownership of case decision-making, chiefly motivated by a desire to monitor and criticise healthcare professionals (Johnston *et al*, 2000). It can also be argued that over-strict guidelines have the potential to impede innovation if they do not leave space for the development of new therapies (Collier, 2000). Assuring clinicians of the confidentiality of audit data can go some way to address these concerns. Confidentiality was one of the common concerns amongst equine surgeons (Mair and White, 2008) and was also a significant concern amongst doctors when introducing clinical audit to the NHS, who worried that disclosing outcomes beyond their peers would result in hasty and inappropriate comparisons. Furthermore, they believed such data would make cases of clinical negligence unjustifiably difficult to defend (Conference of Medical Royal Colleges and their Faculties in the United Kingdom, 1991). Therefore, it appears that mechanisms to anonymise findings and ensure confidentiality of audit results are key to facilitate engagement with clinical audit.

It has been argued that for audit to be completely effective, differences in rates of mortality and morbidity between different clinics should be defined and that, when done carefully, peer reviewed assessment of this should not be considered a betrayal (McIlwraith, 2000). However, direct comparison between clinics or surgeons is ill-advised when it does not take into account the related differences in caseload and facilities. All comparisons should be made carefully and based on robust interpretation of real data. The main value of an international colic audit will be in allowing individual clinics and surgeons to compare their own results with national and international standards (Mair, 2009), thus facilitating the use of QI activities such as clinical audit. It should not be intended to create 'league tables' for comparison which can be severely misinterpreted and may dissuade many clinics from contributing data (Viner, 2009). Addressing the concerns of those who may want to contribute data is an important step in the design of such a project. This thesis sets out the process of establishing the International Colic Surgery Audit (INCISE), based on the database first envisaged by Mair and White nearly two decades ago (Mair and White, 2005). The potential applications of the project are vast but, as with the general process of clinical audit, it is advisable to start simple. The focus thus far has been the establishment of current standards in colic surgery around the world, with the aim of facilitating clinical audit and improving quality of care.

"The best time to plant a tree was twenty years ago. The second best time is now."

(Chinese Proverb)

CHAPTER TWO

ORGANISATIONAL REPORT OF THE INTERNATIONAL COLIC SURGERY AUDIT: INCISE-1

INTRODUCTION

Outcomes of surgical treatment, such as the morbidity and mortality rates of a procedure, may be associated with organisational factors, in addition to intrinsic patient factors (NELA, 2014). These organisational factors include the infrastructure of a hospital and the processes of care delivery (Donabedian, 1966). Clinical audits used to assess organisational factors would fall within Mosedale's 'process' and 'structure' audit definitions (Mosedale, 2020).

The National Emergency Laparotomy Audit (NELA) is one of several National Clinical Audits (NCAs) funded by NHS England and the Welsh government. The project is overseen by the Royal College of Anaesthetists and generates organisational and patient audits that drive quality improvement for people undergoing emergency laparotomy (Murray, 2014). NELA also facilitates high quality research by providing anonymised data to national, multicentre studies (Oliver *et al*, 2018). The first NELA report was an organisational audit of processes, facilities and staffing in place at hospitals that perform emergency laparotomy (NELA, 2014). These data were compared to evidence-based, multidisciplinary recommendations and recognised standards of infrastructure that are required for optimum care of laparotomy patients. This first report found that these standards were not being met at many hospitals and made key recommendations to improve quality of care (NELA, 2014).

Emergency laparotomy in horses is a commonly performed procedure, most frequently undertaken to treat patients presenting with signs of abdominal pain (colic). As discussed in Chapter One, colic surgery in horses is an expensive procedure with relatively high morbidity and mortality rates, and as such is well-suited to clinical audit (Mair and White, 2005; Mair, 2009). The potential benefits of collection of data from clinics undertaking emergency laparotomy in horses to establish current standards in clinical care have been well described (Mair, 2009; Freeman, 2018a). Currently, there are no evidence-based standards pertaining to the optimum infrastructure and processes that should be in place at equine clinics offering colic surgery. Organisational audit of this information would establish current standards and trends between clinics. These benchmarks would allow contributing centres to perform their own comparative clinical audits and would assist identification of key areas for improvement globally and at individual centres. Results could also be used to improve understanding of how provision of care relates to outcome when linked to patient level data, as has been demonstrated by the NELA project (Oliver *et al*, 2018).

The International Colic Surgery Audit (INCISE) was launched in January 2020, with the primary objective to improve the quality of care and outcomes for equine patients undergoing colic surgery (Cullen *et al*, 2020). The launch of INCISE coincided with the start of the Coronavirus (COVID-19) pandemic early in 2020. This global event had profound and wide-reaching effects on all aspects of daily life, including the management of horses (Williams *et al*, 2020; Furtado *et al*, 2021) and the equine veterinary industry (Mair and Lockett, 2021). The effect of the COVID-19 pandemic on provision of colic surgery is currently unknown.

AIMS

The aim of the first phase of INCISE (INCISE-1) was to conduct an organisational audit to gather information about the current provision of colic surgery around the World, and to describe the processes, facilities and staffing in place at clinics offering this service. Due to the timing of data collection, a secondary aim was to determine the effect of the COVID-19 pandemic on provision of colic surgery at participating clinics.

MATERIALS AND METHODS

Clinic Recruitment and Ethics

The INCISE website (www.internationalcolicaudit.com) was designed to provide information about the project and to act as a bespoke data collection platform that was secure and easy-to-use. Based on the potential barriers to this project that have previously been identified (Mair and White, 2008), the priority of the website design was to enable clinics to submit electronic data quickly and confidentially. As data were being collected from private organisations, ethical approval was obtained from the University of Liverpool Veterinary Research Ethics Committee (VREC 739). The Committee approved an information sheet about the INCISE project and a consent form that could be sent out to clinics.

The INCISE project and website were promoted widely within the equine veterinary profession. This included publication of an editorial that provided a background to the project in Equine Veterinary Education, a peer-reviewed journal that has wide readership within the equine veterinary profession, including members of BEVA and AAEP (Cullen *et al*, 2020). The project was also advertised during international conference presentations (ECVS, ACVS, Equine Colic Symposium) and on social media platforms. Concurrently, an extensive search was conducted to identify veterinary clinics worldwide that offered colic surgery, including private clinics and academic (University-based) institutions. This included contacting equine veterinary surgeons known to the INCISE team to perform colic surgery, or to have knowledge of equine clinics in specific countries or geographic regions. Lists of Diplomates of the American and European Colleges of Veterinary Surgeons (ACVS/ECVS) and Members of the Australian College of Veterinary Scientists (MACVSc) were also contacted. Furthermore, internet searches were performed using the terms ‘horse’, ‘equine’, ‘colic’, ‘surgery’, ‘laparotomy’ and specific countries to identify equine clinics that had not been identified already.

Clinics known or believed to offer colic surgery were contacted directly by email between January 2020 and March 2021 formally inviting them to participate in the INCISE project. Material sent to clinics included the INCISE project information leaflet, consent form and platform instructions. Clinics were required to indicate informed consent to the sharing and use of their data by returning completed forms prior to enrolment. Once they had been enrolled, clinics were issued a unique, 5-digit clinic identification number. Authorised clinic personnel were issued with a confidential username and password for a 'User' profile which permitted data entry only. A separate username and password were provided for a 'Superuser' profile which permitted data entry, editing of previously entered data, downloading of their own clinic data, and generation of automated key outcome summary reports. Individual clinics were responsible for storing their 'User' and 'Superuser' details securely and distributing these to appropriate staff members. Clinic identification numbers, usernames and password were only known to one member of the INCISE team (DCA).

Data Collection

Data were collected via the INCISE website. A questionnaire was designed to collect information for the organisational report (see *Appendix 1*) that users were asked to complete prior to entering patient-level colic case data on the INCISE platform. The questionnaire was tested by seven vets and two equine veterinary nurses across three clinics, to ensure the questions were answerable in a reasonable time frame and to gather opinions regarding additional information that the testers thought would be useful to collect. Based on feedback from testing, the wording and structure of some questions were refined to maximise usability. The test responses were also used to ensure the bespoke website was effective at capturing data and reliably exporting this to Microsoft Excel® (version 2302, Microsoft Inc).

The questionnaire originally comprised of 59 questions split into five sections: Hospital facilities and clinical staff; Admission and investigation; Perioperative period; Postoperative care; Clinical governance and audit. The term 'out-of-hours' (OOH) was used to refer to case admissions and treatment performed outside of normal working hours, but the exact definition was left to the discretion of individual clinics. A 'set protocol' was defined as a protocol that was written down or, if not written down, that was explicitly known to all clinic personnel. In April 2020, a sixth section consisting of 11 questions was added to gather information on the effects of the COVID-19 pandemic. Questions were a variety of multiple-choice options, grid style and open-ended questions. No questions were mandatory, as we wished to avoid users failing to complete the questionnaire if a particular question was not relevant to them and did not allow them to progress onto the next question.

The survey was launched in January 2020 and remained open until March 2021 when data were downloaded for final analyses. Due to the design of the survey platform, it was not possible for users to view previously submitted data. Therefore, where clinics completed the questionnaire twice, the most recent submission was used at the time of data analysis. Clinics that had submitted data prior to April 2020 were contacted by email to ask them to complete the additional COVID-19 section separately.

Data Analysis

Anonymised data were exported from the INCISE platform to Microsoft Excel® and IBM SPSS® Statistics for Windows (version 25.0, IBM Corp) for analysis. The unique, 5-digit clinic identification number was used as the key clinic identifier within the database. Data regarding the geographical region and type (private or academic) of each clinic was provided by one of the INCISE team (DCA). Descriptive statistics were used including frequencies and proportions for categorical data and medians with interquartile ranges (IQR) for continuous data. Data were analysed for all clinics and were also stratified by clinic type (private/academic) and by geographical region (continent).

RESULTS

INCISE-1 Contributing Clinics

A total of 226 equine clinics from 40 countries were identified to offer colic surgery as a clinical service and were contacted individually inviting them to participate in the INCISE project. These clinics were located in Europe (n=110; 48.7%), North America (n=59; 26.1%), Australasia (n=21; 9.3%), Asia (n=17; 7.5%), South America (n=11; 4.9%) and Africa (n=8; 3.5%).

Sixty clinics from 24 countries submitted data to the Organisational Report (INCISE-1) giving an overall response rate of 26.5%. Of these 60 clinics, 38 (63.3%) were private clinics and 22 (36.7%) were academic (university-based) clinics. Questionnaire response rates and the number and proportion of contributing clinics by geographical region are shown in *Table 2.1*. Due to the small number of contributing clinics from South America and Africa, information submitted by clinics in these continents is presented collectively under the heading 'Rest of the World' (ROW) in order to preserve anonymity of the data. Some questions were not completed by all contributing clinics.

Table 2.1: Questionnaire response rates and number of clinics contributing to INCISE-1, stratified by continent.

CONTINENT	RESPONSE RATE (%)	NUMBER OF CONTRIBUTING CLINICS	PROPORTION OF CONTRIBUTING CLINICS (%)
Europe	24.5	27	45.0
North America	23.7	14	23.3
Australasia	33.3	7	11.7
Asia	52.9	9	15.0
South America	18.1	2	3.3
Africa	12.5	1	1.7
TOTAL	**26.5**	**60**	**100**

Hospital Facilities and Clinical Staff

The majority of clinics (58/60; 96.7%) offered colic surgery at all times (24 hours a day, 365 days a year). Similarly, most clinics (54/60; 91.5%) offered this service to first opinion and referral clients, with 4 clinics (6.8%) offering colic surgery on a referral-only basis. One clinic (1.7%) offered colic surgery only to their own clinic clients and did not accept referrals from other veterinary practices.

Data regarding the total number of colic admissions in 2019, including cases managed medically, surgically or euthanased after assessment, were obtained from 51 clinics (85%). Of these, 24 clinics (47.1%) were able to provide exact data for all colic admissions and 27 clinics (52.9%) provided approximate numbers. There was wide variation in the number of colic admissions, ranging from 14 to 600 cases, with a median of 150 (IQR 66 – 245).

The same 51 clinics submitted data about the number of exploratory laparotomies performed in horses presenting with signs of colic in 2019, though a greater proportion of clinics were able to provide exact data for this question compared to data on the overall number of admissions. Exact data were provided by 33 clinics (64.7%) and approximate numbers were provided by 18 clinics (35.3%). The number of laparotomies performed at contributing clinics in 2019 ranged from 3 to 130, with a median of 44 (IQR 20.5 – 79). Data regarding the number of colic admissions and number of laparotomies performed per clinic is shown in *Table 2.2*.

Table 2.2: Data regarding total number of colic admissions and the number of exploratory laparotomies performed per clinic in 2019, stratified by clinic type and geographical region.

CLINIC INFORMATION	TOTAL NUMBER OF COLIC ADMISSIONS IN 2019			LAPAROTOMIES PERFORMED IN 2019		
	Median	**Range**	**IQR**	**Median**	**Range**	**IQR**
ALL CLINICS	150	14 – 600	66 – 245	44	3 – 130	20.5 – 79
Private	131.5	14 – 600	63.5 – 237.5	40	13 – 130	22.5 – 74
Academic	150	24 – 375	77 – 274	47.5	3 – 100	20 – 81.5
DATA SPLIT BY GEOGRAPHIC REGION						
Europe	144.5	30 – 600	68.5 – 218	42	14 – 100	25 – 62.5
North America	200	82 – 375	150 – 310	68	18 – 100	45 – 86
Australasia	65	20 – 300	41 – 104.8	20	13 – 22	15 – 20
Asia	100	14 – 450	42.5 – 200	15	3 – 130	14 – 75
ROW	60	60 – 60	60 – 60	55	30 – 80	42.5 – 67.5

Almost all contributing clinics submitted data about the number of clinicians who undertook colic surgery as the primary surgeon (n=59; 98.3%). The term 'primary surgeon' was specified as, in some clinics, surgery may be undertaken by a surgeon in combination with a surgical resident or other trainee, who may not yet be able to perform colic surgery independently. There were a total of 209 primary surgeons based in the 59 contributing clinics, with 126 (60.3%) working in private practice and 83 (39.7%) in university-based, academic clinics. The number of primary surgeons in each clinic ranged from 1 to 12, with a median of 3 (IQR 2 – 4).

Data regarding the total number of surgeons, the number of surgeons on the OOH rota and the number of anaesthetists on the OOH rota is shown in *Table 2.3*. The number of surgeons sharing the OOH rota at clinics (n=58; 96.7%) ranged from 1 to 12, with a median of 3 (IQR 2 – 4). The surgeon OOH rota was 1-in-1 at 4 clinics (6.9%), 1-in-2 at 14 clinics (24.1%) and 1-in-3 or less at 40 clinics (70%). In 47 clinics (81%) all surgeons contributed to OOH provision, while in 8 clinics (13.8%) one or more surgeons were not on the OOH rota. At 3 clinics (5.2%) OOH duties were shared with a neighbouring clinic. The number of anaesthetists sharing the OOH rota at clinics (n-51; 85%) ranged from 2 to 15, with a median of 4 (IQR 2.5 – 5). No clinics had a 1-in-1 OOH rota for anaesthetists. A 1-in-2 anaesthesia rota was in place at 13 clinics (25.5%) and the rota was 1-in-3 or less at 38 clinics (74.5%).

Table 2.3: Data regarding the number of primary colic surgeons and anaesthetists per clinic, stratified by clinic type and geographical region.

CLINIC INFORMATION	NUMBER OF PRIMARY COLIC SURGEONS		NUMBER OF SURGEONS SHARING OOH		NUMBER OF ANAESTHETISTS SHARING OOH	
	Median	IQR	Median	IQR	Median	IQR
ALL CLINICS	3	2 – 4	3	2 – 4	4	2.5 – 5
Private	3	2 – 4	3	2 – 4	4	3 – 5
Academic	3.5	2.3 – 4	3.5	2.3 – 4	4	2 – 5.3
DATA SPLIT BY GEOGRAPHIC REGION						
Europe	3.5	2 – 4	3	2 – 4	4	3.3 – 5
North America	4	3 – 5.5	3.5	3 – 4	4	3.5 – 5.5
Australasia	3	2.5 – 3	3	2.5 – 3	2	2 – 2.8
Asia	3	2 – 3	3	2 – 4	3	2 – 5
ROW	1	1 – 1.5	1	1 – 1.5	3	2.5 – 3.5

Post graduate training and qualifications data were submitted by 58 clinics (96.7%) for 199 surgeons. Experience as a primary surgeon for treatment of colic ranged from 1 to 40 years (median 11 years, IQR 5 – 19 years). Of clinics who answered this question, in 27 (46.6%) all primary surgeons were boarded specialists in surgery (ACVS/ECVS diplomates) or had undertaken residency training in equine surgery. There was at least one surgeon with a specialist qualification in surgery in 46 clinics (79.3%). Data regarding the post graduate training of colic surgeons by region is shown in *Table 2.4*. Surgery specialist training was defined as a residency programme approved by the ACVS or ECVS. Other specialty training was defined as another equine or large animal residency programme approved by an American or European College. A specialist was defined as a boarded diplomate of the ACVS, ECVS or another American or European College. An advanced practitioner surgical qualification was defined as Royal College of Veterinary Surgeons (RVCS) advanced practitioner status or equivalent.

Table 2.4: Data about surgical experience and post graduate training/qualifications of primary surgeons.

CLINIC INFORMATION	SURGICAL EXPERIENCE (YEARS) Median (IQR)	OVERALL PROPORTION OF SURGEONS WITH:				
		Surgery specialist training	Other specialty training	Advanced practitioner surgical qualification	Specialist equine surgery qualification	Other equine specialist qualification
ALL CLINICS	11 (5 – 19)	73.9%	0.5%	13.1%	64.8%	1.5%
Private	13 (6 – 20)	64.7%	0.9%	18.1%	58.6%	0.9%
Academic	10 (5 – 15)	86.7%	0%	6.0%	73.5%	2.4%
DATA SPLIT BY GEOGRAPHIC REGION						
Europe	13 (6 – 20)	62.9%	0%	23.6%	59.6%	1.1%
North America	8 (4 – 15)	93.4%	1.6%	1.6%	83.6%	3.3%
Australasia	15 (10 – 25)	94.4%	0%	0%	77.8%	0%
Asia	10 (6.5 – 15)	51.9%	0%	11.1%	37.0%	0%
ROW	5 (4.25 – 6.25)	75.0%	0%	25.0%	25.0%	0%

All clinics (n=60) provided data regarding emergency daytime and OOH staffing. The number and proportion of clinics with dedicated emergency staff and OOH staff by region are shown in *Table 2.5*. The types of staff with dedicated OOH shifts are shown in *Table 2.6*. Dedicated emergency staff during normal working hours were defined as those kept free of elective appointments to be free for emergency admissions. Dedicated OOH staff were defined as those who worked shift-based night cover instead of doing 'on-call' after a normal working day. A minority of clinics (13.3%) assigned staff to be dedicated to management of emergency cases only during normal working hours. However, most clinics (66.7%) employed dedicated OOH staff and these were most frequently nurses/technicians (48.3%) or interns (41.7%). Just over a quarter (26.7%) of clinics had a dedicated OOH surgeon.

Table 2.5: Number and proportion of clinics with dedicated emergency staff during normal working hours and dedicated OOH staff.

CLINIC INFORMATION	DEDICATED EMERGENCY STAFF IN NORMAL WORKING HOURS (Number of clinics; %)	DEDICATED OOH STAFF (Number of clinics; %)
ALL CLINICS	8 (13.3%)	40 (66.7%)
Private	3 (7.9%)	19 (50.0%)
Academic	5 (22.7%)	21 (95.5%)
DATA SPLIT BY GEOGRAPHIC REGION		
Europe	0 (0%)	16 (59.3%)
North America	5 (35.7%)	13 (92.9%)
Australasia	0 (0%)	4 (57.1%)
Asia	2 (22.2%)	4 (44.4%)
ROW	1 (33.3%)	3 (100%)

Table 2.6: Proportion of clinics with different types of dedicated OOH staff, working overnight shifts instead of 'on-call' after a normal working day.

CLINIC INFORMATION	PERCENTAGE OF CLINICS WITH DEDICATED OOH:					
	Nurses/ technicians	Interns	Surgeons	Anaesthetists	Students	Other
ALL CLINICS	48.3%	41.7%	26.7%	20.0%	35.0%	8.3%
Private	39.5%	34.2%	18.4%	13.2%	13.2%	7.9%
Academic	63.6%	54.5%	40.9%	31.8%	72.7%	9.1%
DATA SPLIT BY GEOGRAPHIC REGION						
Europe	44.4%	48.1%	18.5%	14.8%	37.0%	14.8%
North America	78.6%	57.1%	57.1%	28.6%	35.7%	7.1%
Australasia	42.9%	14.3%	14.3%	14.3%	28.6%	0%
Asia	33.3%	11.1%	11.1%	22.2%	11.1%	0%
ROW	0%	66.7%	33.3%	33.3%	100%	0%

All clinics (n=60) submitted data regarding overall staff composition. This varied greatly, as shown in *Table 2.7*, which shows the data stratified by staff type and the number in each clinic. Specialists were defined as boarded diplomates. *Table 2.8* shows the total number and average per clinic for each type of staff by region.

Table 2.7: Clinical staff composition of clinics offering colic surgery that contributed data to INCISE-1.

STAFF TYPE	NUMBER OF CLINICS WITH:					
	0	1	2	3	4	5 or more
	STAFF MEMBERS OF THIS TYPE (Total = 60 clinics)					
Specialists in large animal/ equine internal medicine	24	12	9	6	5	4
Specialists in emergency and critical care	53	4	2	1	0	0
Specialists in anaesthesia and analgesia	38	7	2	5	1	7
Specialists in imaging	44	3	6	1	3	3
Certificate-holders in any of the above disciplines (with no diploma)	41	9	3	5	0	2
Qualified veterinary nurses/technicians	18	4	6	9	8	15
Student veterinary nurses/technicians	29	2	10	6	2	11
Intern veterinarians	17	6	13	4	9	11
Veterinarians enrolled in specialist residency programmes	32	8	6	2	2	10
Ambulatory veterinarians	15	5	5	4	6	25
Other veterinarians who do not fit any of the other categories	30	7	7	2	4	10

Table 2.8: Total number and average number per clinic of each staff category for clinics contributing data to INCISE-1, stratified by clinic type and by region.

STAFF TYPE	TOTAL NUMBER OF STAFF TYPE (AVERAGE PER CLINIC)							
	ALL CLINICS	Private	Academic	Europe	North America	Australasia	Asia	ROW
Specialists in Large animal/ equine internal medicine	92 (1.5)	28 (0.7)	64 (2.9)	36 (1.3)	41 (2.9)	12 (1.7)	1 (0.1)	2 (0.7)
Specialists in Emergency and critical care	11 (0.2)	2 (<0.1)	9 (0.4)	2 (<0.1)	7 (0.5)	2 (0.3)	0 (0.0)	0 (0.0)
Specialists in Anaesthesia and analgesia	69 (1.2)	7 (0.2)	62 (2.8)	23 (0.9)	37 (2.6)	6 (0.9)	2 (0.2)	1 (0.3)
Specialists in Diagnostic imaging	49 (0.8)	4 (0.1)	45 (2.0)	11 (0.4)	34 (2.4)	4 (0.6)	0 (0.0)	0 (0.0)
Certificate-holders in any of the above disciplines (with no diploma)	46 (0.8)	38 (1.0)	8 (0.4)	26 (1.0)	14 (1.0)	2 (0.3)	4 (0.4)	0 (0.0)
Qualified veterinary nurses/ technicians	230 (3.8)	97 (2.6)	133 (6.0)	97 (3.6)	91 (6.5)	31 (4.4)	8 (0.9)	3 (1)
Student veterinary nurses/ technicians	152 (2.5)	100 (2.6)	52 (2.4)	87 (3.2)	32 (2.3)	5 (0.7)	15 (1.7)	13 (4.3)
Intern veterinarians	146 (2.4)	79 (2.1)	67 (3.0)	74 (2.7)	50 (3.6)	9 (1.3)	3 (0.3)	10 (3.3)
Veterinarians enrolled in specialist residency programmes	108 (1.8)	23 (0.6)	85 (3.9)	37 (1.4)	62 (4.4)	3 (0.4)	2 (0.2)	4 (1.3)
Ambulatory veterinarians	305 (5.1)	257 (6.8)	48 (2.2)	150 (5.6)	50 (3.6)	28 (4.0)	68 (7.6)	9 (3.0)
Other veterinarians who do not fit any of the other categories	124 (2.1)	77 (2.0)	47 (2.1)	52 (1.9)	28 (2.0)	8 (1.1)	25 (2.8)	11 (3.7)

Data regarding the number of operating theatres were submitted by 58 clinics (96.7%) and ranged from 1 to 4 per clinic (median 2; IQR 1 – 2). The number of theatres used for colic surgery per clinic ranged from 1 to 2 (median 1; IQR 1 – 1). Of clinics with more than one theatre (n=31; 53.4%), only two (6.5%) had more than one theatre that was routinely used for colic surgery. Data regarding the number of stables suitable for housing colic patients on intravenous fluid therapy were submitted by 57 clinics and ranged from 2 to 52, with a median of 8 (IQR 6 – 10). A dedicated intensive care unit (ICU) was present in 70% (n=42) of the clinics who answered this question (n=60; 100%).

Data regarding camera monitoring of stables and isolation facilities were provided by 58 clinics (96.7%). The majority of clinics (70.7%) had camera monitoring in at least some or all of the stables used for colic patients (39.7% in at least some; 31% in all). Most clinics had at least one (16 clinics; 27.6%) or multiple (32 clinics; 55.2%) stables designed for isolation of horses from other inpatients to prevent spread of potentially infectious pathogens. Eight clinics (13.8%) adapted normal stables for isolation use and two clinics (3.4%) had no isolation stables.

Admission and Investigation

The staff members with primary responsibility for the admission and initial investigation of colic cases was highly variable between clinics. The staff member with primary responsibility for deciding if a horse needs surgery was also variable but was the primary surgeon in most or all cases at the majority of clinics who answered this question (34/58; 58.6%). The minimum number of staff required to be present for each colic admission was one person in 15.5% of clinics (9/58), two people in 46.5% (27/58) and three or more in 37.9% (22/58).

The diagnostic tests most commonly used in all initial colic investigations (assuming that immediate surgery due to uncontrollable pain was not indicated) were packed cell volume (PCV) and total protein (TP) (81.0%; 47/58 clinics), rectal examination (77.6%; 45/58), abdominal ultrasound and blood lactate (both 70.7%; 41/58). *Figure 2.1* shows the frequency of use of various diagnostic tests in initial colic investigations at contributing clinics.

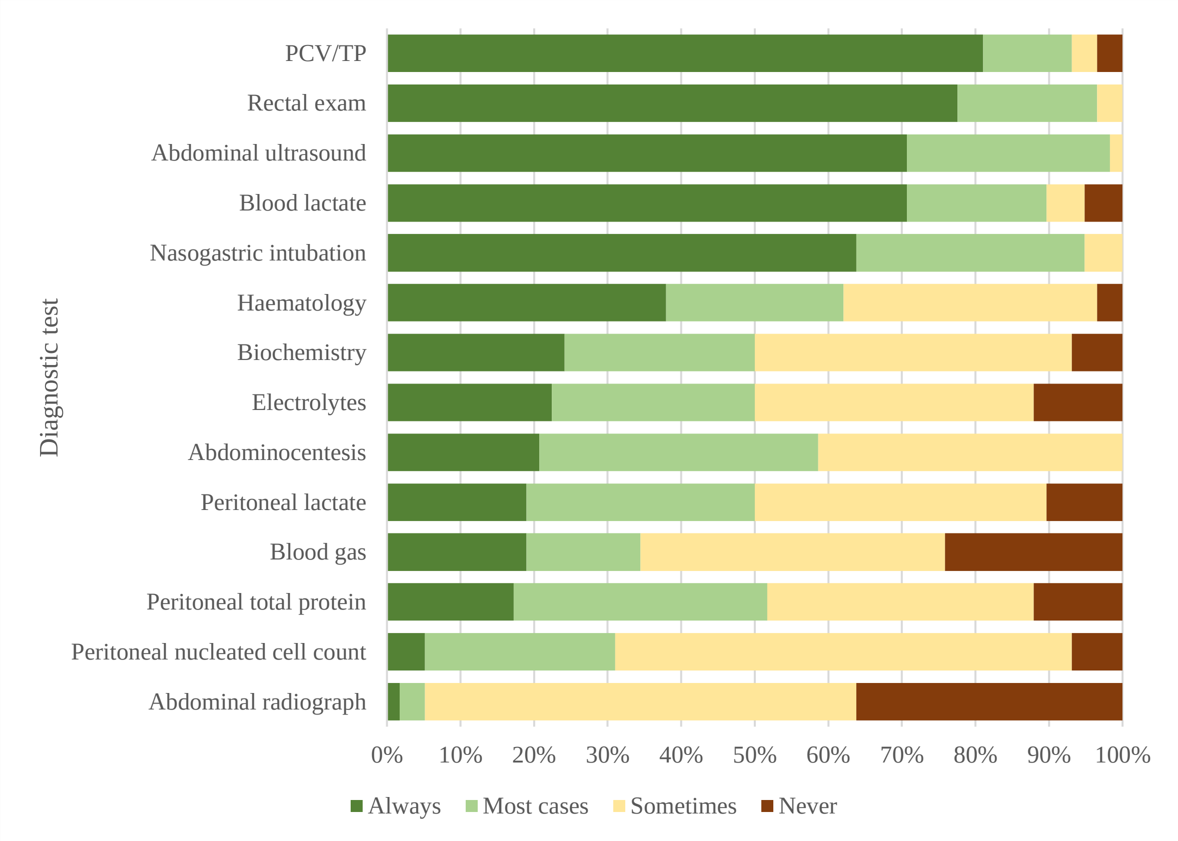


Figure 2.1: Frequency of use of diagnostic tests in initial colic investigations at contributing clinic, assuming immediate surgery due to uncontrollable pain was not indicated.

A third of clinics (33.3%; 20/60) had a set protocol regarding the order in which diagnostics were performed during colic investigations. Just over half of clinics (53.3%; 32/60) used a specific document to record the history and clinical findings of colic cases. *Figure 2.2* shows the proportions of clinics that had defined protocols for diagnostic procedures used in colic cases.

Use of a set protocol for abdominal ultrasonography of colics was common, with 82.8% of clinics (48/58) using a specific scanning protocol. Of these, 75.0% (36/48) used a FLASH (Busoni *et al*, 2011) or modified FLASH protocol for transcutaneous abdominal ultrasonography using defined abdominal locations. The remaining 25% (12/48) used a different protocol or performed a full abdominal scan in every case. Where abdominocentesis was performed, protocol use regarding location and method was variable. Specific protocols for location of abdominocentesis were not defined in 44.8% of clinics (26/58), 29.3% (17/58) always performed this procedure to the right of midline, 17.2% (10/58) always used ultrasound-guidance, and 5.2% (3/58) always performed it on the ventral midline. Regarding method of abdominocentesis, 56.9% of clinics (33/58) had no protocol, 24.1% (14/58) always use a hypodermic needle, 15.5% (9/58) always use a teat cannula, 1.7% (1/58) use a spinal needle, and 1.7% (1/58) use another, unspecified method.

Protocols regarding rectal examination were less common, with 69.0% of clinics (40/58) having no limit on the number of people who can perform a rectal exam on each new case. One clinic (1.7%; 1/58) limited this to one member of staff, 14 clinics (24.1%) limited it to two, and three clinics (5.2%) limited it to three. There was no set protocol on medication administration prior to rectal examination at 70.7% of clinics (41/58). A protocol was in use at 17 clinics (29.3%), with all cases receiving butylscopolamine (6.9%; 4/58), sedation alone (6.9%; 4/58), butylscopolamine and sedation (10.3%; 6/58), or an alternative protocol with no further detail provided (5.2%; 3/58). One clinic reported that some senior clinicians discourage the use of butylscopolamine and sedation simultaneously due to concerns regarding the combined cardiovascular effects of these drugs.

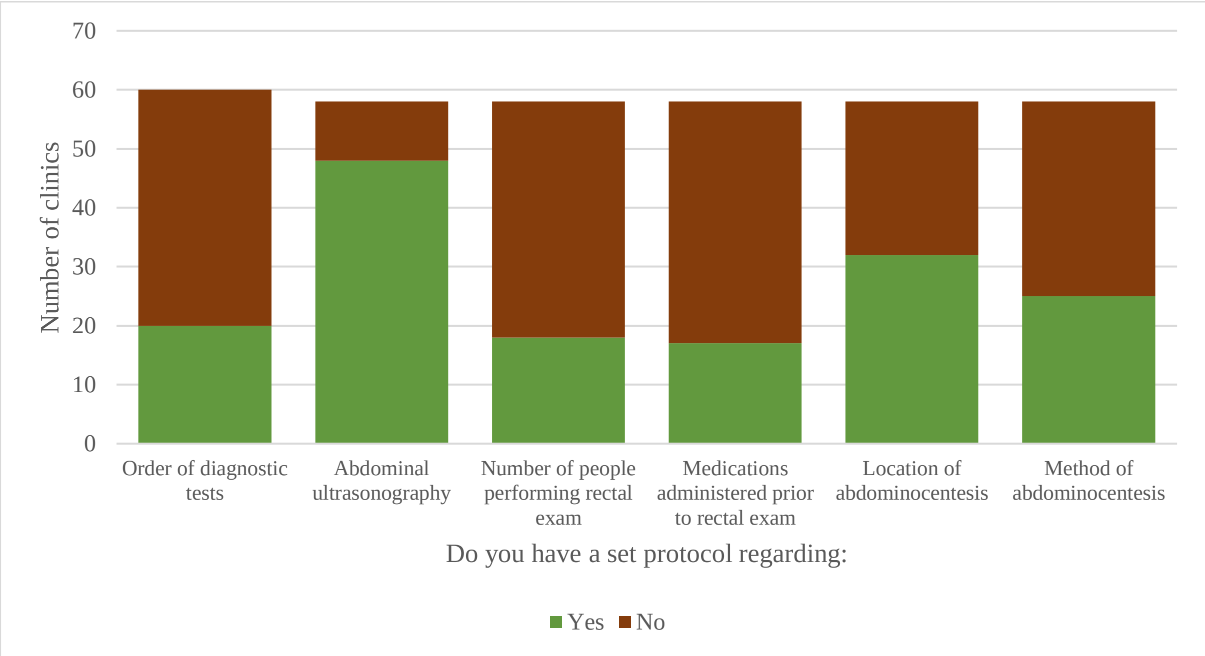


Figure 2.2: Number and proportions of contributing clinics that had set protocols regarding diagnostic procedures used during the initial investigation of colic cases.

Data regarding financial estimates for three hypothetical cases requiring colic surgery were provided by 95% of clinics (57/60). Clinics provided estimates in their own currency. Average conversion rates from 2020 were used to convert estimates to the British Pound (GBP) for the purposes of analysis, which was done by one member of the INCISE team (DCA) to maintain clinic anonymity. The median and IQR of estimates for each scenario by region and type of clinic are shown in *Table 2.9*. Case 1 was a systemically well horse with left dorsal displacement of the large colon which was nonresponsive to medical therapy and uncontrollable with analgesia (PCV <40%, blood lactate <2mmol/L). Estimates for Case 1 ranged from £1,364 to £10,499, with a median of £4,225. Case 2 was a systemically well horse with a strangulating small intestinal lesion which did not require resection (PCV <40%, blood lactate <2mmol/L). Estimates for Case 2 ranged from £2,144 to £10,499, with a median of £5,249. Case 3 was a sick horse with a strangulating small intestinal lesion requiring a resection and jejunocaecal anastomosis (PCV >45%, blood lactate >4mmol/L). Estimates for Case 3 ranged from £2,144 to £15,499, with a median of £6,249. Costs were similar between clinic type and geographical regions, but were generally lower in clinics that submitted data based in Asia and ROW.

Table 2.9: Estimates provided by contributing clinics for three hypothetical cases requiring colic surgery. Estimates covered the costs of surgery and typical aftercare in local currency, and have been converted to GBP (£) using the average 2020 exchange rate.

CLINIC INFORMATION	CASE 1 (Left dorsal displacement of the large colon)		CASE 2 (Strangulating small intestinal lesion requiring no resection)		CASE 3 (Strangulating small intestinal lesion requiring resection and jejunocaecal anastomosis)	
	Median	**IQR (£)**	**Median**	**IQR (£)**	**Median**	**IQR (£)**
ALL CLINICS	£4,225	3,377 – 5,263	£5,249	3,787 – 6,749	£6,249	4,868 – 8,218
Private	£4,225	3,377 – 5,999	£5,249	3,860 – 6,981	£5,749	5,249 – 8,499
Academic	£4,237	3,300 – 5,152	£5,178	3,690 – 6,219	£6,372	4,765 – 7,999
DATA SPLIT BY GEOGRAPHIC REGION						
Europe	£4,237	3,749 – 5,023	£5,249	4,249 – 5,749	£5,999	5,607 – 7,192
North America	£5,263	4,178 – 6,433	£7,212	5,263 – 7,602	£8,967	7,118 – 9,747
Australasia	£3,421	3,292 – 4,652	£3,926	3,420 – 4,652	£5,825	5,343 – 7,116
Asia	£2,923	1,656 – 4,333	£2,923	2,510 – 4,723	£3,794	2,891 – 6,043
ROW	£3,141	2,837 – 3,445	£3,641	3,087 – 4,195	£4,141	3,337 – 4,945

Perioperative Period

The minimum number of staff required to be present in theatre for colic surgery was two in 6.9% of clinics (4/58) and three or more in 93.1% (54/58). The minimum number of veterinarians, nurse/technicians and students present in theatre for colic surgery is shown in *Table 2.10*.

Table 2.10: Minimum number of staff present in theatre for colic surgeries stratified by staff type.

STAFF TYPE	PROPORTION OF CLINICS WITH:			
	Minimum not specified	**Minimum 1**	**Minimum 2**	**Minimum 3 or more**
Veterinarians and nurses/technicians combined	0.0% -	0.0% -	6.9% (4/58)	93.1% (54/58)
Veterinarians	0.0% -	12.1% (7/58)	67.2% (39/58)	20.7% (12/58)
Nurses/technicians	25.9% (15/58)	62.1% (36/58)	10.3% (6/58)	1.7% (1/58)
Students	84.5% (49/58)	6.9% (4/58)	1.7% (1/58)	6.9% (4/58)

Data regarding the number of clinic personnel scrubbing into colic surgery in addition to the primary surgeon was provided by 96.7% of clinics (58/60). There was always at least one or more surgical assistants at 86.2% of clinics (50/58) during normal working hours and at 74.1% (43/58) OOH. *Figure 2.3* shows the number of assistant surgeons during working hours and OOH across all clinics.

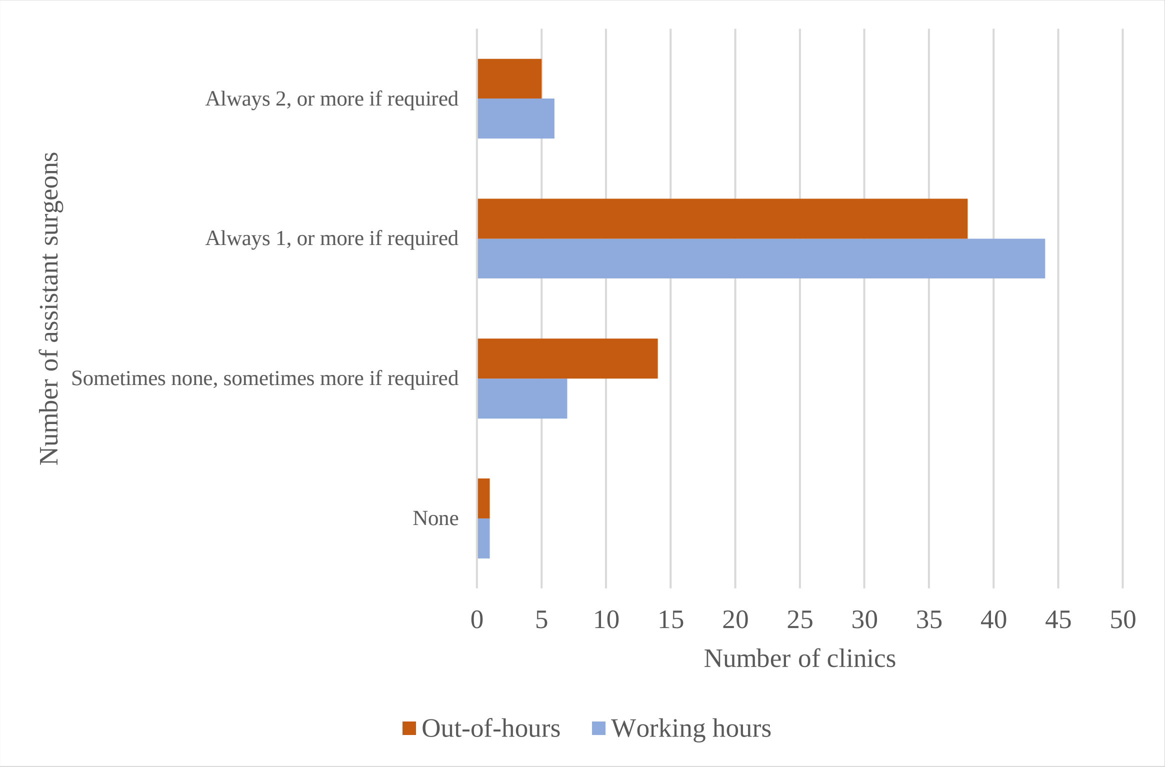


Figure 2.3: The minimum number of members of staff who scrub into colic surgery, in addition to the primary surgeon, during normal working hours and OOH.

The staff members responsible for general anaesthesia in colic patients was highly variable between clinics, during both normal working hours and OOH. Staff with primary responsibility for anaesthesia of horses included nurses/technicians, intern veterinarians, experienced equine veterinarians (with more than two years of equine veterinary experience), and boarded diplomates of the European and American colleges of veterinary anaesthesia and analgesia. Anaesthesia was always directly supervised by a boarded specialist in 6.9% of clinics (4/58), and always by a specialist or experienced equine veterinary surgeon in 44.8% (26/58). Intern veterinary surgeons were responsible for all anaesthesia of colic patients in 18.9% of clinics (11/58). Nurses or technicians were solely responsible for anaesthesia of at least some colic cases in 17.2% of clinics (10/58) and were responsible for all colic anaesthesia in 5.2% (3/58).

Figure 2.4 shows the availability and use of specific anaesthetic equipment across all clinics who submitted data in this section (96.7%; 58/60). The most commonly available items of anaesthetic monitoring equipment were invasive blood pressure monitoring (available at 100% of clinics; 58/58) and electrocardiography (available at 98.3% of clinics; 57/58), which were both regularly used at 93.1% of clinics (54/58). The options least likely to be available were end tidal anaesthetic gas monitoring (available at 72.4% of clinics; 42/58) and end tidal carbon dioxide monitoring (available at 82.8% of clinics; 48/58).

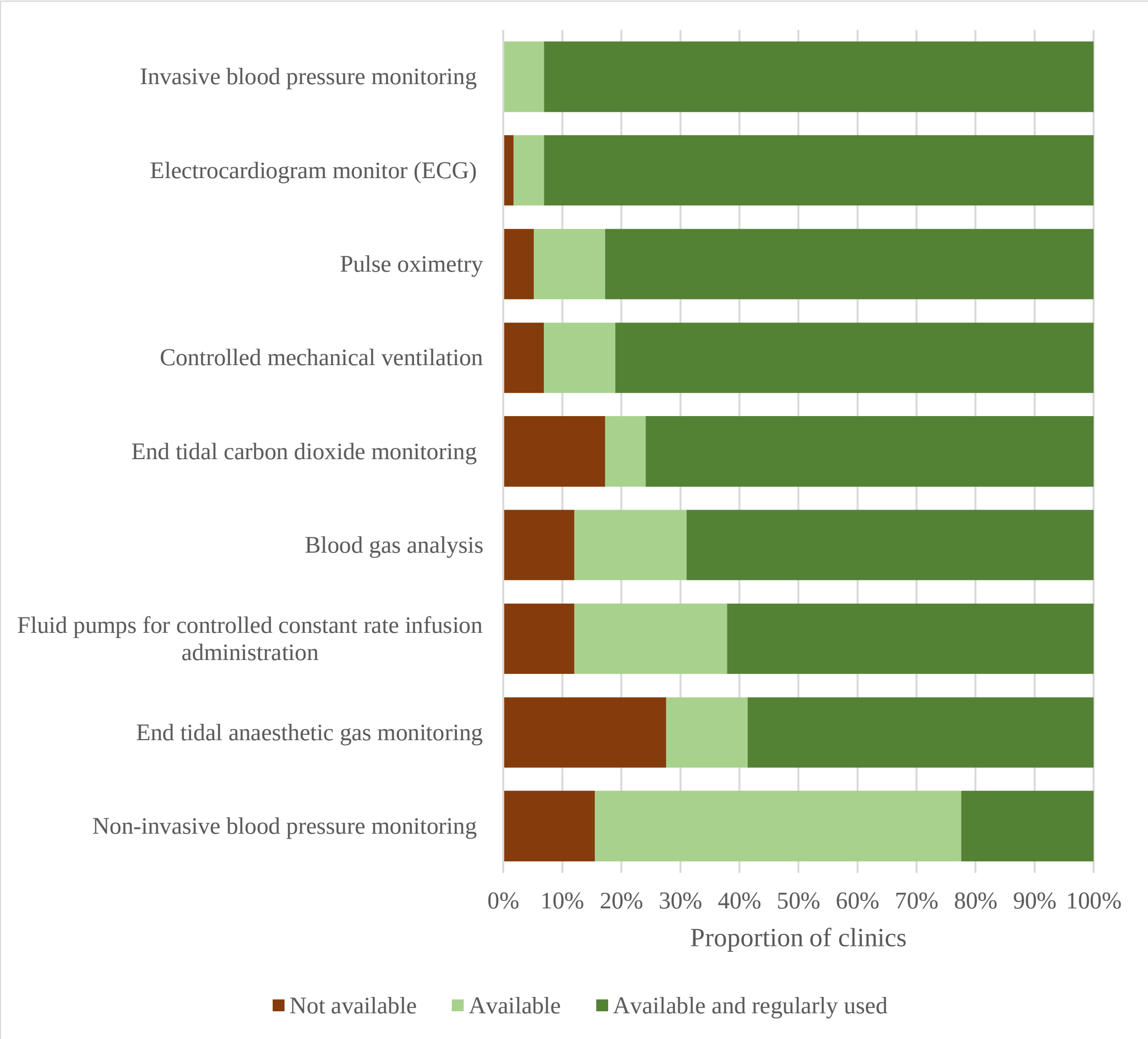


Figure 2.4: Data regarding the availability and use of anaesthetic equipment at contributing clinics.

Figure 2.5 illustrates the use of set anaesthesia protocols across all clinics who submitted these data (96.7%; 58/60). Set protocols were most commonly used for induction of anaesthesia (used in all or most cases at 82.8% of clinics; 48/58) and choice of anaesthetic drugs for colic surgery (used in all or most cases at 77.6%; 45/58). Protocols were least likely to be used for intraoperative prokinetic therapy (used in all or most cases at 36.2% of clinics; 21/58). A set protocol for rope-assisted anaesthetic recovery was used in all or most cases at 65.5% of clinics (38/58).

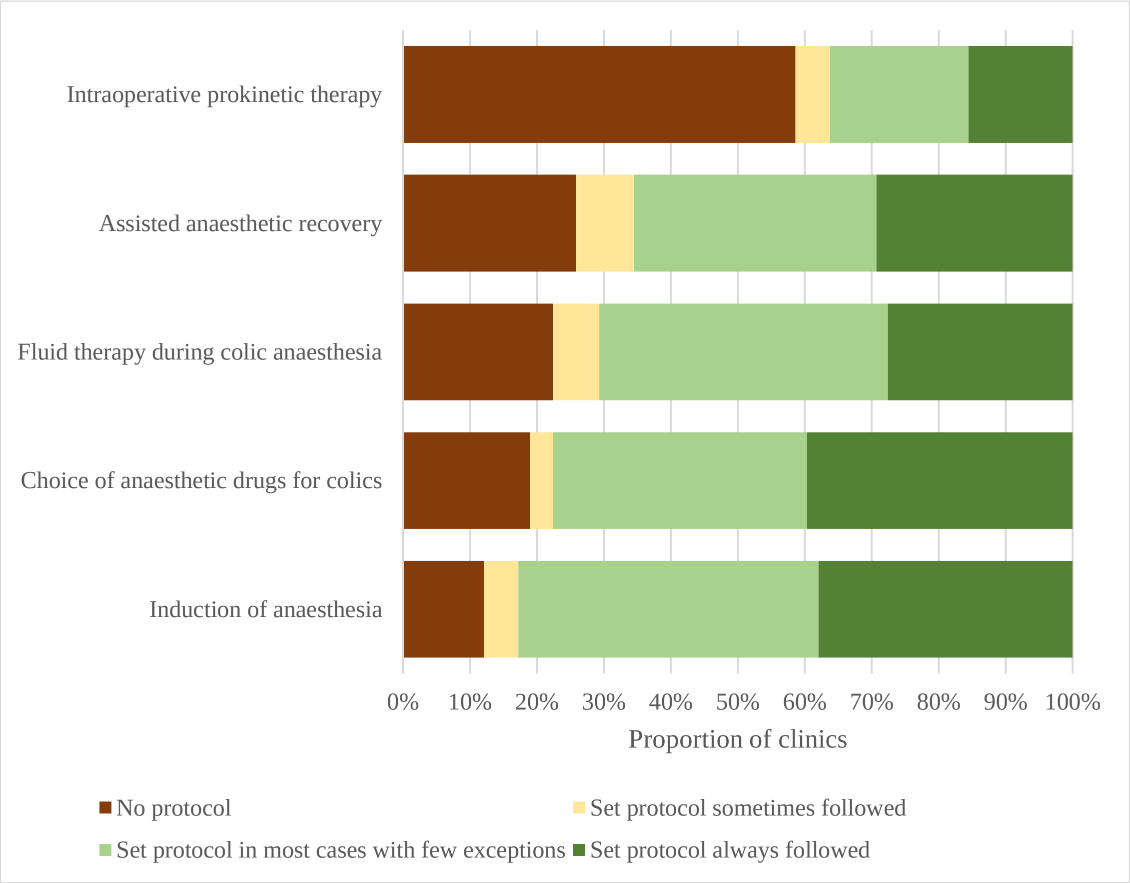


Figure 2.5: Data regarding the use of anaesthetic protocols at contributing clinics.

Figure 2.6 shows the availability of different items of surgical equipment across all clinics who submitted these data (96.7%; 58/60). The most commonly available surgical equipment was active gas suction, which was available at 96.6% of clinics (56/58) and used regularly at 79.3% (46/58). The piece of equipment least likely to be available was a visceral retainer (available at 55.2% of clinics; 32/58). Items of surgical equipment least likely to be used on a regular basis were ILA-100 and TA-90 stapler devices, with only 10.3% of clinics (6/58) reporting regular use of these.

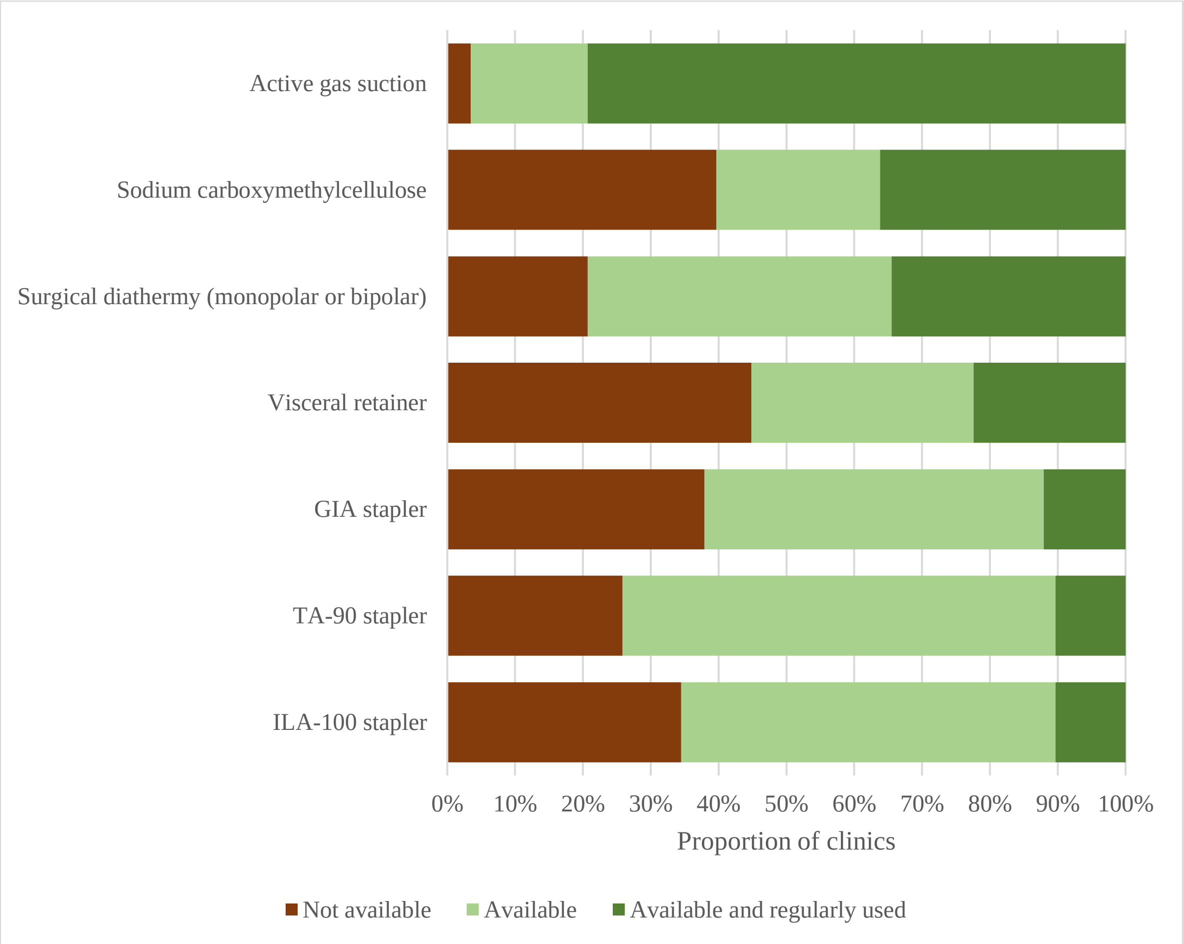


Figure 2.6: Data regarding the availability and use of surgical equipment at contributing clinics.

Figure 2.7 shows the use of set surgical protocols across all clinics who submitted these data (96.7%; 58/60). A set protocol was most likely to be used for preoperative antimicrobial treatment (used in all or most cases at 94.8% of cases; 55/58). Methods of abdominal closure and incisional protection were highly variable. Protocols were least likely to be used for pre-surgical checklists (used in all or most cases at 44.8% of clinics; 26/58) and when performing intestinal resection and anastomosis (used in all or most cases at 50.0% of cases; 29/58).

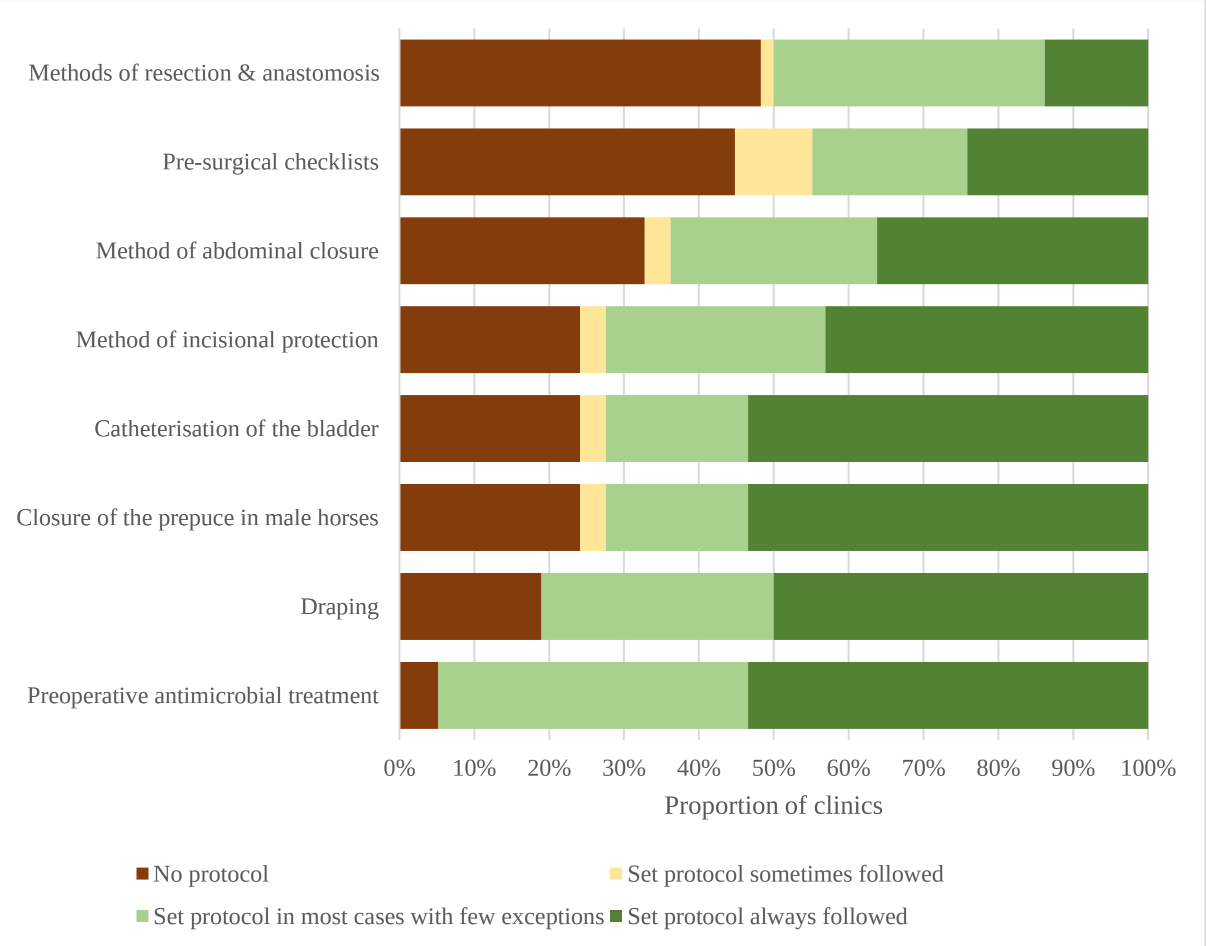


Figure 2.7: Data regarding the use of surgical protocols at contributing clinics.

Data regarding delays to colic surgery were provided by 96.7% of clinics (58/60), of which 67.2% (39/58) reported occasions when they had previously had to significantly delay colic surgery (by more than 30 minutes). Such delays were most commonly cited as being due to a lack of available staff (50.0%; 29/58) or lack of an available operating theatre (43.1%; 25/58). Only 3.4% of clinics (2/58) reported ever having to delay colic surgery due to lack of available equipment.

Postoperative Care

Most clinics required some staff to be present at the clinic at all times OOH (84.5%; 49/58). These were most commonly intern veterinary surgeons or nurses/technicians (both 51.7%; 30/58). These staff were less likely to be primary surgeons (10.3%; 6/58) or veterinary surgeons other than interns (15.5%; 9/58). Only one type of staff member was required to be present at 48.2% of clinics (28/58). At the 36.2% of clinics (21/58) where two staff members were required to be present at the clinic OOH, this combination was most likely to be an intern and nurse/technician (25.9%; 15/58).

Overall, decision-making regarding postoperative care was always overseen by a senior surgeon or boarded specialist in internal medicine or emergency and critical care (ECC) at 72.4% of clinics (42/58). The staff member responsible for postoperative decision-making was always the surgeon who performed surgery on that case in 16 clinics (27.6%) and was always that surgeon or another senior surgeon in 7 clinics (12.1%). Decision-making was exclusively overseen by a specialist in internal medicine at 3 clinics (5.2%), and was overseen by a medicine specialist, ECC specialist or senior surgeon in 16 clinics (27.6%). At the other 16 clinics, responsibility for postoperative decision-making was highly variable. Staff members less likely to be responsible for decision making were residents (15.5%; 9/58), other hospital or ambulatory veterinarians (12.1%; 7/58) and interns (5.2%; 3/58).

Handover of postoperative patient care was achieved by formal rounds at a scheduled time each day in 58.6% of clinics (34/58). This was performed by informal discussion between clinicians at 36.2% of clinics (21/58), while 5.2% (3/58) used another method but did not give further details.

Data regarding the staff members responsible for physical ('hands-on') postoperative care of colic patients, such as performing patient checks and administering medications, were submitted by 96.7% of clinics (58/60). This was most likely to be performed by interns, as shown in *Table 2.11*.

Table 2.11: Staff members responsible for physical postoperative care of colic patients.

STAFF TYPE	PROPORTION OF CLINICS	
	Working hours	OOH
Intern veterinarians	67.2%	67.2%
Nurses/Technicians	58.6%	55.2%
Senior clinicians	32.8%	31.0%
Other veterinarians	29.3%	34.5%
Students	39.7%	36.2%

In the first 24 hours after colic surgery, clinical examinations were performed every 3 to 4 hours at the majority of clinics (58.9%; 33/56), as shown in *Figure 2.8*. Nasogastric intubation was performed routinely in the first 12 hours after colic surgery at a minority of clinics (5.3%; 3/57), as shown in *Figure 2.9*. The majority of clinics only performed intubation if indicated based on clinical signs (n=24) or based this decision on operative findings and the surgical procedures performed (n=28).

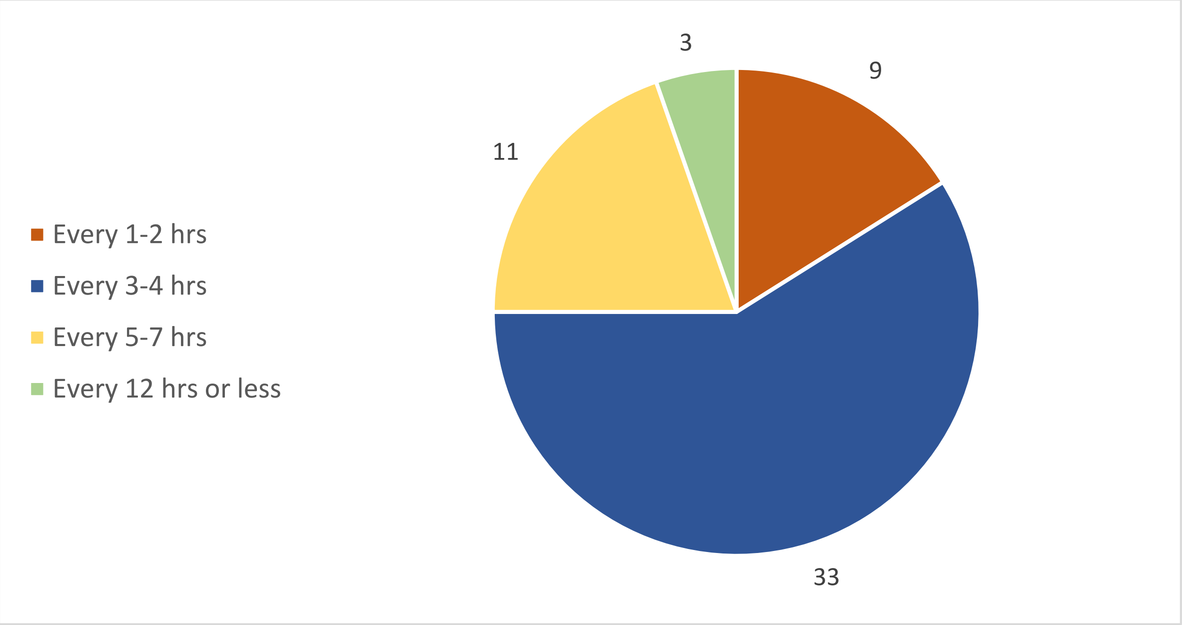


Figure 2.8: The frequency of clinical examinations during the first 24 hours after colic surgery at contributing clinics (n=56).

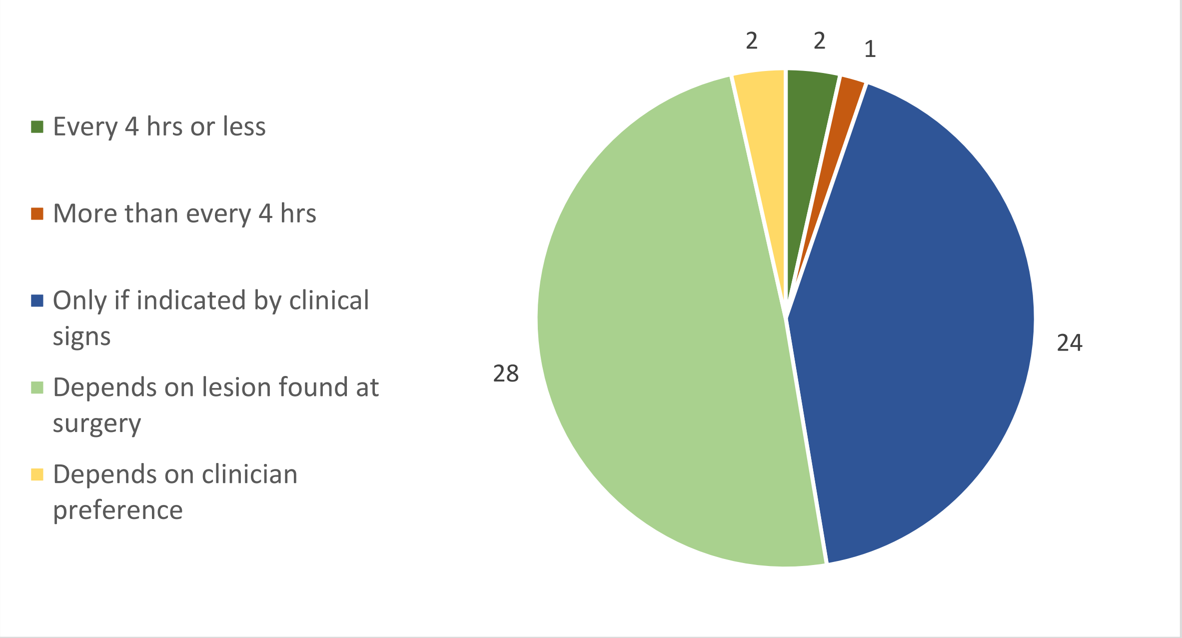


Figure 2.9: The frequency of nasogastric intubation during the first 12 hours after colic surgery at contributing clinics (n=57).

Data regarding diagnostic tests used in the early postoperative monitoring of colic patients (defined as the first 48 hours after surgery) were provided by 95.0% of clinics (57/60) and are shown in *Figure 2.10*. The tests most likely to be used by contributing clinics, at least once daily, during this period were measurement of systemic PCV (94.7%; 54/57) and TP (91.2%; 52/57). Measurement of blood lactate, abdominal ultrasonography and measurement of electrolyte status were performed routinely for early postoperative monitoring in just under half of contributing clinics. The tests least likely to be used were full haematology (3.5%; 2/57) and biochemistry (1.8%; 1/57) panels.

Assessment of patient pain scores as part of routine postoperative monitoring was performed in a minority of clinics (n=13; 22.8%). Within this group of clinics, there was large variation in the scoring systems used with 9 separate systems identified. These were a combination of 'in-house' pain scales used at individual clinics (n=3) and validated scales published in peer-reviewed literature (Pritchett *et al*, 2003; van Loon *et al*, 2010; Dalla Costa *et al*, 2014; Gleerup and Lindegaard, 2016; Van Dierendonck and van Loon, 2016; Lawson *et al*, 2020).

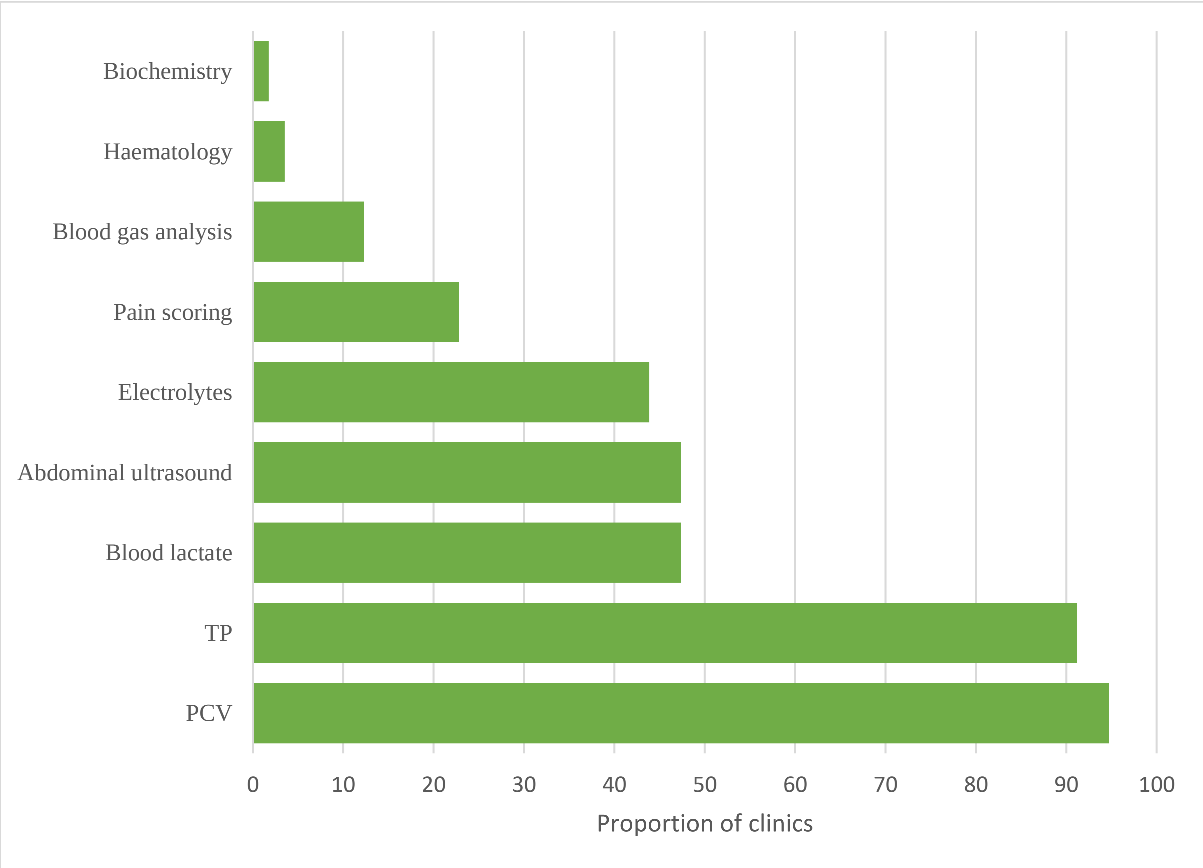


Figure 2.10: Diagnostic tests used routinely (at least once daily) in the early postoperative monitoring of colic patients.

Figure 2.11 shows the use of set protocols for postoperative management across all clinics who submitted this data (96.7%; 58/60). Set protocols were most likely to be used for the method of incisional protection (used in all or most cases at 70.7% of clinics; 41/58). Protocol use regarding other aspects of postoperative management, including duration of incisional protection, intravenous fluid therapy, enteral feeding and prokinetic therapy, was highly variable. Protocols were least likely to be used regarding timing of providing oral fluids after surgery (used in all or most cases at 37.9% of clinics; 22/58).

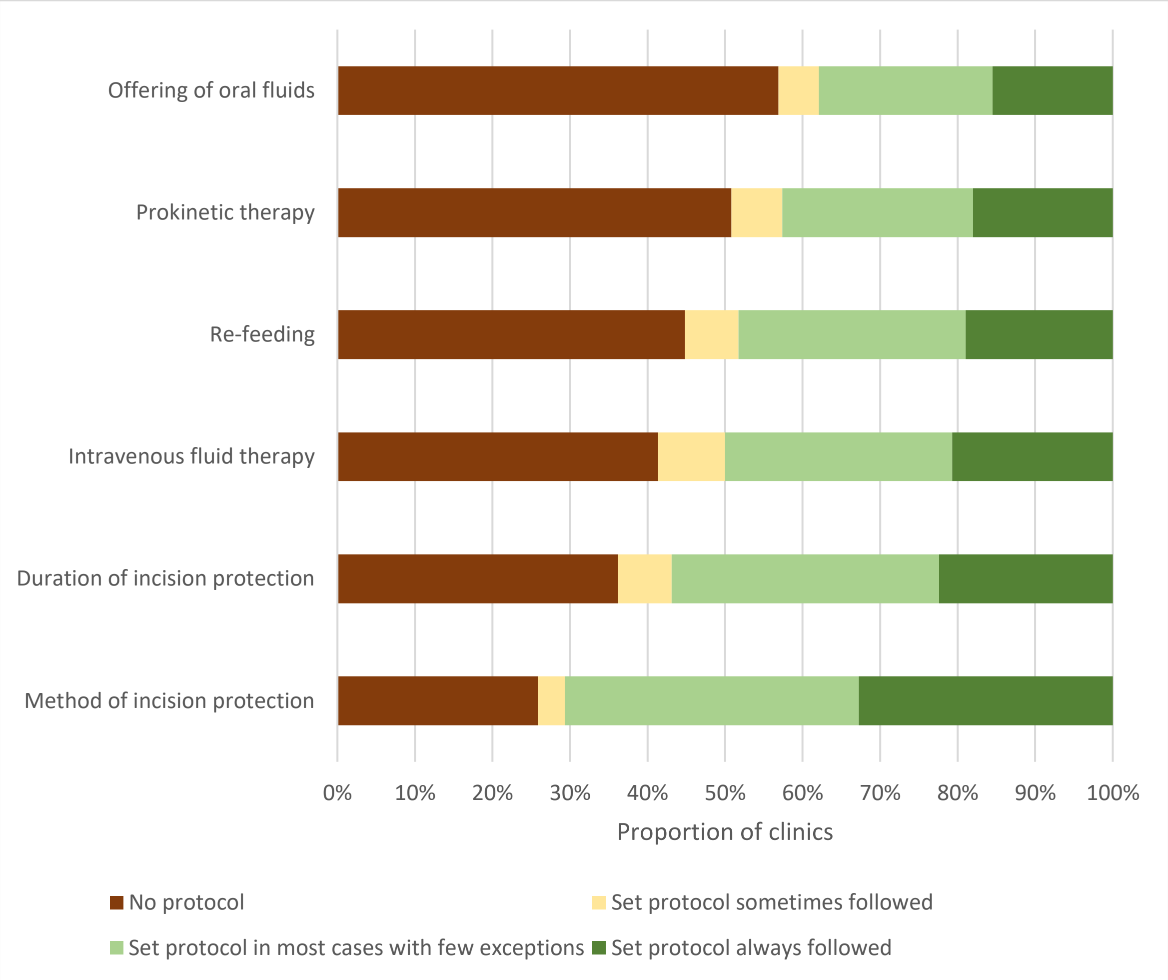


Figure 2.11: Data regarding the use of postoperative management protocols at contributing clinics.

Data regarding the duration of box rest and rest from exercise after colic surgery were submitted by 91.7% of clinics (55/60). The number of weeks of recommended box (stall) rest following surgery, for cases with no postoperative complications, ranged from 0 to 12 weeks, with a median of 6 weeks (IQR 4 – 8). The number of weeks recommended before a horse could begin a gradual return to exercise ranged from 2 to 30 weeks, with a median of 12 weeks (IQR 8 – 12).

Clinical Governance and Audit

Data regarding clinical governance and audit were submitted by 95% of clinics (57/60). Internal audit of surgical colic cases was undertaken by 26.3% of contributing clinics (15/57) at the time of questionnaire completion, but only one clinic published this information externally. This audit was performed every 12 months or less frequently in 19.3% of clinics (11/57), every 6 to 12 months in 3.5% (2/57) and more often than every 6 months in 3.5% (2/57). The staff responsible for undertaking colic audit were the senior clinicians in 14.0% of clinics (8/57), other veterinary surgeons in 8.8% (5/57) and administrative staff in 3.5% (2/57).

Routine follow-up telephone calls or other forms of communication to monitor progress of all surgical colics after clinic discharge were performed by 17.5% of clinics (10/57), while 59.6% (34/57) reported doing this occasionally for selected cases only. No follow-up monitoring was performed by 17.5% of clinics (10/57), while 5.3% (3/57) only obtained follow-up information for cases treated by their own ambulatory veterinary surgeons.

Morbidity and mortality (M&M) rounds were undertaken by 56.1% of contributing clinics (32/57). M&M rounds were held monthly in 26.3% of clinics (15/57), every 2 to 3 months in 10.5% (6/57), every 4 to 6 months in 12.3% (7/57), and less frequently than every 6 months in 7.0% (4/57). *Figure 2.12* shows the attendance of different staff types at M&M rounds. Of those clinics who undertook M&M rounds, all deaths and complications were discussed at 50.0% of clinics (16/32), all deaths and selected complications were discussed at 3.1% (1/32), and only some cases selected by the clinicians were discussed at 46.9% (15/32).

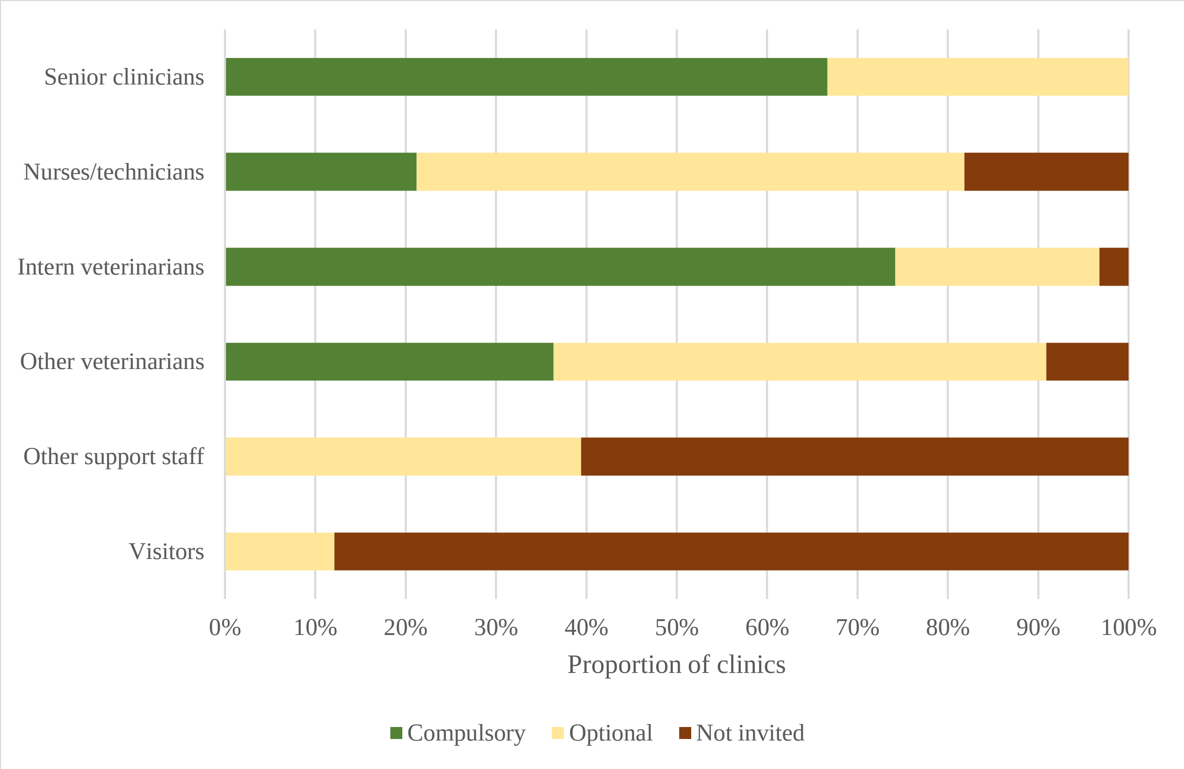


Figure 2.12: Staff attendance at M&M rounds for clinics in which these rounds were undertaken.

Question 57 was a free text box in which clinics were able to provide additional information for questions that required it. This was most commonly used to provide information about surgeon experience and training (n=8) which has been categorised for analysis. It was also used to provide details about the use of guidelines instead of set protocols at some clinics (n=3). Question 58 was a free text box in which clinics were invited to provide any additional information they wished. This was used to provide: specific details on clinics protocols (n=5); information on supervision of anaesthesia by telephone (n=1); information on anaesthesia training provided to nurses/technicians (n=1); specific considerations unique to some geographical locations (n=4). Geographical considerations included the long transport time of some referrals (n=1) and the limited financial budget for veterinary care in some regions (n=1).

Question 59 was a free text box in which clinics were invited to provide any ideas they had for the INCISE project to make clinical audit easier in practice. Likely barriers to participation that were identified included personnel and time limitations (n=4), poor usability of practice management software (n=2) and forgetting to submit data (n=2). Suggestions to make clinical audit of colic cases easier included: software which would automatically harvest required data from each clinic's practice management software (n=1); a mobile telephone app for data entry (n=2); automatic reminders to enter data and obtain follow up information (n=2); guidelines agreed by all clinicians in each clinic regarding postoperative care and feeding (n=2).

COVID-19 Pandemic

Overall, 88.3% of clinics (53/60) submitted data regarding the impacts of the COVID-19 pandemic during 2020, though 5 of these clinics did not answer all questions. Only 7.5% of clinics (4/53) reported that the Coronavirus pandemic and associated restrictions had affected their ability to offer colic surgery during the 2020 calendar year, with two clinics (3.8%; 2/53) reporting this had been greatly affected for a period longer than one week. The number of colic admissions was reported to be unaffected by the pandemic at 73.6% of clinics (39/53), though only 15 clinics based this on actual data, with 24 clinics reporting this based on anecdotal information. Nine clinics (17.0%; 9/53) had experienced a marked reduction in colic admissions (5 anecdotally, 4 based on data) and 5 (9.4%; 5/53) clinics had experienced a marked increase in colic admissions (3 anecdotally, 2 based on data).

Most clinics (71.2%; 37/52) reported that the likelihood of owners being willing to proceed with colic surgery when indicated had been unaffected by the pandemic during 2020. An increased number of owners declining surgery was reported by 25.0% of clinics (13/52), while only two clinics (3.8%; 2/52) had experienced an increased proportion of owners deciding to proceed with colic surgery during the pandemic. The stage at which horses were referred was reported to be unchanged at 76.9% of clinics (40/52), while 19.2% (10/52) reported they had experienced delayed referrals in some cases as a result of the pandemic. Two clinics (3.8%; 2/52) reported they were more likely to see horses referred earlier than usual, due to reduced capacity of referring vets to manage medical colic cases in an ambulatory setting.

The COVID-19 pandemic had not affected the rota of any staff at 56% of clinics (28/50) but had resulted in increased OOH duties for at least some types of staff in 44% (22/50). The types of staff in order of those most likely to be impacted by a more difficult rota were interns (28%; 14/50), nurses and technicians (26%; 13/50), ambulatory vets and surgeons (both 22%; 11/50), anaesthetists (18%; 9/50), and residents (10%; 5/50). In most clinics the number of personnel present for the initial investigation, surgical treatment and aftercare of colic cases was unchanged or decreased. *Table 2.12* shows the variable impact on staffing at each stage of treatment. Where the type of personnel had changed, clinics reported this was due to a change from veterinary student assistants to other members of staff (n=3) or no reason was provided (n=1).

Table 2.12: Impact of the COVID-19 pandemic on staff numbers and type at each stage of care of colic cases.

STAGE OF COLIC CASE MANGEMENT	**IMPACT ON STAFF NUMBER AND TYPE PRESENT**			
	No change	**Number decreased due to staffing restrictions or social distancing**	**Number increased due to absence of owner or student assistants**	**Type of personnel changed**
Initial investigation	41.2% (21/51)	41.2% (21/51)	11.8% (6/51)	5.9% (3/51)
Surgical treatment in theatre	51.0% (26/51)	39.2% (20/51)	2.0% (1/51)	7.8% (4/51)
Aftercare of surgical cases	56.9% (29/51)	33.3% (17/51)	5.9% (3/51)	3.9% (2/51)

The way in which case information and patient care was handed over to colleagues was reported to be unaffected by the pandemic during 2020 in 60% of clinics (30/50). In 24% of clinics (12/50) fewer staff were present at patient rounds, while 10% (5/50) had changed to email or text message handovers, and 6% (3/50) had changed to video call handovers. Only 8% of clinics (4/50) had changed clinic protocols relating specifically to colic case management due to the pandemic, which were unrelated to COVID-19 biosecurity measures. One clinic had stopped using single-use, protective surgical gowns due to a 5-fold price increase and another clinic changed patient preparation protocols due to an unexpected increase in surgical site infections. Two clinics did not provide any further information regarding their protocol changes.

Question 70 was a free text box in which clinics were asked to provide any additional comments they had regarding the impacts of the COVID-19 pandemic on management of colic cases during 2020. This was most commonly used to provide information on the limitations that clinics had to impose preventing clients from entering the hospital at admission and visiting their horses during the postoperative period (n=7). Comments indicated that this, in turn, caused emotional strain to owners and increased difficulties communicating with clients in some cases. Other themes from responses given to question 70 included: further detail regarding reduced staffing and absence of veterinary student assistants (n=6), the increased workload and emotional demands on staff (n=3), the lower level and shorter duration of ‘lockdown’ restrictions in New Zealand and parts of Australia (n=2), and a trend towards more clients asking for payment plans and struggling to pay veterinary invoices for colic surgery (n=1).

DISCUSSION

To date, there has been a lack of information regarding the provision of emergency laparotomy for management of equine colic at an international level. In addition, there has been little standardised reporting of clinic facilities, staffing and clinical care across different clinics. Data obtained during INCISE-1 provide a snapshot regarding the current status of colic surgery in a range of clinics located across a large geographical area. In addition, and for the first time, the effects of the COVID-19 pandemic on contributing clinics and their ability to undertake colic surgery are described.

Most of the clinics that contributed data to INCISE-1 were located in either Europe (45.0%) or North America (23.3%). Around two-thirds were private clinics and the other third were academic (university-based) clinics. These findings are consistent with the distribution of clinics that present colic research at conferences and in scientific journals. However, these regions are also those that are best known to the INCISE team, who are based in the United Kingdom. The number of clinics invited to participate in each region is likely to give a more accurate representation of actual colic surgery provision. However, some of the clinics identified may not offer colic surgery. It is also possible that some clinics that do offer colic surgery were not identified by the clinic recruitment strategy, particularly in regions that were less well known to the INCISE team. As no formal database of equine clinics that offer colic surgery exists, it is not possible to reliably confirm accurate representation of clinics. Establishing this type of database and keeping it updated would be helpful for future research and clinical governance projects relating to colic surgery and is part of future plans of the INCISE collaboration.

Africa and South America combined represented only 5.0% of the clinics that contributed to INCISE-1. Furthermore, questionnaire response rates were 12.5% for clinics in Africa and 18.1% for clinics in South America. These are both lower than the average global response rate of 26.5%, so it seems likely that these regions are underrepresented in this study. These were also the continents in which the INCISE team had fewest links to equine veterinary networks and where it was more difficult to conduct internet searches for clinics offering colic surgery. As outlined in Chapter One, there is no legal or veterinary regulatory requirement for routine audit data to be submitted by veterinary surgeons or clinics. As a result, these activities rely on voluntary submission by those who are willing and able to access relevant data. This study provides baseline data that can be used to compare future audits in this particular veterinary discipline. Factors that altered willingness to contribute data to INCISE-1 were not specifically investigated and are unknown. However, they are likely to be multifactorial and may include knowledge of the INCISE team through professional contacts, level of interest in clinical audit and research and the ability to access the data requested.

INCISE-1 has demonstrated that the size, facilities and personnel at clinics offering exploratory laparotomy vary widely. This is unsurprising and may reflect the difference in caseload between clinics, though it is important to note that this was not assessed by this study. It is also important to recognise that, currently, there are no formal, evidence-based guidelines that define minimum staffing and resources required for clinics that offer emergency laparotomy in horses, nor what constitutes best practice regarding most of the processes and treatments used by clinicians. Provided a clinic has the minimum resources that are required to surgically treat a horse with colic and manage it postoperatively, evaluating whether the staffing and facilities at that clinic are acceptable will largely be determined by caseload. Therefore, finite resources such as number of staff or number of stables, may be best evaluated by dividing them by the number of colic surgeries performed in a set time period. However, this approach assumes that the number of non-colic cases being treated in the clinic are directly related to the number of colic cases. This is not necessarily true and for that reason this analysis has not been performed. What constitutes the minimum acceptable standard can also be debated. The nature and intensity of treatment can vary hugely depending on the lesion(s) causing signs of colic. However, as these can only be identified with certainty at surgery, it can be argued that clinics should be prepared for all eventualities.

Nearly all clinics who contributed data to INCISE-1 (96.7%) offered colic surgery 24 hours a day, 365 days a year, so should be staffed accordingly. As outlined in Chapter One, this requires a mixed clinical team including veterinary surgeons with advanced training in disciplines such as surgery and anaesthesia, veterinary nurses and lay staff. While staffing depends, to some extent, on the caseload of a clinic, 24-hour care requires teams to undertake nightshifts or on call duties. Insufficient rest and sleep deprivation have marked negative effects on work performance (Steffey, *et al* 2023), which can impact staff and patient safety. Finances also have to be considered as colic surgery is a high-cost procedure that is typically associated with low profit margins. Therefore, equine clinics that offer colic surgery as a 24-hour service need to ensure appropriate staffing that is safe, sustainable and economically viable. The median number of surgeons sharing the OOH rota at clinics contributing to INCISE-1 was 3 but in around a third of clinics the rota was 1-in-1 (6.9%) or 1-in-2 (24.1%). A 1-in-2 anaesthetist OOH rota was in place at 25.5% of clinics, though no clinics reported a 1-in-1 OOH rota for anaesthetists. Historically, economic limitations have been given as a key limiting factor in veterinary staff levels and the issue is currently compounded by shortages of veterinary surgeons in some countries (Hagen *et al*, 2020). Long hours and sleep deprivation have been viewed as signs of strength and dedication that are required to ‘get on’ in the profession. However, this view is no longer defensible, and it has been argued that if a clinic cannot ensure adequate rest for its staff, it is an unambiguous indicator that the clinic’s business model is fundamentally flawed (Steffey *et al*, 2023). At clinics where increased staffing cannot be justified on financial grounds, affiliations or agreements with nearby clinics may be considered. Although some may be reluctant to explore collaborations with business competitors, such agreements can work well when carefully arranged and were reported to be in operation at some contributing clinics (n=3).

Shift-based night cover and limited shift lengths have been used within the human medical profession to improve working conditions and reduce sleep deprivation of staff. Dedicated OOH staff were employed by two thirds of clinics (66.7%) and were most frequently nurses/technicians or interns. Dedicated OOH staff were more commonly employed by academic clinics (95.5%) in comparison to private clinics (50%), and in North America (92.9%) in comparison to other regions. Only 26.7% of clinics had a dedicated OOH surgeon who did not perform daytime clinical duties, and this was more common at clinics in North America (57.1%). The number of clinics requiring some staff to be present at the clinic overnight (84.5%) was higher than the number of clinics who employed dedicated OOH staff. This would suggest that in some cases these staff were 'on-call' after a normal working day. Interns and nurses/technicians were required to perform this role in most clinics. Data regarding accommodation and rest facilities at clinics were not collected and would be an interesting addition to a repeat organisational audit. Information should also be collected regarding OOH rotas of junior staff. Reliance on intern veterinarians and nurses/technicians was a common feature in OOH provision and the 'hands-on' care of horses postoperatively. In addition, these staff were the most likely to be negatively impacted by rota changes during restrictions imposed by the COVID-19 pandemic. Recruitment and retention of junior veterinary surgeons and veterinary nurses is currently a major issue causing concern within the veterinary industry, particularly within the equine veterinary sector (Hagen *et al*, 2020; Hagen *et al*, 2022). This could have major future impacts for equine clinics aiming to provide intensive care to horses with colic and strategies to adapt to these shortages are needed.

Improved surgical outcomes in equine colic surgery have been associated with increased surgical experience and residency training in surgery (Freeman *et al*, 2000; Garcia-Seco *et al*, 2005; Brown *et al*, 2015; Wormstrand *et al*, 2014). There was large variation in the experience of primary surgeons at contributing clinics, with a median of 11 years of experience performing colic surgery. Although the majority of clinics (79.3%) employed at least one boarded surgical specialist, under half (46.6%) employed only specialist or residency trained primary surgeons. Overall, most surgeons represented in this study (73.9%) had received residency training in surgery and 64.8% were boarded surgical specialists. A higher proportion of surgeons were residency trained in academic clinics (86.7%) compared to private clinics (64.7%), and in North America (93.4%) and Australasia (94.4%) in comparison to other geographical regions. Completion of surgical residency training and passing surgical board examinations, however, does not necessarily reflect the level of surgical expertise for procedures such as emergency abdominal surgery. It is assumed that surgeons performing emergency laparotomy at contributing clinics who did not fall into these categories would have undergone some form of informal surgical training, but this was not explored further within INCISE-1, nor was individual surgeon data collected. The latter may be better measured by other indicators of surgical experience, for example the numbers of laparotomies performed overall or on an annual basis, and can be linked to patient outcomes for individual surgeons. However, as discussed in Chapter One, unlike in the human medical field where surgeon-level procedure outcome data are publicly available, this type of formal reporting is not required by veterinary regulators. As discussed by Mair and White (2008) sensitivities around anonymity at clinic and individual surgeon level were factors likely to act as major barriers to submission of this type of data to an audit of equine colic surgery.

Overall staff composition was highly variable between clinics in all regions. Emergency laparotomy is a multidisciplinary procedure which, in people, recommendations state should include consultant radiologists, consultant anaesthetists and critical care consultants (NELA, 2014). In INCISE-1, postoperative care was always overseen by a senior surgeon or specialist in internal medicine or critical care at most contributing clinics (72.4%). Over half of clinics (60%) employed at least one specialist in internal medicine or emergency and critical care, though fewer clinics employed specialists in veterinary anaesthesia (36.7%) and diagnostic imaging (26.7%). These data were collected to gather information regarding current levels of multidisciplinary specialist staffing in clinics performing colic surgery and not to be indicative of what is considered 'gold-standard'. Collection of data to describe the total experience and qualifications of all staff at all clinics was not feasible, although around a third (31.7%) of clinics employed veterinarians who were not specialists but had achieved Advanced Practitioner Status in the UK, or an equivalent qualification elsewhere. There is no evidence linking multidisciplinary specialist care to improved outcomes in equine veterinary practice and many veterinarians have extensive clinical experience caring for horses after colic surgery. The author has worked with many clinicians with no additional qualifications who have excellent knowledge and outstanding clinical acumen in the field. However, assessment and decision-making by specialist clinicians is frequently recommended in NHS guidelines (Loughlan, 2011; NELA, 2014). As the number of residency-trained equine veterinarians increases it seems intuitive that more clinics undertaking colic surgery will look to employ boarded specialists.

Protocol use in general was highly variable and less common than reported in human hospitals undertaking exploratory laparotomy (NELA, 2014). This was true for all stages of care. Frequency of regular protocol use was over 80% for only four areas of care, namely abdominal ultrasonography at admission, preoperative antimicrobial choice, induction of anaesthesia, and draping for surgery. Similar variation has been documented in equine anaesthesia (Wohlfender *et al*, 2015). This highlights the lack of consistency in many aspects of veterinary care and the need for evidence-based guidelines, which has been cited as a barrier to the use of clinical audit in colic surgery (Mair and White, 2008). A limitation of this study was the lack of detail obtained regarding types of protocol in use at clinics. For example, many clinics (n=26) varied the frequency of postoperative nasogastric intubation to check for gastric reflux based on surgical findings and the procedures performed, but no further detail was obtained. Attempts to produce guidelines or protocols for treatment of horses with colic will require more detailed information and are best informed by clinical research. Alternatively, where evidence is lacking or conflicted, guidelines can be created by specialist consensus statements produced by specialty colleges (Durham *et al*, 2019) or multidisciplinary panels (Bowen *et al*, 2019). The creation and use of evidence-based guidelines or protocols for diagnostic investigation and treatments can speed up the delivery of care, improve consistency of care, improve clinical decision-making and reduce the incidence of errors (Woolf *et al*, 1999). Enhanced recovery after surgery (ERAS) protocols were popularised in the field of human colorectal surgery (Zhuang *et al*, 2013), but have now been proven to reduce the morbidities and costs of treatment in a range of surgical disciplines (Bond-Smith *et al*, 2016; Joliat *et al*, 2018; Parizh *et al*, 2018; Ashok *et al*, 2020). The results of this chapter support the need for further work in this area to produce similar resources for equine clinics performing colic surgery.

Surgical checklists are an example of a simple protocol that is easy to design, requires minimal evidence-based data and has been proven to improve quality of health care. A surgical safety checklist (SSC) was introduced by the World Health Organisation in 2009 (Haynes *et al*, 2009) and has been shown to significantly decrease surgical complications and mortality in people (Bergs *et al*, 2014). However, INCISE-1 found that checklists are infrequently used at clinics performing colic surgery, with just over half of contributing clinics (55.2%) reporting that they used a presurgical checklist. Furthermore, checklists were only used in all cases at 24.1% of clinics. Multiple single-centre studies across North America and Europe have investigated the impact of SSCs in small animal surgery, finding that they significantly reduce the frequency of perioperative and postoperative complications (Bergström *et al*, 2016; Cray *et al*, 2018; Ward *et al*, 2019). Other benefits include decreased anaesthesia duration, increased administration of planned preoperative antimicrobial therapy and increased completion of safety measures, such as verbal confirmation of the patient's identity and surgery site (Mankin *et al*, 2021). Use of a checklist has also been shown to reduce the number of adverse events in veterinary anaesthesia (Hofmeister *et al*, 2014). A recent survey of veterinary professionals in the UK found that 70% of respondents used SSCs, with 87.1% of these using them for every surgical procedure (Hill *et al*, 2022). Although veterinary professionals' attitudes to checklists are generally positive (Hawker *et al*, 2021; Hill *et al*, 2022), barriers to their use include the time taken and perceived delays in care, forgetfulness, hierarchal concerns, lack of clarity regarding who should perform the checklist and inadequate training (Kilbane *et al*, 2020; Hawker *et al*, 2021). These factors should be considered when designing checklists and strategies to increase the use of SSCs in colic surgery.

Optimising the return to training of performance horses that have had colic surgery has been the focus of recent investigation, including the use of physiotherapy techniques to promote abdominal muscular strengthening (Holcombe *et al*, 2019). The results of INCISE-1 demonstrate a wide range in the duration of stable rest and the duration of time from surgery to return to exercise that are recommended by contributing clinics. Although the median reported rest periods were similar to previous standard recommendations (Kirker-Head *et al*, 1989), some clinics recommended periods less than half of the

30 days required for the abdominal wall to regain its original strength (Chism *et al*, 2000). However, this question was not well-designed and what constituted 'exercise' was not defined. Therefore, clinics may have interpreted return to exercise as including horses that returned to light walking while still being largely restricted to a stable. For future studies this question should be modified to obtain more specific detail. However, it is possible that current practice does differ widely between clinics. This aspect of postoperative care would be well-suited to clinical guidelines developed using evidence generated by research in this area.

A minority of contributing clinics (26.3%) performed internal audit of colic surgery outcomes at the time of survey completion. However, this compares favourably to the 15.1% of surgeons who reported undertaking this activity in a survey of equine surgeons published in 2008 (Mair and White, 2008). Regular M&M rounds can be considered an informal form of clinical audit (Pang *et al*, 2018) and are essential for UK clinics wishing to attain Veterinary Hospital status under the RCVS Practice Standards Scheme (RCVS, 2022). M&M rounds should be "open, honest discussions with clear actions and no barriers to feedback," which are ideally face-to-face and held at least monthly (RCVS, 2022). Over half of clinics contributing to INCISE-1 (56.1%) reported holding M&M rounds, though the frequency of these and the composition of staff attendance were variable. This is less than the proportion of centres who reported holding M&M rounds in a recent survey of centres that offer ACVS surgical residency programmes (Kieffer and Mueller, 2018). The same survey found the primary goals of M&M rounds most frequently cited were improvement of patient care and education (Kieffer and Mueller, 2018). To achieve these goals, it is recommended that all morbidities related to adverse events and all mortalities are discussed (Pang *et al*, 2018), though this may be impractical due to time limitations. All deaths and complications were discussed at 50% of clinics that contributed to INCISE-1 and undertook regular M&M rounds, with variable methods of selection reported by other clinics. Therefore, the organisation and frequency of clinical governance activities appears to be an area that can be improved at many clinics offering colic surgery. Future monitoring of these activities can be compared to benchmarking data provided by INCISE-1.

The widespread effects of the Coronavirus pandemic are reflected in the survey responses. It is also clear that experiences varied markedly depending on geographical location of each clinic. Whilst only 7.5% of contributing clinics reported that their ability to offer colic surgery had been affected by local or national restrictions during the start of the pandemic in 2020, over 50% reported that it had resulted in changes to OOH rotas, increasing the workloads of particular staff teams. Overall, changes to staffing and the number of personnel involved in the admission and care of colic cases were more commonly reported than changes to the number or type of colic referrals clinics experienced during the pandemic, suggesting that the general workload of staff was increased. However, data regarding the effect on the elective caseload was not collected and would be required to draw such conclusions. The likelihood of horse owners deciding to proceed with surgery and the general timing of referral was reported to be unaffected by the pandemic at most clinics. However, 25% of clinics reported an increase in the number of owners declining surgery and 19.2% reported they had experienced delayed referrals in some cases. Delayed referral is believed to have a significant impact on colic surgery outcomes (Freeman, 2018a) but no data relating to outcomes was collected as part of INCISE-1.

Some limitations of this study have already been outlined within this discussion and include aspects of question design. Despite efforts to ensure sufficient testing of the questionnaire, during data analysis it became apparent that the phrasing of some questions could have been improved to obtain more specific detail or additional information. These questions should be modified for subsequent organisational reports of INCISE. Common to all questionnaires, an important balance must be struck between the ability to collect useful data and minimising the time input required from respondents, in order to increase compliance. Inclusion of a wider panel of clinicians from clinics contributing to INCISE would be one way to assist refinement of the questions that were poorly designed and to seek feedback on changes that might improve or worsen compliance of data collection.

The questionnaire was initially constructed using commercial survey-design software but was subsequently redesigned and custom-built using the INCISE website. Although laborious, the aim of this was to seamlessly link clinic information obtained in INCISE-1 to subsequent patient-level data collected in the second phase, the results of which are presented in Chapter Three of this thesis. Linking organisational factors to surgical outcomes has allowed the identification of several potential changes that can be made to improve care provided to people undergoing emergency laparotomy (Oliver *et al*, 2018) and this was an attractive aim for the INCISE project. Unfortunately, after the questionnaire had been redesigned it became apparent that software limitations would prevent linking of these data. A large amount of time had been spent on this process and on retesting the website-version of the questionnaire. However, it was a valuable lesson and illustrates the importance of clear communication between clinical and software design teams. When designing electronic data collection tools for projects such as clinical audit, key elements of this communication should include clarification of fundamental objectives, capability of the technology available and accurate information regarding the time involved in the tasks required. This can be achieved by frequent periods of protected time for cooperative working between the clinical team and technical support staff, during which they can discuss issues encountered and the costs involved.

In conclusion, this organisational audit provides a valuable snapshot of current processes, facilities and staffing in veterinary clinics that perform colic surgery across a range of clinic types in different geographical regions. The key features of these clinics provide context to the second phase of INCISE, which is presented in the next chapter. The results of INCISE-1 have identified areas where improvements to care of horses undergoing emergency laparotomy can be focused. They can also be used to monitor the effects of interventions developed in response to these findings and general trends in the discipline over time. Finally, work presented in this chapter outlines the impacts that the COVID-19 pandemic had on contributing clinics and may be useful to studies investigating long-term changes within the equine veterinary industry.

CHAPTER THREE

FIRST PATIENT REPORT OF THE INTERNATIONAL COLIC SURGERY AUDIT: INCISE-2

INTRODUCTION

Outcomes are the physical and behavioural changes in a patient's health status that can be attributed to a preceding healthcare intervention (Donabedian, 1966). Although clinical audits of outcomes can be more difficult to perform than process or structure audits, they most readily demonstrate measurable improvements (or reductions) in healthcare. Before we can be certain that achieving a desired standard relating to a structure or process will improve healthcare, that standard must have been proven to improve outcomes. An improved outcome is in itself an improvement in healthcare. However, using outcome measures alone may provide insufficient information to allow the audit team to identify changes which can improve practice (Ashmore *et al*, 2011). A combination of different audit criteria often provides the most useful information.

Multiple studies have reported outcomes of colic surgery that can be used for clinical audit (Pascoe *et al*, 1983; Proudman *et al*, 2002a,b; French *et al*, 2002; Mair and Smith, 2005a,b,c; Proudman *et al*, 2006; Christopherson *et* al, 2014; Wormstrand *et al*, 2014; Dybkjær *et al*, 2022; Straticò *et al*, 2022). However, these studies most frequently represent the patient outcomes from single hospital populations. This can make comparisons between such studies difficult, due to both horse- and human-related factors. Features of local horse populations, such as breed and management, can differ greatly between and within geographical regions. Furthermore, owner demographics and finances, veterinary expertise and facilities can vary. These combined factors may impact on provision of care and potential outcomes. Concern around the difficulties in comparing outcomes from different populations of horses and different countries was expressed by equine surgeons that provided feedback on the feasibility of setting up an international colic surgery database to facilitate clinical audit (Mair and White, 2008).

Studies in the human medical field have shown that clinical audit is more likely to drive change and QI at a local level when clinicians have access to local standards that they trust and can use to compare their own data against (Loughlan, 2011). Therefore, the establishment of both national and international benchmarks of colic surgery outcomes is important. Generation of national benchmarks may encourage the increased use of clinical audit at equine veterinary clinics performing colic surgery. International benchmarking data would also be important to demonstrate the range of patient outcomes across a wide geographical area and the optimal outcomes that can be achieved. This may identify aspects of care where changes aimed at QI should be introduced and would allow the monitoring of these changes over time.

AIMS

The aims of this second phase of INCISE (INCISE-2) were to collect patient-level data from horses undergoing colic surgery and to generate benchmarking data regarding patient outcomes. To optimise the usefulness of these data for the purpose of clinical audit, morbidity and mortality data were stratified by geographical region and by the most frequently occurring primary lesions.

MATERIALS AND METHODS

Data Collection

Clinics were recruited and enrolled as described in Chapter Two of this thesis. Data were collected using the bespoke website platform (www.internationalcolicaudit.com) that has already been described. Authorised clinic personnel with the 'User' or 'Superuser' log-in details were asked to enter patient-level data for colic cases admitted between the 1st of January 2019 and the 31st of December 2021. Clinics were requested to submit data retrospectively for 2019, using available patient data, and to enter data prospectively for horses admitted during 2020 and 2021. In addition to the website platform, a paper data collection form was designed and refined based on discussions within the INCISE team and on feedback from potential INCISE users in clinics known to the INCISE team. These potential users represented equine surgeons and other clinical staff working in a range of clinic types in different geographical regions. A summary of the data collected in INCISE-2 is shown in *Table 3.1*.

Out-of-hours (OOH) admissions were defined as horses admitted outside the standard working weekday and times. The standard working week was Monday to Friday in most countries but was Sunday to Thursday in some countries. Unlike INCISE-1 where these definitions were left to the discretion of individual clinics, standard working hours during the week were defined as between 08:00 and 17:59. Variables such as breed, surgical procedures, primary lesions and secondary lesions could be selected from a list of drop-down options on the INCISE website platform. Alternatively, clinics could select 'Other' and provide further details in a free text box. 'Other' options were categorised for analysis following data collection. Date and time were automatically populated using the date and time patient details were first entered and users were required to adjust these values in subsequent questions. Units of measurement were also specified and, for some questions, could be selected based on the units used in different countries. For example, weight could be entered in kilograms or pounds. The definitions used for each morbidity are shown in *Table 3.2*. These were based on definitions used within the published literature (Salem *et al*, 2016) and, where these differed, on consensus by the INCISE team and feedback from potential project collaborators. If recorded, primary lesions of horses that died or were euthanased prior to surgery were not included in the analysis.

Table 3.1: A summary of data collected for horses included in INCISE-2.

DATA COLLECTED FOR INCISE-2	
Horse details	• Horse name • Clinic horse identification number • Age • Breed
Admission data	• Date and time of admission • Weight • Heart rate • Packed cell volume (PCV) • Type of treatment (surgical / medical / euthanasia following initial investigation)
Intraoperative data *(if applicable)*	• Primary lesion • Secondary lesion(s) • Surgical procedure(s) performed • Date and time at the start and end of anaesthesia • Date and time at the start and end of surgery • Euthanasia / death during surgery • Recovery from anaesthesia (yes / no) • Time between end of anaesthesia and recovery
Postoperative data *(if applicable)*	• Date and time of return to normal levels of oral fluid • Date and time of return to normal levels of food • Morbidities recorded during hospitalisation
Outcome data	• Survival to hospital discharge (yes / no) • Date and time of discharge / death / euthanasia • Reason for death or euthanasia (if applicable) • Cause of mortality • Owner consent to be contacted for long-term follow up (if applicable; yes / no)

Table 3.2: Definitions of morbidities provided to clinics on the INCISE website.

MORBIDITY	DEFINITION
Surgical site infection	Any purulent discharge from the incision or serous discharge for longer than 24 hours.
Postoperative colic	Signs of abdominal pain that required administration of additional analgesia.
Postoperative reflux	More than 2 litres of gastric content obtained on passage of a nasogastric tube.
Postoperative pyrexia	A rectal temperature of greater than 38.6^{0}C on at least one occasion.
Postoperative diarrhoea	The passage of unformed faeces for more than 24 hours or on two or more consecutive occasions.
Repeat laparotomy	A second laparotomy performed within the same period of hospitalisation.
Dehiscence of the linea alba	Complete dehiscence of all layers of the abdominal wall for any proportion of the length of the incision.
Intra-abdominal haemorrhage	Evidence of active haemorrhage confirmed by abdominal ultrasonography or abdominocentesis.
Septic peritonitis	The presence of toxic or degenerative changes to neutrophils and the presence of intracellular or extracellular bacteria in peritoneal fluid.
Jugular thrombophlebitis	Thickening of the venous wall or subcutaneous, peri-venous tissues with signs of pain on palpation or a local increase in temperature, with or without ultrasonographic evidence of a thrombus.
SIRS	The presence of two or more of the following signs: rectal temperature over 38.6^{o}C; heart rate over 60 beats per minute; respiratory rate over 30 breaths per minute; white blood cell count over 12.5×10^{9}/L or under 4.5×10^{9}/L.
SIRS-related laminitis	Elevated digital pulses or a shifting weight stance in a horse with systemic inflammatory response syndrome (SIRS).

Data Cleaning

Anonymised data for all surgical colic cases admitted during the three year study period were exported from the INCISE website as a comma separated values (CSV) file to Microsoft Excel® (version 2302, Microsoft Inc). Surgical cases were defined as cases that underwent colic surgery or were euthanased when surgical treatment was indicated but not performed. Duplicate entries of the same case with inconsistent data were excluded from this preliminary analysis. For cases with two separate entries due to genuine readmission or repeat laparotomy, only details from the first surgery were included in this analysis. Duplicate entries were identified by searching the clinic horse identification number (CHID). Cases with a matching CHID were included if they were submitted by different clinics. For cases with a matching CHID submitted by the same clinic, the horse name, admission date, signalment, diagnoses and other clinical details were assessed as follows:

- Cases admitted with a different name and different signalment were treated as separate horses and included for analysis, provided they had different diagnoses. If the diagnoses and other clinical details did not make it clear that such cases were different horses, they were excluded.
- Cases admitted within 5 days of each other with the same name and signalment were treated as the same horse. These cases were merged into one entry and included for analysis if all data (including the admission date) matched but were excluded if they had any inconsistent data.
- Cases admitted more than 5 days apart with the same name and signalment were included for analysis if the discharge date of the first visit and the admission date of the second visit did not overlap, and if the clinical details were otherwise consistent with genuine readmission. If the dates of hospitalisation and other clinical details did not make it clear that such cases were due to a genuine readmission, they were excluded.

To double check for duplicate entries missed using the method described above, duplicate entries were also identified by searching the horse name. Cases with a matching horse name were included if they were submitted by different clinics. For cases with a matching horse name submitted by the same clinic, the admission date, signalment, diagnoses and other clinical details were assessed as previously described to identify and exclude duplicate entries of the same colic episode in the same horse.

Data Analysis

Data analyses were performed using Microsoft Excel® and IBM SPSS® Statistics for Windows (version 25.0, IBM Corp). Descriptive statistics were used including frequencies and proportions for categorical data and medians with interquartile ranges (IQR) for continuous data. Data were stratified by geographical region as detailed in Chapter Two and by primary lesion type.

RESULTS

In total, 4,146 cases had been submitted by 63 clinics onto the INCISE data collection platform at the time data was downloaded from the website for analysis. Data cleaning identified two horses with triplicate entries (6 entries; 0.1%) and 73 horses with duplicate entries (146 entries; 3.5%). The two horses with triplicate entries and 33 (45.2%) of the horses with duplicate entries had inconsistent data that could not be verified and were, therefore, excluded from further analysis. One (1.4%) of the horses with duplicate entries had matching data that were merged into one case and included in analyses. Thirty-nine (53.4%) of the horses with duplicate entries were confirmed to be due to genuine readmission, for which the second admissions were excluded from analysis; only data from the first admission was included in the main analyses. Four cases (<0.1%) were excluded due to major inconsistencies in the surgical and postoperative details that could not be verified. One case (<0.1%) was excluded due to being used as a test entry by one clinic. Two cases (<0.1%) were excluded as they underwent laparotomy for Caesarean section due to dystocia. Therefore, data from a total of 4,027 cases from 63 contributing clinics were included in the main analysis.

Clinic and Case Admission Data

The 63 clinics were located in Africa (n=1; 1.6%), Asia (n=8; 12.7%), Australasia (n=7; 11.1%), Europe (n=34; 54.0%), North America (n=12; 19.0%) and South America (n=1; 1.6%). Of these, 39 (61.9%) were private clinics and 24 (38.1%) were academic (university-based) clinics. Due to the small number of contributing clinics from South America and Africa, data submitted by these regions are presented collectively under the heading 'Rest of the World' (ROW) to preserve anonymity. Clinic information is shown in *Table 3.3*. The approximate numbers of annual colic admissions to these clinics (which included horses treated medically and surgically) ranged from 8 to 750. The median admissions for each geographical region ranged from 40 to 200. Median admissions for clinics that contributed to INCISE-2 were greater for clinics located in North America (200 cases) and Europe (100 cases) compared to other regions.

Table 3.3: Features of clinics that contributed data to INCISE-2 split by geographical region.

CLINIC INFORMATION	TOTAL NUMBER OF CLINICS	PROPORTION OF		APPROXIMTE NUMBER OF COLIC ADMISSIONS / YEAR	
		ACADEMIC	PRIVATE	Median (IQR)	Range
ALL CLINICS	63	38.1%	61.9%	100 (47.5 – 200)	8 – 750
Europe	34	32.4%	67.6%	100 (61.3 – 235.3)	20 – 750
North America	12	58.3%	41.7%	200 (53.8 – 285.8)	20 – 600
Australasia	7	28.6%	71.4%	40 (30 – 137.5)	8 – 200
Asia	8	25.0%	75.0%	47.5 (20 – 107.5)	14 – 130
ROW	2	100.0%	0.0%	92.5 (63.8 – 121.3)	35 – 150

The number of colic cases managed surgically for which data were submitted by each clinics varied widely from 1 to 580 colic cases, with a median of 28. *Table 3.4* shows the median number of cases per clinic that contributed to INCISE-2 split by region.

Table 3.4: Summary of the number of cases submitted to INCISE-2 per clinic split by geographical region.

CLINIC INFORMATION	NUMBER OF CASES CONTRIBUTED TO INCISE-2 / CLINIC	
	Median (IQR)	**Range**
ALL CLINICS	28 (12.5 – 92.5)	1 – 580
Europe	44.5 (13.3 – 118)	1 – 580
North America	39 (12.3 – 101.8)	2 – 141
Australasia	24 (3.5 – 25)	1 – 28
Asia	26 (14.5 – 36.5)	1 – 54
ROW	77.5 (63.3 – 91.8)	49 – 106

Of the 4,027 cases submitted by contributing clinics, 1,481 (36.8%) were admitted in 2019, 1,606 (39.9%) were admitted in 2020 and 940 (23.3%) were admitted in 2021. *Table 3.5* shows the number of cases submitted each year split by region. The majority of case data (n=2,865; 71.1%) were submitted by clinics in Europe, followed by North America (n=692; 17.2%).

Table 3.5: Total number of colic cases submitted to INCISE-2 split by year and by geographical region.

CLINIC INFORMATION	NUMBER OF CONTRIBUTED CASES			
	TOTAL	**2019**	**2020**	**2021**
ALL CLINICS	4,027	1,481	1,606	940
Europe	2,865	1,106	1,118	641
North America	692	190	322	180
Australasia	110	54	24	32
Asia	205	97	87	21
ROW	155	34	55	66

Overall, the number of cases admitted was relatively evenly distributed when split by month of the year, as shown in *Figure 3.1*. Some variation in these data was evident when month of admission was split by geographical region but this was not marked. *Figure 3.2 (a-e)* shows the number of surgical colic cases admitted per month split by geographical region.

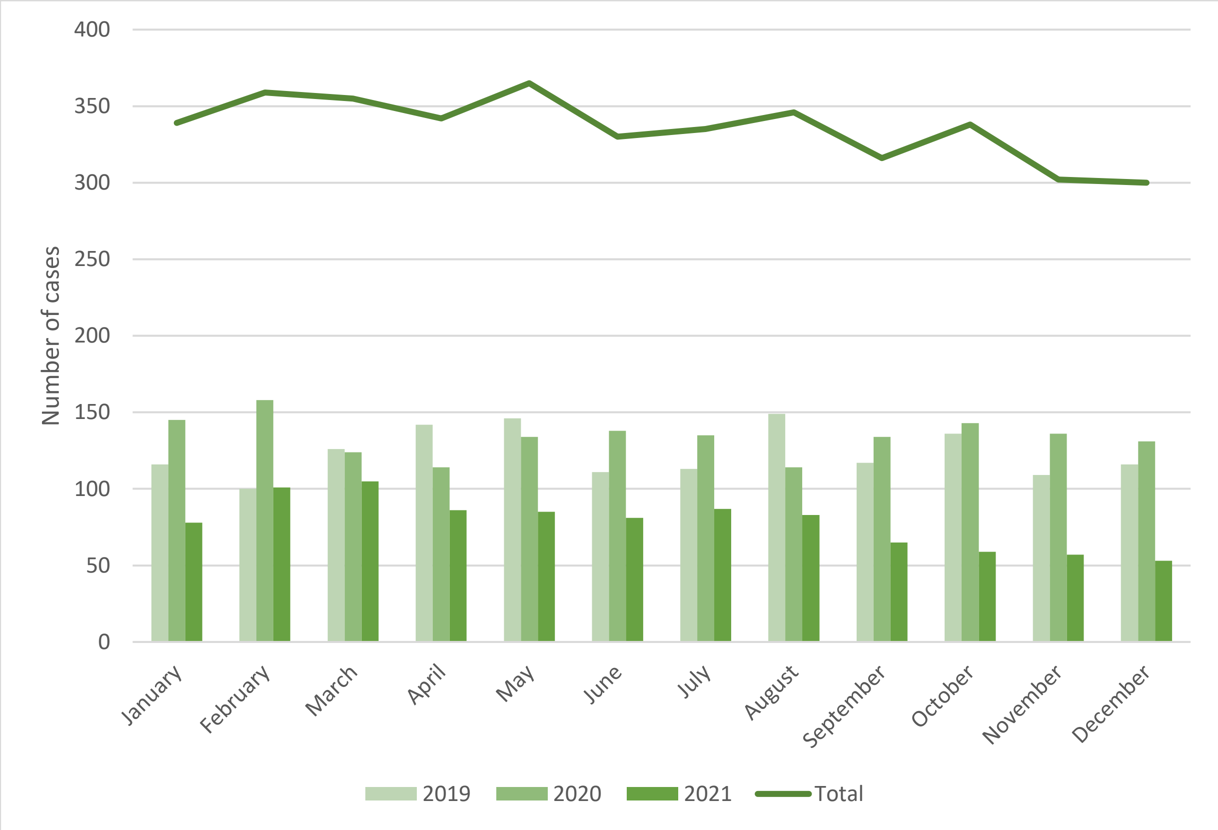


Figure 3.1: Number of INCISE-2 surgical colic cases admitted per month in total and for each year.

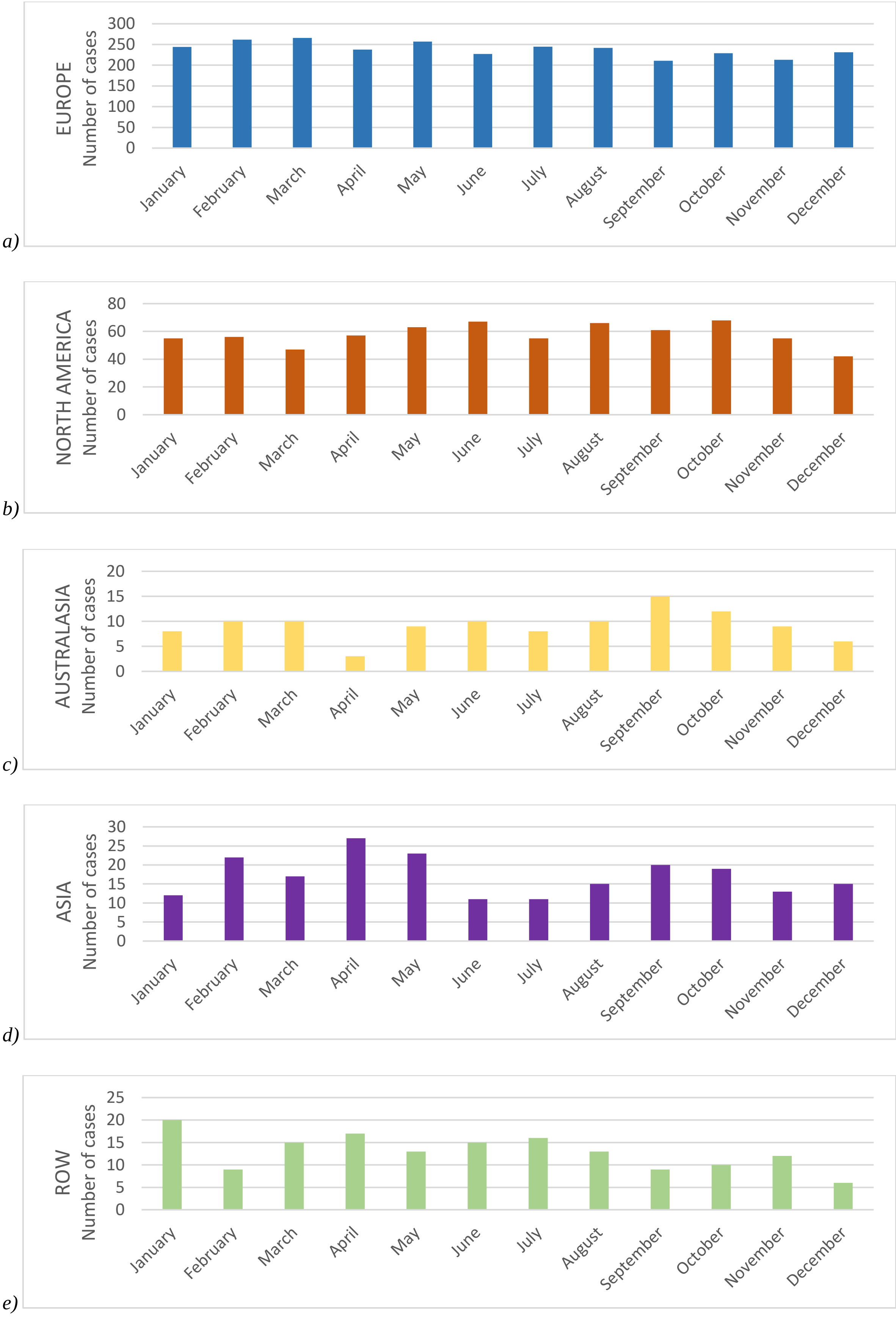


Figure 3.2: Number of INCISE-2 surgical colic cases admitted per month for Europe (a), North America (b), Australasia (c), Asia (d) and the ROW (e).

The number of cases admitted during standard working hours (from 08:00 – 17:59) (n=2,114; 52.5%) versus those admitted OOH overnight (n=1,913; 47.5%) were fairly evenly distributed across the 7 day week. However, when categorising admissions during non-standard working days (i.e. weekends) as OOH, more cases were admitted OOH (n=2,488; 61.8%) than in normal working hours (n=1,539; 38.2%). These proportions were similar when split by geographical region. *Figure 3.3* shows the temporal distribution of admissions for all INCISE-2 cases and split by geographical region. *Figure 3.4 (a-e)* illustrates the proportions of normal working hours and OOH admissions split by geographical region.

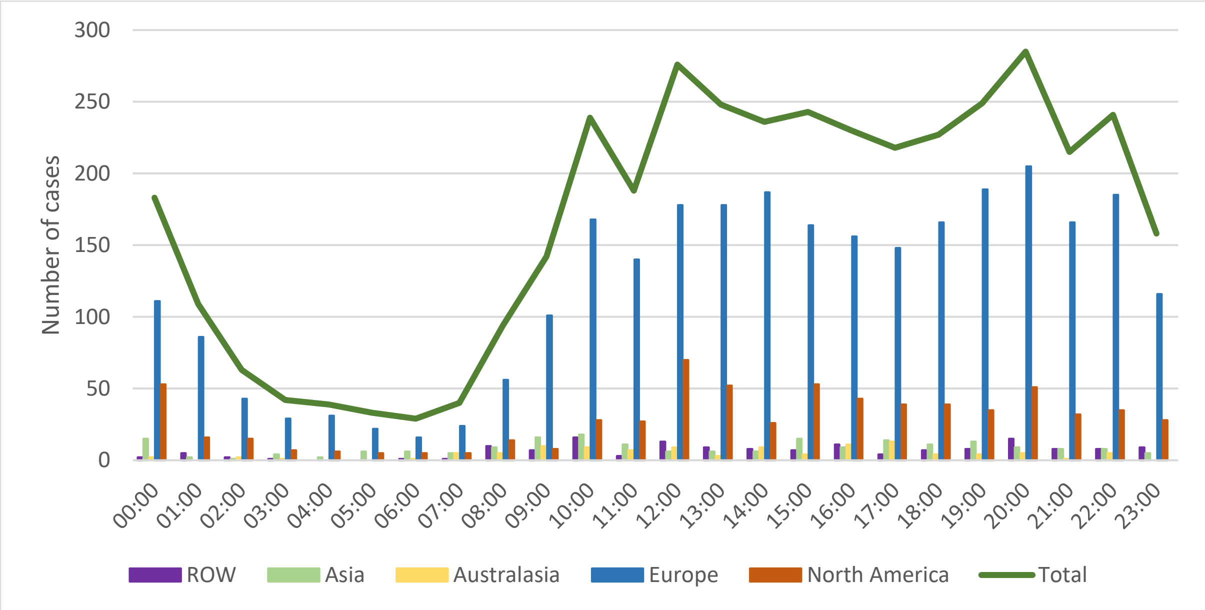
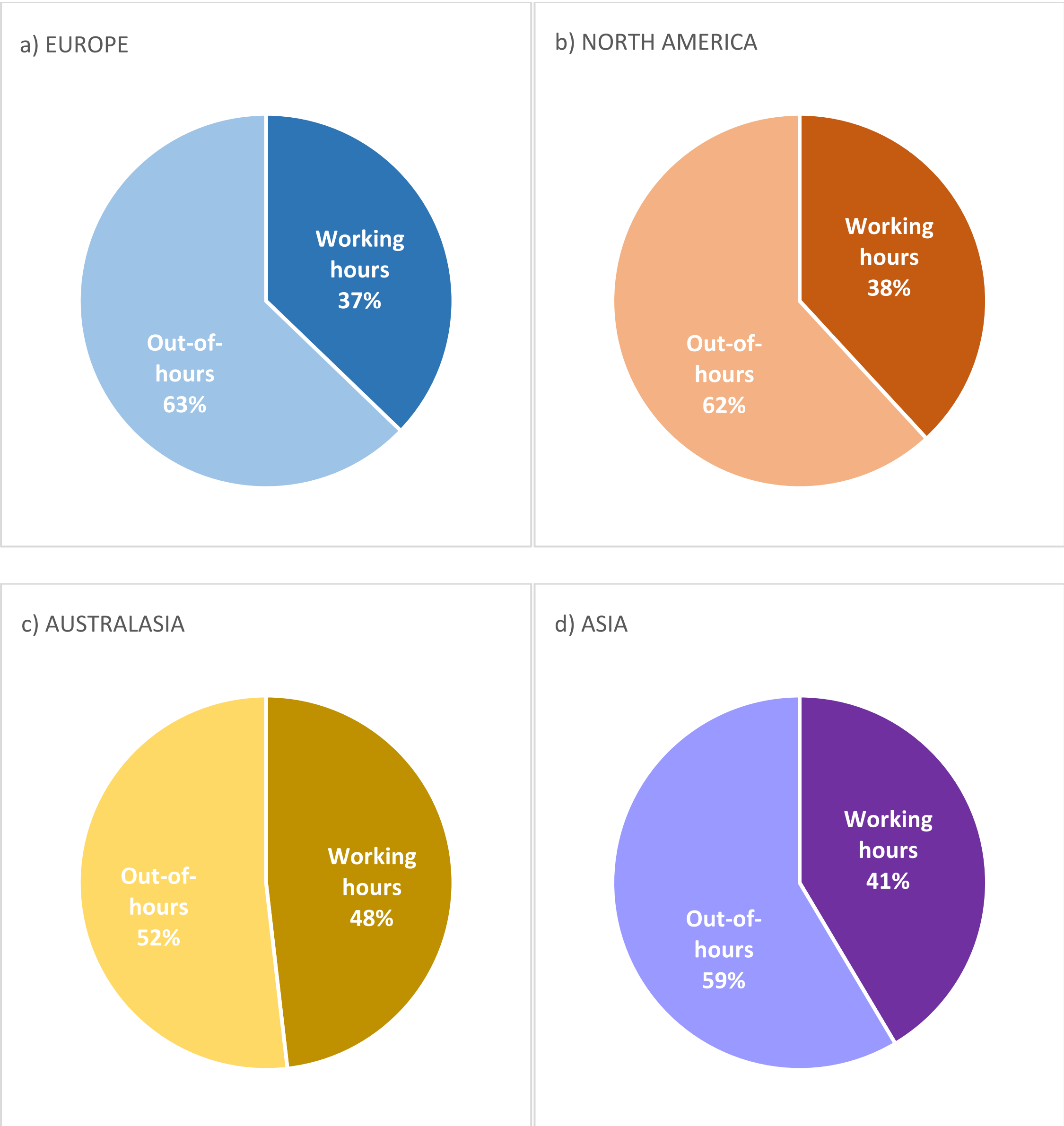


Figure 3.3: The number of cases admitted each hour across all contributing clinics and split by geographical region.



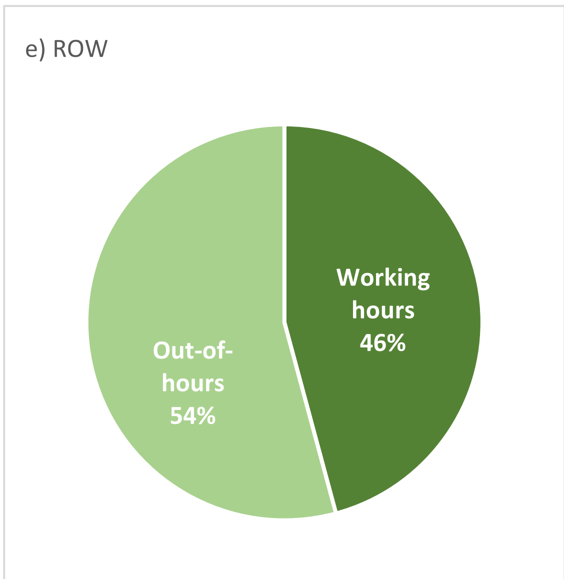


Figure 3.4: The relative proportions of colic admissions during standard working hours (daytime during the normal working week) and OOH admissions for Europe (a), North America (b), Australasia (c), Asia (d) and the ROW (e).

Preoperative Patient Data

The median age of horses was 11.0 years (IQR 6.0 – 16.0 years) with a range of 1 day to 38 years. The median weight of horses was 500 kg (IQR 435 – 565 kg) with a range of 11 to 1050 kg. The age and weight of horses split by geographical region is shown in *Table 3.6*. The distribution of age split by region is shown in *Figure 3.5a* and the same information for weight is shown in *Figure 3.5b*.

Table 3.6: Age and weight of horses included in INCISE-2 split by geographical region.

CLINIC INFORMATION	HORSE AGE		HORSE WEIGHT (kg)	
	Median (years) (IQR)	Range	Median (IQR)	Range
ALL CLINICS	11.0 (6.0 – 16.0)	1 day – 38 years	500 (435.0 – 565.0)	11 – 1050
Europe	11.0 (6.0 – 16.0)	1 day – 38 years	500 (430.1 – 569.9)	11 – 1050
North America	12.0 (6.5 – 17.5)	1 day – 32 years	500 (445.4 – 554.6)	39 – 966
Australasia	8.0 (3.0 – 13.0)	7 days – 32 years	500 (430.0 – 570.0)	31 – 780
Asia	5.6 (2.1 – 9.1)	55 days – 26 years	479 (427.8 – 530.3)	39 – 718
ROW	9.0 (4.0 – 12.0)	1 day – 24 years	470 (400.0 – 533.8)	29 – 630

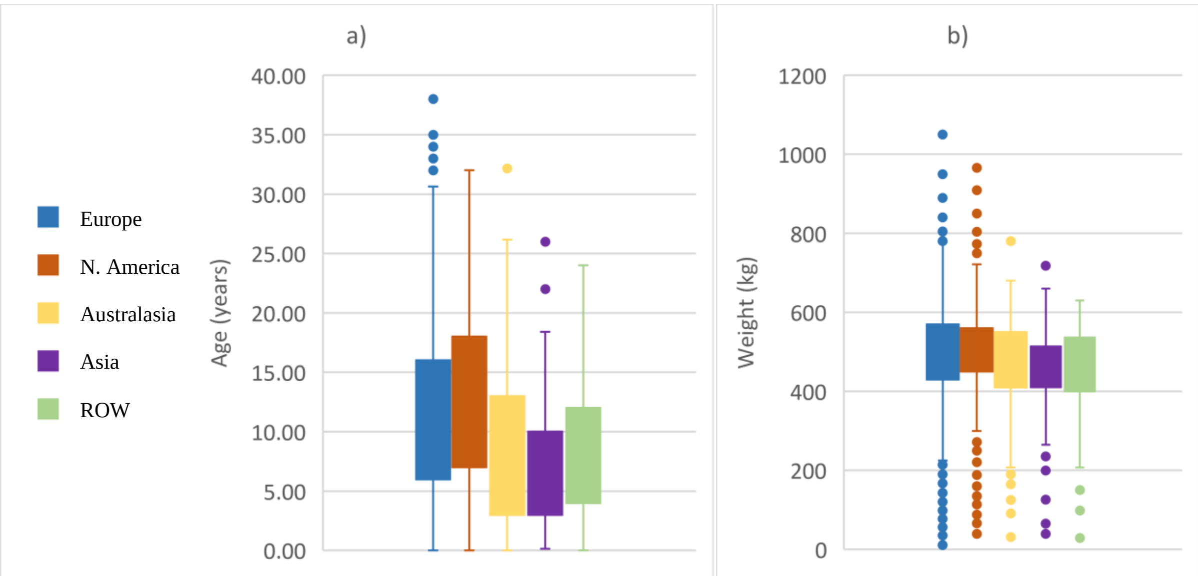


Figure 3.5: The distribution of age (a) and weight (b) for horses included in INCISE-2, split by geographical region.

The horses included in INCISE-2 comprised of 46.6% mares and fillies (n=1,878) 41.6% geldings (n=1,676) and 11.7% stallions and colts (n=473) as shown in *Figure 3.6*. The sex distribution of cases by region is shown in *Figure 3.7*. The five most common breeds across all regions were Warmblood (n=751), Thoroughbred (n=647), Sports horse (n=231), Quarter horse (n=207) and Standardbred (n=138). The five most common breeds for each region are shown in *Figure 3.8*.

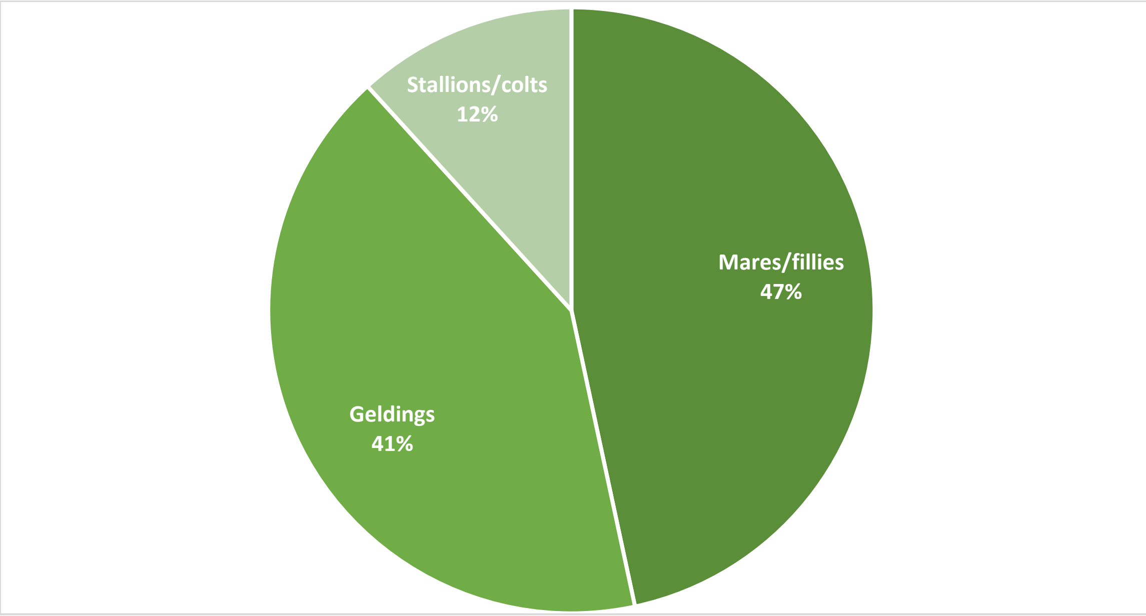


Figure 3.6: The sex distribution of all cases included in INCISE-2.

Figure 3.7: The sex distribution of horses included in INCISE-2 split by geographical region.

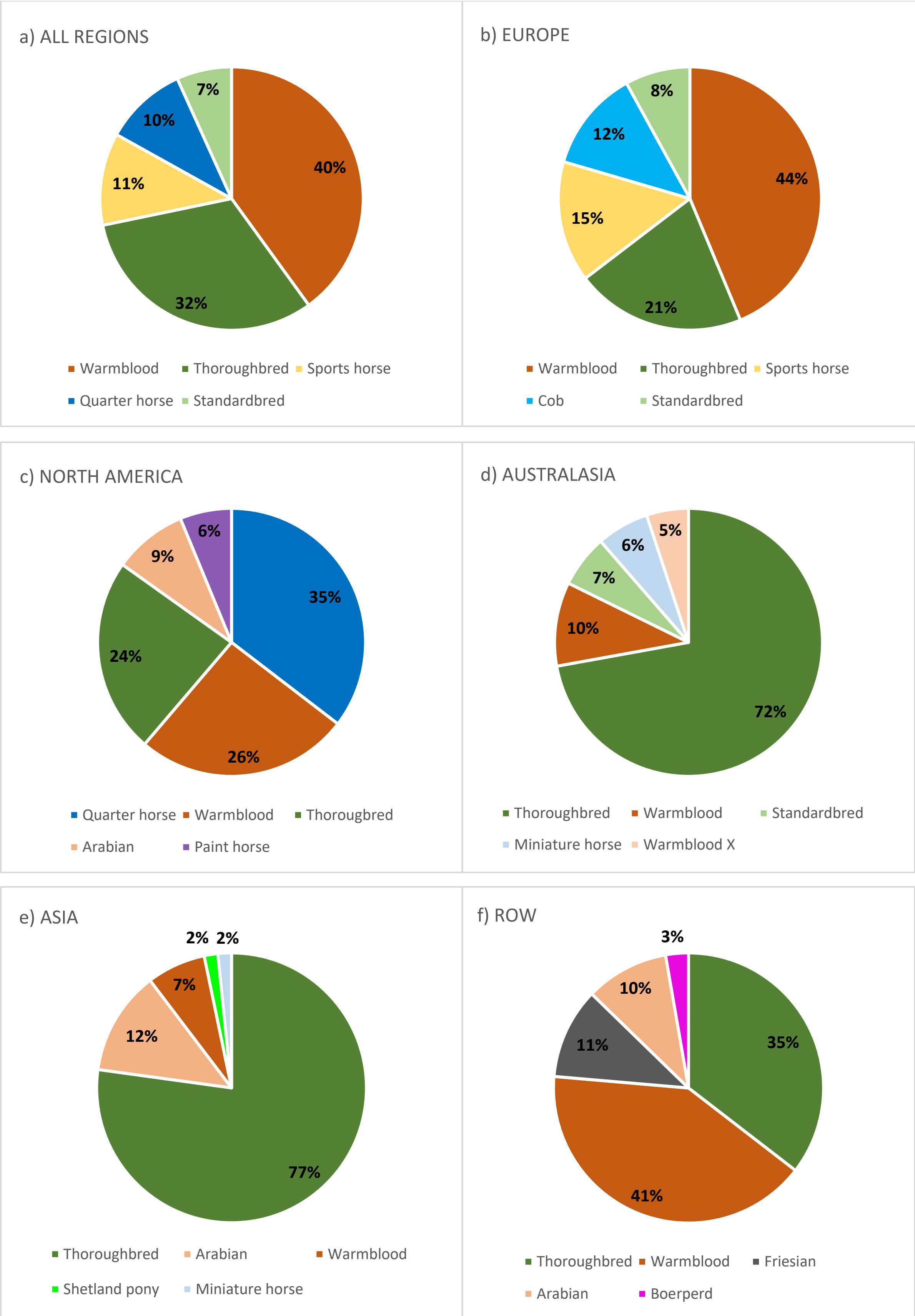


Figure 3.8: The five most common breeds included in INCISE-2 across all regions (a), in Europe (b), in North America (c), in Australasia (d), in Asia (e) and in the ROW (f).

Summary of Key Outcomes

Surgical treatment was undertaken in 93.6% of horses included in INCISE-2 (n=3,770), while 6.4% (n=257) were euthanased or died following initial assessment. Of those horses in which emergency laparotomy was undertaken, 82.2% (n=3,100) survived surgery and were placed in the anaesthetic recovery box. Mortality during recovery from anaesthesia was 6.2% (n=192). Overall, 60.2% of horses that underwent laparotomy survived to hospital discharge. Of those horses that walked out of the anaesthetic recovery box (n=2,908), 78.1% survived to hospital discharge (n=2,271). A summary of key outcomes for all horses included in INCISE-2 is illustrated in *Figure 3.8*.

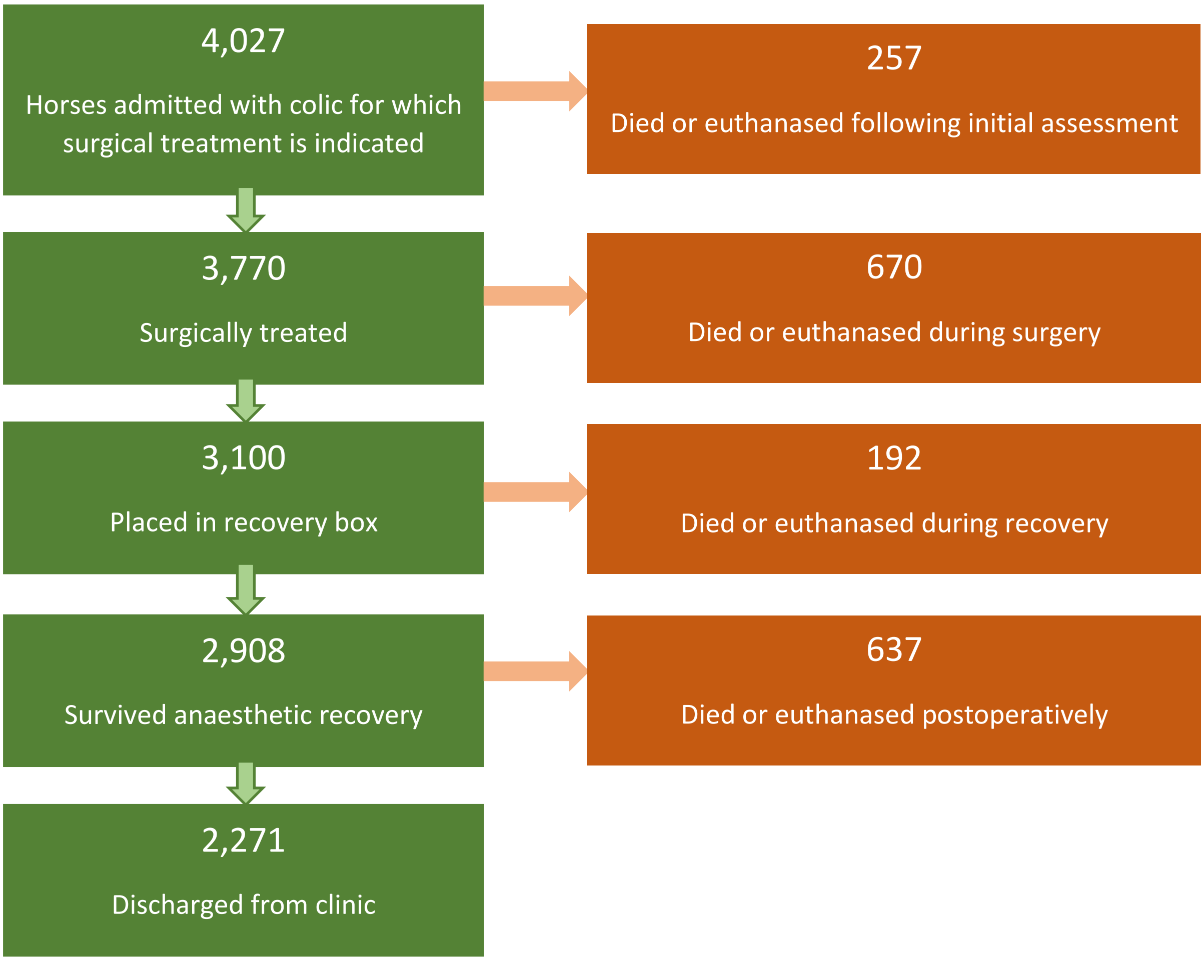


Figure 3.9: Overview of key outcomes for all horses included in the main analysis of INCISE-2.

The treatment choices and outcomes split by region are shown in *Table 3.7*. Further analysis of this data, stratified by geographical region, is presented in the 'Survival and mortality data' subsection of these results.

Table 3.7: Number of horses for which data were submitted to INCISE-2 at key stages at which outcomes were measured, split by geographical region.

CLINIC INFORMATION	**NUMBER OF HORSES**				
	Admitted	**Surgically treated**	**Placed in recovery**	**Walked out of recovery box**	**Discharged from clinic**
ALL CLINICS	4,027	3,770	3,100	2,908	2,271
Europe	2,865	2,699	2,191	2,075	1,601
North America	692	645	553	492	407
Australasia	110	93	76	71	56
Asia	205	205	164	157	116
ROW	155	128	116	113	91

Surgical Data

Of the 3,770 horses that underwent surgical management, the surgical approach was via a ventral midline laparotomy under general anaesthesia in 96.1% (n=3,624) and was not recorded in 3.5% (n=132). Other approaches under general anaesthesia included paramedian (n=4), parainguinal (n=2), inguinal (n=2) and scrotal (n=2). The two horses that underwent a scrotal approach were treated for inguinal herniation of small intestine; in both cases this was reduced via the inguinal canal, which was then closed with no form of conventional laparotomy being undertaken. All horses that had standing surgery (n=4) underwent a flank laparotomy. Data were not collected for horses undergoing repeat laparotomy.

The primary lesion was recorded in nearly all cases (97.1%; n=3,660) for which data were submitted but was not recorded, or was reported as unknown, in 2.9% of cases (n=110). The 10 most common primary lesions in order of descending occurrence were: pedunculated lipomas causing small intestinal strangulation (10.2%; n=384); right dorsal displacement of the large colon (9.8%; n=368); large colon volvulus greater than or equal to 270º (9.6%; n=363); nephrosplenic entrapment (left dorsal displacement) of the large colon (6.3%; n=236); epiploic foramen entrapment of the small intestine (5.9%; n=222); ingesta impaction of the large colon (4.7%; n=179); small intestinal volvulus (4.5%; n=170); large colon volvulus less than 270º (3.3%; n=123); sand impaction of the large colon and/or small colon (3.1%; n=115); ileal impaction (2.7%; n=100). The incidence of all primary lesions split by geographical region is shown in *Appendix 2*. 'Intermediate' large colon displacements were defined as those not clearly identifiable as left dorsal or right dorsal displacements.

The primary lesion was non-strangulating in 51.7% of horses (n=1,948) and strangulating in 43.8% (n=1,651). This information was unknown or not recorded in 4.5% (n=171). *Table 3.8* shows the location of the primary lesion and nature of the lesions (strangulating or non-strangulating) for all cases.

Table 3.8: The location of the primary lesion responsible for signs of colic for all horses in INCISE-2 that underwent exploratory laparotomy and the nature of the lesions (strangulating / non-strangulating / unknown) at each location.

LOCATION OF PRIMARY LESION	NATURE OF LESION			TOTAL
	Non-strangulating	Unknown / not recorded	Strangulating	
Large colon	1,204	13	399	1,616
Small intestine	366	42	1,152	1,560
Small colon	159	5	28	192
Caecum	69	2	69	140
Unknown / not recorded	0	103	0	103
Stomach	27	2	1	30
Uterus	28	0	0	28
Generalised ileus	26	0	0	26
Panabdominal	16	1	0	17
Caecum & large colon	10	0	1	11
Large colon & small colon	9	0	0	9
Bladder	8	0	0	8
Mesentry	3	3	0	6
Neoplasia (unspecified location)	5	0	0	5
Ovary	3	0	0	3
Rectum	3	0	0	3
Small intestine & large colon	3	0	0	3
Liver	2	0	0	2
Small intestine & caecum	1	0	1	2
Spleen	2	0	0	2
Body wall	1	0	0	1
Omentum	1	0	0	1
Small colon & rectum	1	0	0	1
Vagina	1	0	0	1
TOTAL	**1,948**	**171**	**1,651**	**3,770**

The portions of the gastrointestinal tract that were most commonly affected were the large colon (n=1,616; 42.9%) and the small intestine (n=1,560; 41.4%). Most large colon lesions were non-strangulating in nature (n=1,204; 74.5%). In contrast, the majority of small intestinal lesions were strangulating (n=1,152; 73.8%). *Table 3.9* shows the nature of lesions for the five most commonly affected locations split by geographical region.

Table 3.9: The nature of lesions at the five most commonly affected locations split by geographical region. NR = not recorded.

PRIMARY LESION		GEOGRAPHICAL REGION				
LOCATION	**NATURE**	**Europe**	**North America**	**Australasia**	**Asia**	**ROW**
Large colon	**Non-strangulating**	828	215	25	76	60
	Unknown / NR	10	1	1	1	0
	Strangulating	277	87	7	24	4
	TOTAL	**1,115**	**303**	**33**	**101**	**64**
Small intestine	**Non-strangulating**	284	44	8	13	17
	Unknown / NR	22	7	1	8	4
	Strangulating	869	169	41	58	15
	TOTAL	**1,175**	**220**	**50**	**79**	**36**
Small colon	**Non-strangulating**	94	32	3	12	18
	Unknown / NR	5	0	0	0	0
	Strangulating	23	4	1	0	0
	TOTAL	**122**	**36**	**4**	**12**	**18**
Caecum	**Non-strangulating**	56	9	0	1	3
	Unknown / NR	2	0	0	0	0
	Strangulating	59	3	2	5	0
	TOTAL	**117**	**12**	**2**	**6**	**3**
Stomach	**Non-strangulating**	21	3	0	2	1
	Unknown / NR	2	0	0	0	0
	Strangulating	1	0	0	0	0
	TOTAL	**24**	**3**	**0**	**2**	**1**

Secondary and incidental lesions were identified in 31.6% of horses (n=1,191) and were not identified in 65.8% (n=2,482). The presence or absence of a secondary lesion was not recorded in 2.6% of horses (n=97). The 10 most common secondary lesions in order of descending occurrence were: secondary large colon impaction (5.3%; n=198); right dorsal displacement of the large colon (3.4%; n=128), primary large colon impaction (2.8%; n=104); intermediate displacement of the large colon (2.2%; n=82); peritonitis (2.1%; n=79); large colon volvulus less than 270º (2.0%; n=76); adhesions (1.4%; n=53); sand impaction of the large colon and/or small colon (1.2%; n=46); gas distension of the caecum (1.1%; n=41); gastric impaction (0.7%; n=28). The incidence of all secondary lesions split by geographical region is shown in *Appendix 3*.

Data for the procedures performed during surgery were provided for 85.1% of horses (n=3,210) that underwent surgical treatment. Of the horses for which the procedure details were provided, 56.4% (n=1,810) required more than one procedure and 43.6% (n=1,400) had only one procedure recorded.

The five most common surgical procedures were: pelvic flexure enterotomy (n=1,335; 35.4%); large colon reposition (n=962; 25.5%); correction of entrapment (n=547; 14.5%); omentectomy (n=460; 12.2%); correction of large colon volvulus (n=451; 12.0%). *Table 3.10* shows the overall frequency of all procedures and the numbers of horses undergoing each procedure split by geographical region.

Intestinal resection and anastomosis was performed in a total of 654 horses (17.3%). The most common of these were end-to-end jejunojejunal anastomoses (7.1%) followed by side-to-side jejunocaecal anastomoses (3.0%), end-to-end jejunoileal anastomoses (2.2%) and large colon resections (1.0%). Other intestinal anastomoses were performed in 4.1% of horses.

Table 3.10: Frequency of surgical procedures performed split by geographical region.

SURGICAL PROCEDURE	ALL CLINICS N (%)	Europe	North America	Australasia	Asia	ROW
COLIC SURGERY	**3,770 (100%)**	**2,699**	**645**	**93**	**205**	**128**
Pelvic flexure enterotomy	1,335 (35.4%)	934	232	19	89	61
Large colon reposition	962 (25.5%)	688	163	18	63	30
Correct entrapment	547 (14.5%)	436	72	10	18	11
Omentectomy	460 (12.2%)	244	180	2	33	1
Correct large colon volvulus	451 (12.0%)	289	123	8	20	11
Small intestine 'other' (e.g. decompression)	334 (8.9%)	237	64	6	22	5
End-to-end jejunojejunal anastomosis	266 (7.1%)	203	30	16	12	5
Other resection	154 (4.1%)	113	31	1	5	4
Typholotomy	153 (4.1%)	129	10	2	1	11
Other surgical procedure	145 (3.8%)	117	17	3	5	3
Other enterotomy	138 (3.7%)	67	49	5	9	8
Caecum 'other'	134 (3.6%)	104	16	4	9	1
Intestinal biopsy	125 (3.3%)	91	28	2	0	4
Side-to-side jejunocaecal anastomosis	113 (3.0%)	93	12	3	4	1
Large colon 'other'	91 (2.4%)	64	19	4	2	2
End-to-end jejunoileal anastomosis	84 (2.2%)	61	16	1	6	0
Small colon 'other'	77 (2.0%)	55	17	1	3	1
Adhesiolysis	47 (1.2%)	31	12	3	0	1
Large colon resection	37 (1.0%)	24	10	0	2	1
Epiploic foramen mesh placement	23 (0.6%)	23	0	0	0	0
Uterine reposition	20 (0.5%)	17	1	1	1	0
Gastric procedure	17 (0.5%)	6	2	0	9	0
Partial resection	15 (0.4%)	13	2	0	0	0
Large colon pexy	12 (0.3%)	5	1	1	5	0
Caecal bypass	7 (0.2%)	7	0	0	0	0
Diaphragm repair	4 (0.1%)	3	0	0	1	0

Postoperative Morbidity Data

Of those horses which underwent surgical treatment, 77.1% (n=2,908) were included in postoperative analysis having successfully recovered from general anaesthesia (77.1%; 2,905/3,766) or standing sedation (75.0%; 3/4). The most common postoperative morbidities identified during hospitalisation that were reported on the INCISE data platform were postoperative colic (25.7%; n=746) and intra-abdominal haemorrhage (21.7%; n=631). *Table 3.11* shows the postoperative morbidity incidence split by geographical region. *Figure 3.10* demonstrates the percentage incidence of each postoperative morbidity by geographical region.

Table 3.11: Postoperative morbidities that were recorded on the INCISE-2 data platform for all horses that survived surgery and anaesthesia, split by geographical region. SIRS = systemic inflammatory response syndrome.

MORBIDITY	ALL CLINICS	Europe	North America	Australasia	Asia	ROW
	Percentage of horses (n)					
Survived surgery	**n=2,908**	n=2,075	n=492	n=71	n=157	n=113
Postoperative colic	**25.7% (746)**	23.0% (478)	32.7% (161)	32.4% (23)	29.3% (46)	33.6% (38)
Intra-abdominal haemorrhage	**21.7% (631)**	20.5% (425)	22.0% (108)	43.7% (31)	20.4% (32)	31.0% (35)
Septic peritonitis	**19.0% (553)**	16.9% (351)	22.8% (112)	21.1% (15)	19.1% (30)	39.8% (45)
Postoperative reflux	**11.9% (345)**	11.9% (246)	7.7% (38)	19.7% (14)	14.6% (23)	21.2% (24)
Repeat laparotomy	**8.4% (244)**	6.7% (139)	9.3% (46)	19.7% (14)	14.0% (22)	20.4% (23)
Postoperative diarrhoea	**8.3% (242)**	7.7% (159)	9.6% (47)	9.9% (7)	10.8% (17)	10.6% (12)
Surgical site infection	**5.1% (149)**	4.6% (96)	5.9% (29)	4.2% (3)	6.4% (10)	9.7% (11)
SIRS-related laminitis	**2.3% (66)**	1.9% (40)	2.4% (12)	2.8% (2)	3.2% (5)	6.2% (7)
Postoperative pyrexia	**1.8% (51)**	1.3% (28)	2.0% (10)	2.8% (2)	5.1% (8)	2.7% (3)
Jugular thrombophlebitis	**1.2% (34)**	1.1% (22)	0.6% (3)	4.2% (3)	1.9% (3)	2.7% (3)
Dehiscence of the linea alba	**1.0% (29)**	1.0% (20)	1.2% (6)	1.4% (1)	0.6% (1)	0.9% (1)

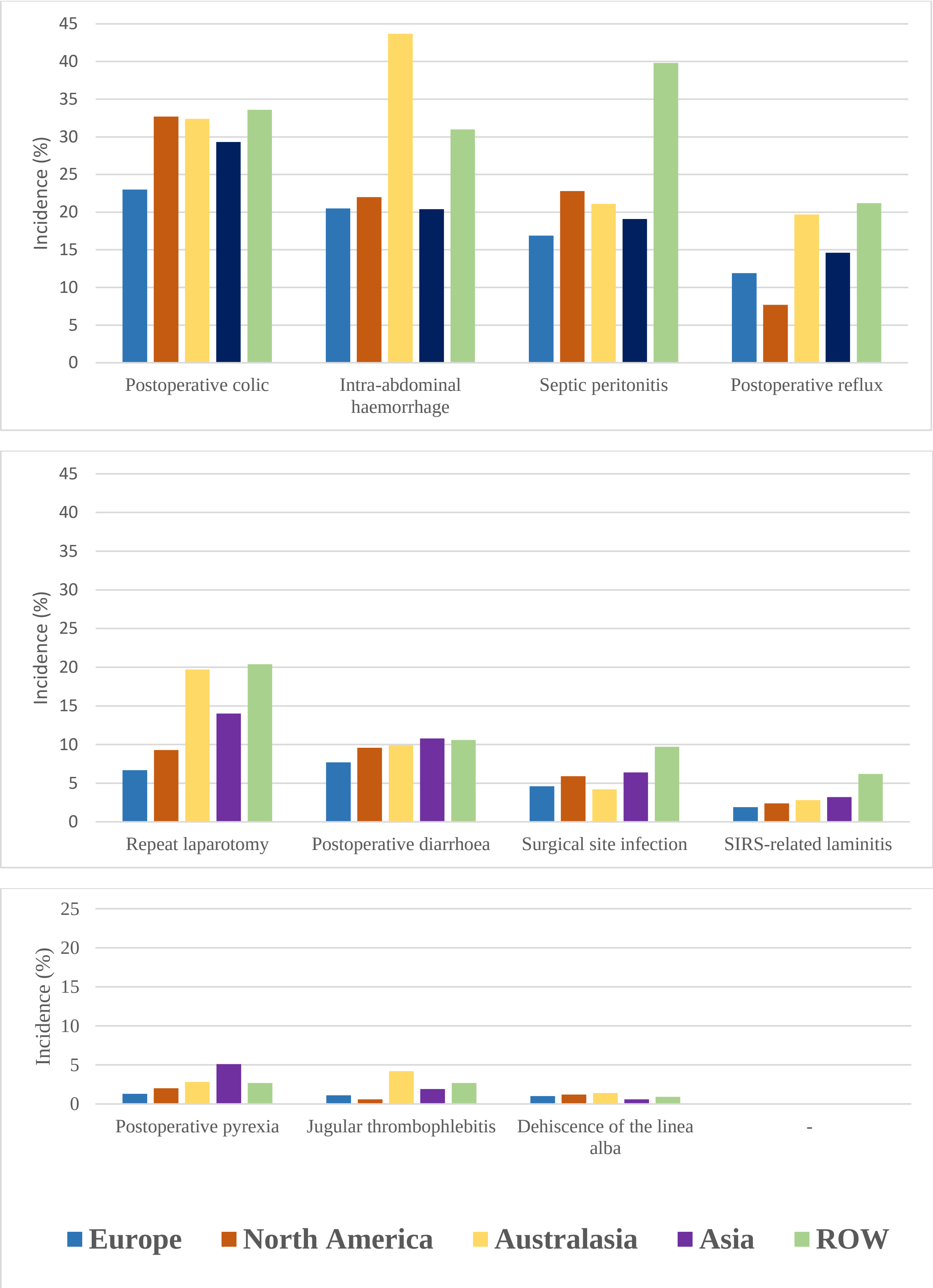


Figure 3.10: Percentage incidence (vertical axis) of each postoperative morbidity submitted to INCISE-2, split by geographical region.

The overall incidence of postoperative morbidities was greater in horses that died or were euthanased during hospitalisation than in horses that survived to discharge. This pattern was true for every morbidity except for postoperative reflux, which had a higher incidence in horses that survived (13.4%) than in horses that died or were euthanased (6.3%).

The incidence of postoperative morbidities reported on the INCISE-2 data platform was similar for horses admitted OOH and horses admitted during normal working hours. *Table 3.12* shows the postoperative morbidity rates for horses that died during postoperative care versus those that were discharged, and for horses admitted OOH versus those admitted during working hours.

Table 3.12: Postoperative morbidity data submitted to INCISE-2 for horses that died or were euthanased postoperatively versus those that survived to discharge, and for horses admitted out-of-hours (OOH) versus those that were admitted in normal working hours (WH).

MORBIDITY	**Horses that died or were euthanased during postoperative care (n=637)**	**Horses that were discharged from clinics (n=2,271)**	**Horses admitted:**	
			OOH (n=1,813)	**WH (n=1,095)**
Postoperative colic	49.0%	19.1%	25.3%	26.1%
Intra-abdominal haemorrhage	24.8%	20.8%	21.5%	22.1%
Septic peritonitis	41.3%	12.8%	19.2%	18.7%
Postoperative reflux	6.3%	13.4%	11.6%	12.3%
Repeat laparotomy	9.3%	8.1%	7.9%	9.2%
Postoperative diarrhoea	21.4%	4.7%	8.3%	8.4%
Surgical site infection	13.5%	2.8%	4.8%	5.7%
SIRS-related laminitis	3.3%	2.0%	2.3%	2.3%
Postoperative pyrexia	6.1%	0.5%	1.7%	1.9%
Jugular thrombophlebitis	2.4%	0.8%	1.2%	1.2%
Dehiscence of the linea alba	3.1%	0.4%	1.3%	0.5%

There was a large degree of variation in the incidence of postoperative morbidities recorded for the 10 most common primary lesions identified at surgery, as shown in *Table 3.13*.

Table 3.13: Postoperative morbidity data submitted to INCISE-2 for the 10 most common primary lesions. Cells are colour coded by frequency: <5.0% (white); 5.0-14.9% (yellow), 15.0-30.0% (amber),>30.0% (red).

MORBIDITY	Pedunculated lipoma strangulating small intestine	Right dorsal displacement of the large colon	Large colon volvulus >/=270º	Nephrosplenic entrapment of the large colon	Epiploic foramen entrapment
Postoperative colic	40.0%	23.0%	26.6%	13.8%	38.3%
Intra-abdominal haemorrhage	20.8%	18.3%	27.0%	15.1%	13.6%
Septic peritonitis	37.7%	11.0%	16.5%	6.9%	34.0%
Postoperative reflux	15.8%	13.1%	10.1%	9.5%	13.6%
Repeat laparotomy	7.3%	9.6%	16.0%	4.7%	3.7%
Postoperative diarrhoea	11.2%	6.4%	21.9%	3.0%	8.0%
Surgical site infection	8.5%	2.3%	4.6%	0.4%	8.0%
SIRS-related laminitis	2.3%	0.9%	1.3%	1.3%	3.1%
Postoperative pyrexia	0.8%	0.6%	1.7%	0.0%	0.6%
Jugular thrombophlebitis	0.8%	2.0%	0.8%	0.4%	0.6%
Dehiscence of the linea alba	1.9%	0.6%	1.3%	0.9%	1.2%

MORBIDITY	Ingesta impaction of the large colon	Small intestinal volvulus	Large colon volvulus <270º	Sand impaction of the large colon and/or small colon	Ileal impaction
Postoperative colic	16.6%	27.8%	14.8%	24.5%	25.8%
Intra-abdominal haemorrhage	25.2%	23.8%	20.0%	18.9%	19.4%
Septic peritonitis	14.7%	34.1%	9.6%	7.5%	28.0%
Postoperative reflux	9.8%	15.1%	10.4%	4.7%	15.1%
Repeat laparotomy	8.6%	10.3%	7.8%	7.5%	6.5%
Postoperative diarrhoea	9.2%	10.3%	6.1%	3.8%	3.2%
Surgical site infection	3.7%	4.8%	3.5%	4.7%	3.2%
SIRS-related laminitis	4.3%	4.8%	2.6%	2.8%	4.3%
Postoperative pyrexia	0.0%	0.8%	2.6%	1.9%	0.0%
Jugular thrombophlebitis	0.6%	1.6%	1.7%	1.9%	0.0%
Dehiscence of the linea alba	0.6%	0.8%	1.7%	0.9%	0.0%

Survival and Mortality Data

Preoperative mortality (horses that died or were euthanased following initial assessment) across all contributing clinics was 6.4% (257/4,027). This accounted for 5.8% of admissions in Europe (166/2,865), 6.8% in North America (47/692), 15.5% in Australasia (17/110), 0% in Asia (0/205) and 17.4% in the ROW (27/155). A diagnosis was not recorded in 52.9% of horses that died or were euthanased following initial assessment (136/257). For horses in which a diagnosis was recorded (47.1%; 121/257), this was confirmed by post-mortem examination in 26.4% (32/121) and was suspected in the remainder. The five most common diagnoses were: small intestinal strangulation (n=59); large colon displacement (n=13); large colon volvulus (n=12); small intestinal obstruction (n=9); gastrointestinal rupture (n=5). The reasons for preoperative death or euthanasia split by geographical region are shown in *Table 3.14* and *Figure 3.11*.

Table 3.14: Reasons for death for horses that were euthanased or died after initial assessment split by geographical region. N/A = not applicable.

CLINIC INFORMATION	NUMBER OF HORSES (%)				
	Died	Euthanased due to economic and welfare reasons	Euthanased due to economic reasons only	Euthanased due to welfare reasons only	Reason for euthanasia not recorded
ALL CLINICS	3 (1.2%)	109 (42.4%)	98 (38.1%)	30 (11.7%)	17 (6.6%)
Europe	2 (1.2%)	57 (34.3%)	70 (42.2%)	22 (13.3%)	15 (9.0%)
North America	1 (2.1%)	31 (66.0%)	9 (19.1%)	6 (12.8%)	0 (0%)
Australasia	0 (0%)	7 (41.2%)	8 (47.1%)	1 (5.9%)	1 (5.9%)
Asia	N/A	N/A	N/A	N/A	N/A
ROW	0 (0%)	14 (51.9%)	11 (40.7%)	1 (3.7%)	1 (3.7%)

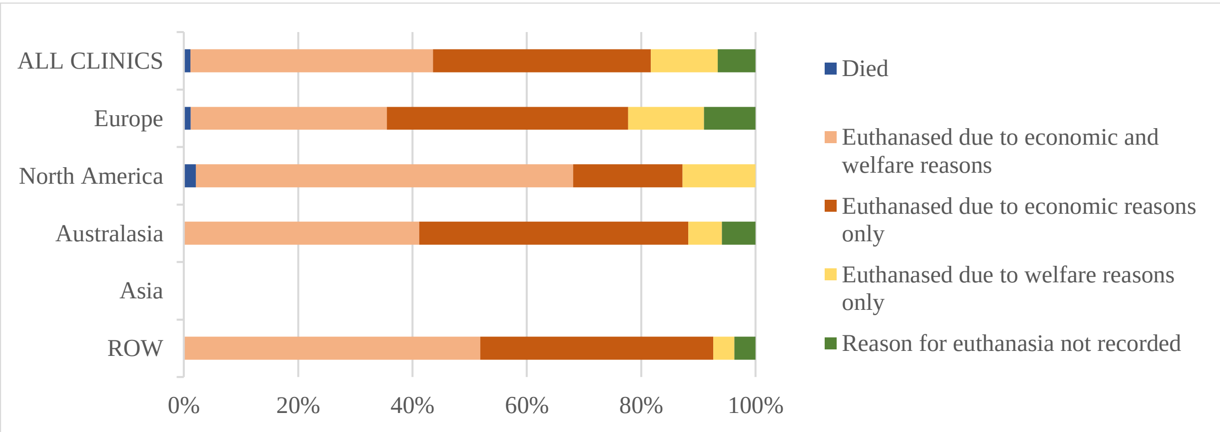


Figure 3.11: Reasons for death for horses that were euthanased or died after initial assessment split by geographical region.

Euthanasia or death during surgery was reported in 17.8% of horses undergoing surgical treatment (670/3,770), the majority of which were euthanased due to welfare reasons only (60.6%; 402/670). Intraoperative death was uncommon and occurred in 2.5% of all horses (range 0 - 7.3%) for which data was recorded on the INCISE-2 platform. The reasons for death or euthanasia of horses that died during surgery split by geographical region are shown in *Table 3.15* and *Figure 3.12*.

Table 3.15: Reasons for death for horses that were euthanased or died during surgery split by geographical region.

CLINIC INFORMATION	NUMBER OF HORSES (%)			
	Died	**Euthanased due to economic and welfare reasons**	**Euthanased due to economic reasons only**	**Euthanased due to welfare reasons only**
ALL CLINICS	17 (2.5%)	115 (17.2%)	136 (20.3%)	402 (60.0%)
Europe	11 (2.2%)	88 (17.3%)	106 (20.9%)	303 (59.6%)
North America	3 (3.3%)	23 (25.0%)	14 (15.2%)	52 (56.5%)
Australasia	0 (0%)	3 (17.6%)	2 (11.8%)	12 (70.6%)
Asia	3 (7.3%)	1 (2.4%)	12 (29.3%)	25 (61.0%)
ROW	0 (0%)	0 (0%)	2 (16.7%)	10 (83.3%)

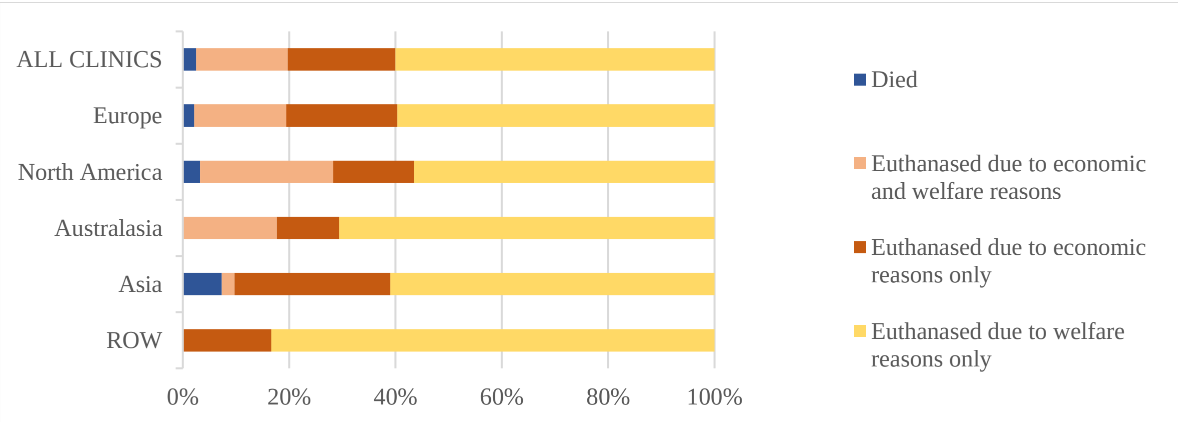


Figure 3.12: Reasons for death for horses that were euthanased or died during surgery split by geographical region.

Euthanasia or death during recovery from anaesthesia occurred in 6.2% of horses placed in recovery (192/3,100). Combining surgical mortality and anaesthetic recovery mortality led to an overall intraoperative mortality of 22.9% (862/3,770) across all contributing clinics. The surgical, anaesthetic recovery and overall intraoperative mortality rates split by geographical region are shown in *Table 3.16.*

The 10 most common lesions for horses that died intraoperatively were: pedunculated lipomas causing small intestinal strangulation (n=131); large colon volvulus greater than or equal to 270^{o} (n=126); epiploic foramen entrapment of the small intestine (n=60); small intestinal volvulus (n=44); mesenteric entrapment (n=24); right dorsal displacement of the large colon (n=24); gastric rupture (n=21); diaphragmatic hernia (n=17); adhesions causing small intestinal obstruction (n=16); ingesta impaction of the large colon (n=16).

Table 3.16: Surgical mortality, anaesthetic recovery mortality and overall intraoperative mortality split by geographical region.

CLINIC INFORMATION	SURGICAL MORTALITY	ANAESTHETIC RECOVERY MORTALITY	OVERALL INTRAOPERATIVE MORTALITY
ALL CLINICS	17.8%	6.2%	22.9%
Europe	18.8%	5.3%	23.1%
North America	14.3%	11.0%	23.7%
Australasia	18.3%	6.6%	23.7%
Asia	20.0%	4.3%	23.4%
ROW	9.4%	2.6%	11.7%

Postoperative mortality across all clinics was 21.9% (637/2,908). The majority of horses that recovered from surgery and anaesthesia, but did not survive to discharge, were euthanased due to welfare reasons only (44.6%; n=284) or a combination of welfare and economic reasons (20.1%; n=128). The reasons for postoperative death or euthanasia split by geographical region are shown in *Table 3.17* and *Figure 3.13*. The rates of postoperative mortality and survival to hospital discharge split by geographical region are shown in *Table 3.18*. These rates were broadly similar across the different geographical regions.

Table 3.17: Reasons for death for horses that were euthanased or died postoperatively split by geographical region.

CLINIC INFORMATION	NUMBER OF HORSES (%)				
	Died	Euthanased due to economic and welfare reasons	Euthanased due to economic reasons only	Euthanased due to welfare reasons only	Reason for euthanasia not recorded
ALL CLINICS	63 (9.9%)	128 (20.1%)	22 (3.5%)	284 (44.6%)	140 (22.0%)
Europe	48 (10.1%)	100 (21.1%)	20 (4.2%)	187 (39.5%)	119 (25.1%)
North America	7 (8.2%)	16 (18.8%)	2 (2.4%)	54 (63.5%)	6 (7.1%)
Australasia	3 (20.0%)	6 (40.0%)	0 (0.0%)	4 (26.7%)	2 (13.3%)
Asia	5 (12.2%)	3 (7.3%)	0 (0.0%)	25 (61.0%)	8 (19.5%)
ROW	0 (0.0%)	3 (13.6%)	0 (0.0%)	14 (63.6%)	5 (22.7%)

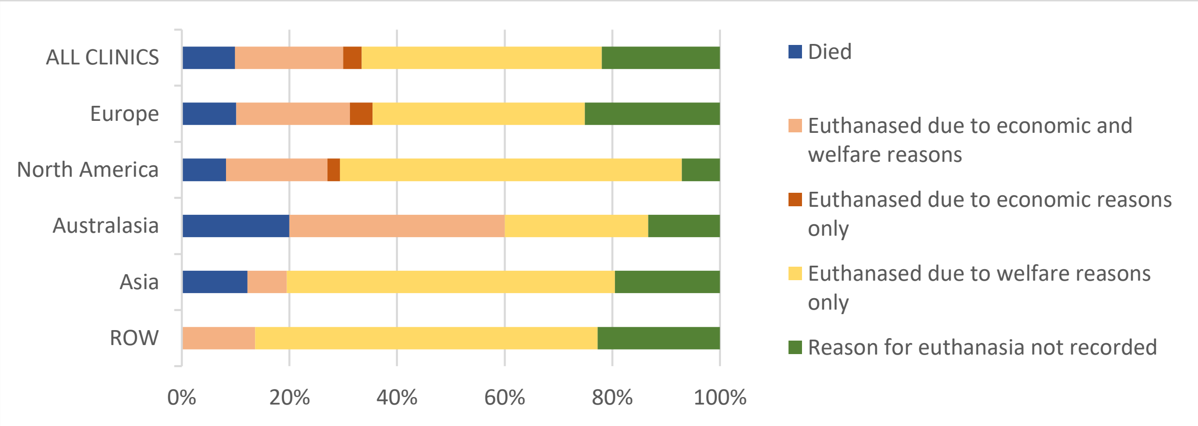


Figure 3.13: Reasons for death for horses that were euthanased or died postoperatively split by geographical region.

Table 3.18: Rates of postoperative mortality and survival to hospital discharge split by geographical region.

CLINIC INFORMATION	POSTOPERATIVE MORTALITY	SURVIVAL TO HOSPITAL DISCHARGE OF:		
		Horses admitted with a surgical lesion	Horses that underwent surgical treatment	Horses that survived surgery and anaesthesia
ALL CLINICS	21.9%	56.4%	60.2%	78.1%
Europe	22.8%	55.9%	59.3%	77.2%
North America	17.3%	58.8%	63.1%	82.7%
Australasia	21.1%	50.9%	60.2%	78.9%
Asia	26.1%	56.6%	56.6%	73.9%
ROW	19.5%	58.7%	71.1%	80.5%

Rates of survival to hospital discharge split by all horses undergoing surgical treatment and for those that survived surgery and anaesthesia split by the 10 most common primary lesions are shown in *Table 3.19*. The primary lesion with the highest rates of overall and postoperative survival was nephrosplenic entrapment of the large colon (86.9% and 88.4% respectively). For all horses undergoing surgery, including those that died or were euthanased intraoperatively, survival to hospital discharge was lowest for large colon volvulus greater than or equal to 270º (46.2%), followed by pedunculated lipoma strangulating obstruction of the small intestine (48.4%), epiploic foramen entrapment (49.6%) and small intestinal volvulus (51.2%). The same four primary lesions had the lowest rates of survival to hospital discharge for horses that survived surgery and anaesthesia (epiploic foramen entrapment 67.9%; small intestinal volvulus 69.0%; large colon volvulus greater than or equal to 270º 70.9%; pedunculated lipoma strangulating obstruction of the small intestine 71.3%).

Table 3.19: Proportion of horses that survived to hospital discharge reported for the 10 most common primary lesions.

PRIMARY LESION	SURVIVAL TO HOSPITAL DISCHARGE OF:	
	Horses that underwent surgical treatment	Horses that survived surgery and anaesthesia
Pedunculated lipoma strangulating small intestine	48.4%	71.3%
Right dorsal displacement of the large colon	79.9%	85.5%
Large colon volvulus >/=270º	46.2%	70.9%
Nephrosplenic entrapment of the large colon	86.9%	88.4%
Epiploic foramen entrapment	49.6%	67.9%
Ingesta impaction of the large colon	74.9%	82.2%
Small intestinal volvulus	51.2%	69.0%
Large colon volvulus <270º	82.1%	87.8%
Sand impaction of the large colon and/or small colon	79.1%	85.8%
Ileal impaction	73.0%	78.5%

DISCUSSION

This chapter is the first patient-level report of the INCISE project (INCISE-2) and includes data from 63 veterinary clinics that perform colic surgery, representing private and academic clinics across multiple countries. This is the first time that such data has been collected at a global level on a co-ordinated, simultaneous basis. INCISE-2 aimed to generate benchmark rates of morbidity and mortality for horses undergoing colic surgery. Outcomes, from the largest database of surgical cases to date, have been stratified by geographical region and by the 10 most common primary lesions. It is intended that these can be used as standards against which clinics can compare their own results to facilitate clinical audit. This data will also assist veterinary surgeons and horse owners when making informed decisions around treatment of horses with colic.

As detailed in Chapter Two, the INCISE project invited participation from all clinics across the world identified to offer emergency laparotomy for treatment of colic. The clinics that contributed data to INCISE-2 comprised predominantly those who submitted data for the organisational audit (INCISE-1), together with those who joined the project after data collection for INCISE-1 had been completed. Although the number of equine clinics that offer this service around the world is unknown, data were submitted by 27.9% of clinics that were invited to participate in INCISE. As these data can only be collected on a voluntary basis and there is no formal requirement to record them, it would have been impossible to obtain data from all clinics and for all horses undergoing colic surgery. Whilst it is possible that there may have been some bias between clinics that did and did not decide to contribute to INCISE, the key features of clinics presented demonstrate that data were submitted by a range of clinic types from multiple different regions with varying colic caseloads. Therefore, these results are relevant to all equine clinics that undertake colic surgery.

Of note, most contributing clinics were private clinics (61.9%). The latter are a group that is relatively under-represented in terms of published colic surgery data when compared to academic clinics. Their inclusion was important to ensure data from INCISE-2 were of maximum use to clinics around the World. Just over half of contributing clinics (54.0%) and over two-thirds of submitted patient data (71.1%) were from clinics located in Europe, which may introduce some imbalance in the overall data presented. However, data were deliberately split by geographical region to account for any such imbalance. Results were not reported by country in this initial phase of analysis as, for some countries, this may have enabled individual clinics to be identified. Confidentiality of data was one of the key barriers that Mair and White (2008) identified when investigating the feasibility of setting up an international colic surgery database and was an important aspect of the INCISE project when obtaining informed consent to use data from individual clinics.

Measuring clinical performance and comparing this to an agreed standard is the fundamental starting point of a successful clinical audit. Direct comparison between different clinics is a more difficult task and a sensitive issue, which can dissuade veterinary surgeons from engaging with audit projects (Mair and White, 2008; Viner, 2009). QI should be undertaken at individual clinics to identify any deficiencies in care so that improvements can be made. However, it is essential to account for confounding factors which may account for differences between clinics. One way to achieve this is by using a standard obtained from a clinic, or group of clinics, where the conditions and population are similar to your own, or as close as possible. For example, doctors are more likely to trust and engage with audits that use local standards (Loughlan, 2011). To increase the value of INCISE-2 to colleagues around the world, key findings have been stratified by geographical region. The importance of doing this is highlighted by the variation in patient-level factors, such as median age and breed distribution, between different regions that was identified in this study. Other differences were also apparent. For example, none of the horses admitted to clinics in Asia were euthanased prior to surgery, which was not the case in any other region. Attitudes to animal welfare, economics and a variety of other factors can vary between countries and this is likely to affect decision-making of owners and veterinary surgeons.

The underlying pathological cause of colic signs is another important factor to consider when comparing outcomes of colic surgery. The relative distribution of lesions in INCISE-2 was similar across each of the geographical regions. However, the type and distribution of lesions may vary markedly between clinics, adding to difficulties in making direct comparisons. Numerous published studies have demonstrated that rates of morbidity and mortality vary with surgical lesion (Phillips and Walmsley, 1993; Santschi *et al*, 2000; Mair and Smith, 2005a; Christophersen *et al*, 2014; Wormstrand *et al*, 2014; Dybkjær *et al*, 2022). To account for this and allow clinics to focus on specific lesions of interest to them, the results of this study have also been stratified by the 10 most common primary lesions. Ongoing analysis of INCISE-2 data will also report outcomes stratified by heart rate and PCV, both of which are key preoperative risk factors for survival following colic surgery. This will provide benchmark data stratified by patient risk that will help clinics to account for underlying differences between individual horses undergoing colic surgery.

Like previous studies, INCISE-2 has demonstrated that rates of morbidity and mortality vary between differing lesions. However, the factors that may account for different outcomes within a specific lesion type have not been investigated. This would require collection of additional data that were deemed impractical to obtain during the initial design of the INCISE project. Controllable factors that are associated with poorer outcomes should continue to be a focus for future work, but are best investigated by prospective, well-designed clinical research studies. This will allow the identification of key areas in which change implementation may improve outcomes. An alternative approach is the adoption of clinical audit at individual clinics wishing to evaluate a specific aspect of care. For example, a clinic may identify that their rate of surgical site infections amongst patients undergoing surgical treatment of sand impactions compares unfavourably with the benchmark data provided by INCISE. That clinic could then undertake a clinical audit of these cases, collecting additional data that will help elucidate reasons for the disparity in their outcomes and changes that should be introduced to improve quality of care.

Rates of survival to hospital discharge among all surgically treated horses (60.2%), and horses that recovered from surgery (78.1%), are similar to those reported by previous studies that have considered multiple lesions rather than focusing on one diagnosis or procedure (Mair and Smith, 2005a; Christophersen *et al*, 2014; Wormstrand *et al*, 2014; Dybkjær *et al*, 2022). These studies were all conducted at European clinics and the majority of horses included in INCISE-2 were also treated at European clinics, which could account for these similarities. Some variation in the short-term survival rates of different geographical regions was identified in this study, though the significance and cause of this variation was not assessed. Similar variation has been found by research studies conducted at clinics outside of Europe (Sutton *et al*, 2009; Voigt *et al*, 2009). However, closer appraisal reveals large differences in the distribution of lesion types represented by these studies in comparison to published data from Europe. Comparison between regions in this study was precluded by the large differences in the number of cases that each region contributed. Furthermore, that was not the intention of this study, in which stratification of outcomes by region has only been done to provide local standards for clinics to conduct clinical audits. Further analysis of data stratified by level of patient risk may also help to explore these differences in outcome and would provide additional benchmarking data at a global and regional level.

The incidence of most morbidities reported in this study fall within previously reported ranges (Mair and Smith, 2005b; Salem *et al*, 2016; Gardner and Dockery, 2019). However, these vary widely between published studies which is, in part, attributable to the different populations and lesion types investigated. Comparison of these studies is further complicated by the different definitions and inclusion criteria used by different groups (Salem *et al*, 2016; Gandini *et al*, 2022). To combat this difficulty, definitions of each morbidity were provided at the point of data entry on the INCISE platform. The incidence of surgical site infection (5.1%), postoperative pyrexia (1.8%) and jugular thrombophlebitis (1.2%) were much lower than expected based on previous reports (Proudman *et al*, 2002a; Mair and Smith, 2005b; Salem *et al*, 2016) and the anecdotal experience of the author. This may be due to under-reporting of these morbidities. It is possible that all morbidities were under-reported as this is a common problem in veterinary and human medicine (Pang *et al*, 2018) and this is made more likely by retrospective data collection. Although data for many cases included in INCISE-2 were added retrospectively, it is hoped that most cases will be added contemporaneously as clinics get used to using the website and that this will improve recording of morbidities. The rates of intra-abdominal haemorrhage (21.7%) and septic peritonitis (19.0%) were much higher than expected based on previous reports (Mair and Smith 2005b; Salem *et al*, 2016). Further exploration of these data will be undertaken to explore whether these are real findings or are due to website or user-related errors.

The information collected for INCISE-2 was intended to be a pragmatic approach that balanced the desire to collect all data that were considered of interest with the need to minimise the demands on clinicians entering the data. This required compromise to achieve what was considered a realistic but useful dataset that focused on key factors likely to influence outcomes. The primary purpose of this stage of the project was to establish a user-friendly audit tool that allows the production of benchmark data for various outcomes. Although some clinics have added data retrospectively, this study has demonstrated that the INCISE website allows easy input of patient-level data as cases progress through hospitalisation and accurately collects these data to produce audit reports. Additional information can be collected in future stages that may elucidate areas for change implementation, but this should remain as targeted as possible to improve compliance and make the process efficient for contributing clinics.

Additional data were collected as part of INCISE-2 which have not been included in this preliminary analysis. These included duration of surgery, duration of anaesthesia, time taken to return to normal feed and oral fluids, and duration of hospitalisation. These data were particularly prone to errors in data entry which could not be adequately corrected due to time limitations on this initial analysis. The errors were largely attributable to two main areas. Firstly, most data were collected using drop-down lists of options aimed at increasing the speed of entry. However, the default option for most drop-down boxes was a valid date or multiple-choice option which was transferred to the CSV file unless clinics actively changed the default setting, thus introducing multiple errors. This could be improved by making the default option 'No data added' or a similar option that would make missing data easily identifiable. The second common cause of error was accidental entry of the incorrect date or time entry which caused obvious inaccuracies in duration of surgery or anaesthesia for some cases. This was caused by human error and is more difficult to control. However, it would be possible to add automated error alerts that inform clinics of likely inaccuracies when they enter an incorrect time or date. For example, if a horse had a calculated surgery time longer than 8 hours the website could be programmed to ask clinics to double-check the data entry for that horse. Whilst electronic data collection has major benefits, as already outlined, design of bespoke data collection tools is complex and has to take into account software capabilities and limitations, the time and cost of software development and methods of manually or automatically checking of data queries.

In conclusion, this chapter reports the first exploratory analysis of data collected by INCISE-2. Data submitted by a range of clinic types in different geographical locations has been used to generate key outcome data to facilitate clinical audit. Analysis of data is ongoing and will be used to generate formal benchmarks that will be published for use by veterinary clinics and the wider equine industry.

CHAPTER FOUR

FINAL CONCLUSIONS

Colic signs in horses have a multitude of possible aetiologies that vary in severity and have a range of pathophysiological effects. These clinical signs may resolve with conservative management, with or without veterinary treatment, or may require surgical intervention (or euthanasia where surgery is not a treatment option). Colic surgery in horses is a complex procedure requiring a team of trained personnel, suitable facilities, and the willingness of owners to invest significant money and time into the treatment and rehabilitation of their horses. Morbidity and mortality rates for horses undergoing emergency laparotomy are high relative to other equine surgical procedures. It has been suggested that horse owners have a right to see evidence that treatment of their animal is appropriate and meets optimum standards (Mair, 2009). Clinics should aim to perform colic surgery and subsequent aftercare as efficiently and competently as possible (Mair, 2009; Freeman, 2018a). Clinical audit can be used to achieve these goals and to identify areas where improvements are required. This thesis describes the initial steps in the establishment of the International Colic Surgery Audit (INCISE). The data represent the first two phases of the INCISE project, which report the infrastructure, processes and outcomes of colic surgery at a large number of contributing clinics.

The establishment of an international colic surgery database was first suggested by Mair and White (2005). This work provided the essential foundations for the INCISE project. Clinical audit was relatively infrequently undertaken within the veterinary profession at that time and Mair and White helped to educate equine veterinary professionals about the key principles of clinical audit and how it could be used in the field of equine colic surgery. In the absence of regulatory requirements to provide patient outcome data, this process is reliant on the willingness of veterinary professionals to engage with clinical audit and data collection. Understanding barriers and motivators to setting up the proposed database was a fundamental next stage, engaging potential stakeholders to help understand what factors would encourage or dissuade submission of outcome data (Mair and White, 2008). The INCISE project used this information, particularly issues raised around anonymity and use of data, as the project was being developed. The fact that around a quarter of invited clinics submitted data to the INCISE platform was encouraging and it is hoped that other clinics may start to engage with this toolkit once the results of INCISE-1 and -2 are published.

The results of INCISE-1 demonstrate current variations in facilities, personnel and patient care across a variety of different equine clinics undertaking colic surgery globally. This work provides a snapshot of information that can be used to monitor changes and trends over time. It is important to note that OOH staffing and provision of care is important for clinics that undertake equine colic surgery. The results of INCISE-2 highlight this, with 61.8% of cases being admitted OOH. As demonstrated in INCISE-1, staffing is reliant on a large team that may or may not include veterinary surgeons with specialist expertise in equine surgery, internal medicine and other disciplines. ‘Hands on’ patient care has been shown to be reliant on junior veterinary surgeons (interns) and veterinary nurses or technicians in many contributing clinics. Concerns have been raised within the veterinary profession in many countries regarding current shortages in the veterinary workforce and, in particular, a current reduction in the number of veterinary surgeons entering and remaining in equine clinical work (American Association of Equine Practitioners, 2022). This could have important implications for equine clinics and the general provision of equine colic surgery, which should be monitored with ongoing clinical audit.

The data collected for INCISE-1 and -2 will be used to establish benchmarks that can be used at individual clinic level, and more widely, to assess and compare standards of care in equine colic surgery. In addition, they can be used to identify areas for change implementation and improvement, a process that will involve the INCISE team and collaborating clinics. It should also include a range of other stakeholders, such as equine veterinary surgeons working in first-opinion ambulatory practice, specialist veterinary clinicians across various clinical disciplines and horse owners. This will assist generation of evidence-based recommendations by the INCISE collaboration and will form the basis of future work to define multidisciplinary guidance around standards of care. Crucially, the INCISE project (and clinical audit in general) should not be a finger-pointing exercise. Instead, it is intended to be a collaborative effort to improve standards of care across all contributing clinics. Data was sought from as many clinics as possible so that the findings are a true representation of current clinical practice, with the aim of making practical, achievable recommendations for improvement that are financially realistic. As outlined in Chapter One, the collection of data for INCISE-1 and -2 does not constitute a clinical audit cycle and will not in itself improve quality of care. To improve healthcare, audit must include a mechanism for change (Williams, 1996) and it is hoped that the INCISE project will help to achieve this.

Time for planning, data collection and analysis is essential for successful clinical audit and inadequate time is the most frequently cited barrier to the process. The same is true of any clinical governance or research activity and must be a consideration for the future success of INCISE, which should be measured by its capacity to stimulate genuine improvement in the care of horses undergoing colic surgery. Thus far, the project has generated a very large database requiring long periods of data cleaning and analysis. This thesis has performed initial analyses and exploration of the data to produce valuable standards to facilitate clinical audit at individual clinics. However, due to time constraints, the analyses have been superficial and limited. Further, in-depth analysis is ongoing and may be used to elucidate trends between regions and aspects of care, which in turn can be used to identify changes that should be introduced globally. In addition to providing comparative information regarding organisational and outcome criteria, National Clinical Audit programmes in human healthcare, such as NELA, facilitate the development of effective change initiatives and make national recommendations of what constitutes best practice (Burgess, 2011; NELA, 2014). To do this they require vast investment of resources and the dedicated time of a large audit team. Although on a smaller scale, INCISE has similar objectives which may be achieved by further analysis and collaboration with colleagues from clinics around the world. Achieving the full potential of the project is likely to require a larger audit team and funding for a greater time commitment from this team.

Ongoing management of the database also requires careful consideration. INCISE represents a collaboration between a large number of private and academic clinics across the world, of a scale which has not previously been undertaken in equine colic surgery. The task of collecting, appraising and protecting these data carries tremendous responsibility. The fact this has been done by one academic institution, albeit with a large input from colleagues at other centres, is one point of criticism that could be levelled at the project. However, it could also be viewed by some as a way to ensure that data is housed within an academic organisation that is independent of commercial organisations, including veterinary corporate companies, and where the data can be protected and managed in an ethical, co-ordinated and collaborative way.

The way a multicentre audit is initiated and administrated is a complex issue with sensitive professional considerations and logistical difficulties. It has been proposed that it should be performed by a professional body, such as the RCVS or at speciality board level (McIlwraith, 2000), or by interested parties coming together to form an independent research group. Concerns regarding anonymity and handling of clinic and surgeon data are important barriers to involvement in such a project (Mair and White, 2008) so it is crucial that there is widespread trust in those responsible for its management. It is also important that those leading the project provide energy and strong direction to ensure it continues to be a useful and active force for change. Whatever the next stages of the INCISE project are, the focus should be on using the findings from the first two phases to instigate quality improvement (QI) initiatives. Proposing, implementing and successfully embedding change is difficult in even simple, hierarchal institutions, even where the benefits of change are self-evident. The difficulties and time taken to set up INCISE are indicative of the challenges involved in introducing change to a multi-national, regionally diverse and varied equine veterinary profession. There are many variables and complicating factors, however, these are too often excuses, rather than substantive reasons, for not implementing change where evidence indicates it is required.

As with many areas of colic research, previous studies of long-term surgical outcomes have been performed at single centres (Proudman *et al*, 2002a,b; Mair and Smith, 2005c; Immonen *et al*, 2017). Collection of data regarding long-term recovery and prognosis will provide useful information for veterinary surgeons and horse owners, as has been demonstrated by INCISE-2 with regards to short-term outcomes. In this thesis, only data up to the point of hospital discharge has been presented and a small number of clinics have entered ongoing follow-up of patient outcomes on the platform. However, this requires a further time commitment by veterinary clinics which may limit the ability of contributing clinics to provide such data. One way to assist generation of follow-up data is to engage the owners and carers of horses that have undergone colic surgery to engage with data collection. This is an area that is being explored currently and may evolve into creation of a colic surgery registry, similar to registries established in the human medical field.

In summary, the work presented in this thesis provides information about the current provision of colic surgery around the world, the infrastructure in place at clinics offering this service and has described the impact of COVID-19 on contributing clinics during the early stages of the pandemic. In addition, key colic surgery outcomes from the first patient-level report of the INCISE project have been presented. INCISE has developed an international colic surgery database and has engaged a large number of clinics, representing a range of clinic types from across the world. Development of a bespoke, website-based, audit data collection tool has enabled users to enter data easily, confidentially and has enabled key benchmark data to be generated. These data can be used by individual clinics to facilitate their own clinical audits and the platform will be continued and developed further to assist repeat and new audit cycles. It is hoped that the INCISE project serves as a model that may help to promote wider clinical audit within the veterinary profession and that our findings and experiences can be shared to assist development of other veterinary audits and audit toolkits.

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APPENDIX ONE: Questionnaire used to collect data for INCISE-1

Colic Research Questionaire

Please complete the questionnaire online.

A paper (PDF) copy is available to assist entering the data onto the online questionnaire.

'SET PROTOCOLS' are defined as protocols that are written down or if not written down, are explicitly known by clinic personnel;

SECTION A: HOSPITAL FACILITIES AND CLINICAL STAFF

1 **When do you offer colic surgery?**

- ○At all times (365 days per year, 24 hours a day)
- ○Some of the time (e.g. depending on which staff are working)

2 **Who do you offer colic surgery to?**

- ○Your practice clients and referral clients
- ○Practice clients only
- ○Referral clients only

3 **How many horses were admitted to your clinic for investigation of colic in 2019 (exact or approximate)?**

3.2 3.2 Exact or Approximate

Exact

4 **How many exploratory laparotomies for signs of colic were performed at your clinic in 2019 (exact or approximate)?**

4.2 4.2 Exact or Approximate

Exact

5 **How many clinicians undertake colic surgery as the primary surgeon at your clinic?**

6 **For each of these clinicians please complete the following information, ticking all that apply. We do not require any names. For any additional surgeons please fill their details in the 'Notes' section (question 57) under the heading 'Question 6'.**

	Residency training in surgery	Residency training in another discipline	RCVS Advanced Practitioner Status or equivalent qualification in surgery	Diplomate in equine surgery	Diplomate in another equine specialty
Clinician 1	☐	☐	☐	☐	☐
Clinician 2	☐	☐	☐	☐	☐
Clinician 3	☐	☐	☐	☐	☐
Clinician 4	☐	☐	☐	☐	☐
Clinician 5	☐	☐	☐	☐	☐
Clinician 6	☐	☐	☐	☐	☐

Clinician 1 - Approximate years experience performing colic surgery

Clinician 2 - Approximate years experience performing colic surgery

Clinician 3 - Approximate years experience performing colic surgery

Clinician 4 - Approximate years experience performing colic surgery

Clinician 5 - Approximate years experience performing colic surgery

Clinician 6 - Approximate years experience performing colic surgery

7 **How many clinicians who perform colic surgery share the out-of-hours rota?**

8 **Do you have any staff dedicated to emergency cases only during normal working hours (i.e. kept free of routine appointments)?**

- Yes
- No

9 **Do you have any dedicated out-of-hours staff (i.e. shift-based night cover instead of 'on call' after a normal working day)?**

9.1 9.1 Nurses/technicians

- Yes
- No

9.2 9.2 Interns

- Yes
- No

9.3 9.3 Surgeons

- Yes
- No

9.4 9.4 Anaesthetists

- Yes
- No

9.5 9.5 Students

- Yes
- No

9.6 9.6 Other

- Yes
- No

10 **How many clinicians share the anaesthesia out-of-hours rota?**

11 **How many of the following work full time at your clinic?**

11.2 11.1) Diploma-holding specialists in large animal/equine internal medicine

11.3 11.2) Diploma-holding specialists in emergency and critical care

11.4 11.3) Diploma-holding specialists in anaesthesia and analgesia

11.5 11.4) Diploma-holding specialists in imaging

11.5 11.5) Certificate-holders in any of the above disciplines (who do not also have a diploma)

11.6 11.6) Qualified veterinary nurses or technicians (e.g. RVN/EVN/ET or equivalent)

11.7 11.7) Student veterinary nurses or technicians

11.8 11.8) Intern veterinarians

11.9 11.9) Veterinarians enrolled in specialist residency training programmes

11.10 11.10) Ambulatory veterinarians

11.11 11.11) Veterinarians who do not fit into any of the above categories

12 **How many operating theatres are at your clinic?**

13 **How many of these theatres are routinely used for colic surgery?**

14 **How many stables/stalls at your clinic are suitable for housing colic patients on intravenous fluid therapy?**

15 **Do you have a dedicated intensive care unit/barn for the care of critical patients?**

- ○Yes
- ○No

16 **Do you have camera monitoring in stables/stalls used for colic patients?**

- ○No
- ○Some stables used for colic patients
- ○All stables used for colic patients

17 **Do you have isolation stables/stalls available at your clinic?**

- ☐None
- ☐Normal stables are adapted for isolation use
- ☐One specific isolation stable
- ☐More than one specific isolation stable

SECTION B: ADMISSION AND INVESTIGATION

18 **Who has primary responsibility for the admission and initial investigation of colic cases at your clinic?**

	Never	Sometimes	Most Often	Always
Intern	○	○	○	○
Resident	○	○	○	○
Primary surgeon	○	○	○	○
Internal medicine or Critical care specialist	○	○	○	○

Other hospital veterinarian	○	○	○	○

Ambulatory veterinarian	○	○	○	○

19 **Who makes the decision that a horse with colic requires surgery?**

	Never	Sometimes	Most Often	Always
Intern	○	○	○	○
Resident	○	○	○	○
Primary surgeon	○	○	○	○
Internal medicine or Critical care specialist	○	○	○	○
Other hospital veterinarian	○	○	○	○
Ambulatory veterinarian	○	○	○	○

20 **What is the minimum number of staff present for every colic admission?**

	No minimum	1	2	3 or more
Veterinarians and nurses/technicians combined	○	○	○	○
Veterinarians	○	○	○	○
Nurses/technicians	○	○	○	○
Students	○	○	○	○

21 **For each diagnostic test listed, please indicate how often it is used in colic investigations at your clinic. Please assume immediate surgery due to uncontrollable pain is not indicated.**

	Never	Sometimes	Most Often	Always
Packed cell volume and total protein	○	○	○	○
Full haematology	○	○	○	○
Routine biochemistry profile	○	○	○	○
Blood lactate	○	○	○	○
Blood gas analysis	○	○	○	○
Electrolytes	○	○	○	○
Abdominal ultrasonography	○	○	○	○
Rectal examination	○	○	○	○
Nasogastric intubation	○	○	○	○
Abdominocentesis	○	○	○	○
Abdominal radiography	○	○	○	○
Peritoneal fluid lactate	○	○	○	○

Peritoneal fluid total protein	○	○	○	○
Peritoneal fluid nucleated cell count	○	○	○	○

22 **Do you have a set protocol for the order of diagnostic processes used when investigating colic cases?**

○Yes

○No

23 **Do you have a specific recording sheet/document for colic admissions (i.e. for history and clinical findings)?**

○Yes

○No

24 **Do you use a set protocol for abdominal ultrasonography of colics?**

○Full abdominal scan

○FLASH protocol (fast localised abdominal sonography of horses)

○No protocol

○Not performed

○Other protocol, please specify

25 **Do you have a set protocol regarding the number of people performing a rectal examination on one horse?**

○No protocol

○Maximum 1 person

○Maximum 2 people

○Maximum 3 people

26 **Do you have a set protocol regarding medication administration prior to rectal examination?**

○No protocol

○All cases receive butylscopolamine

○All cases receive sedation

○All cases receive butylscopolamine and sedation

○Butylscopolamine and sedation are not co-administered

○Other protocol, please specify

27 **Do you have a set protocol regarding location of abdominocentesis?**

○No protocol

○Midline

○Right of midline

○Always ultrasound-guided

○Other, please specify

28 **Do you have a set protocol regarding method of abdominocentesis?**

○Hypodermic needle (1-2 inches)

○Spinal needle

○Teat cannula

○No set protocol

○Other, please specify

29 **Question 30 relates to financial estimates. Please type out the currency you will be using to answer it (e.g. Euro, US dollar, British pound e.t.c.)**

30 **For the following case scenarios, please indicate what you would be likely to estimate as the cost of complete surgical treatment (until discharge with no unforseen complications) at your clinic**

surgical treatment (until discharge with no unforseen complications) at your clinic.

Left dorsal displacement of the large colon, nonresponsive to medical therapy and uncontrollable with analgesia, in a systemically well horse (packed cell volume < 40%, blood lactate < 2mmol/L, no clinical signs of endotoxaemia)	-- Plea
Strangulating small intestinal lesion with no resection required, in a systemically well horse (packed cell volume < 40%, blood lactate < 2mmol/L, no clinical signs of endotoxaemia)	-- Plea
Strangulating small intestinal lesion requiring resection and a jejunocaecal anastomosis in a sick horse (packed cell volume > 45%, blood lactate > 4mmol/L, with or without signs of endotoxaemia)	-- Plea

SECTION C: PERIOPERATIVE PERIOD

31 **What is the minimum number of employed members of staff (or veterinary student assistants) in theatre for every colic surgery?**

	No minimum	1	2	3 or more
Veterinarians and nurses/technicians combined	○	○	○	○
Veterinarians	○	○	○	○
Nurses/technicians	○	○	○	○
Students	○	○	○	○

32 **How many members of staff scrub into each colic surgery in addition to the primary surgeon?**

	None	Sometimes none, sometimes more if required	Always 1 or more if required	Always 2 or more if required
Working hours	○	○	○	○
Out-of-hours	○	○	○	○

33 **Who is responsible for general anaesthesia of colic patients? This should be the person actually present and directly overseeing the anaesthetic. If this is variable please tick all potential answers.**

	Intern veterinarian	Experienced veterinarian (>2 years equine experience)	Veterinary nurse or technician	Diploma holder in Veterinary Anaesthesia and Analgesia	Certificate holder in Veterinary Anaesthesia
Out-of-hours	☐	☐	☐	☐	☐
Working hours	☐	☐	☐	☐	☐

34 **Which of the following anaesthetic equipment is available at your clinic? Please tick all that apply.**

	Available	Regularly Used
Electrocardiogram monitor (ECG)	☐	☐
Non-invasive blood pressure monitoring	☐	☐

Invasive blood pressure monitoring	☐	☐
Blood gas analysis	☐	☐
Fluid pumps for controlled constant rate infusion administration	☐	☐
Controlled mechanical ventilation	☐	☐
End tidal carbon dioxide monitoring	☐	☐
End tidal anaesthetic gas monitoring	☐	☐
Pulse oximetry	☐	☐

35 **Do you have any set anaesthesia protocols for the following at your clinic?**

	Set protocol always followed	**Set protocol in most cases with few exceptions**	**Set protocol sometimes followed**	**No specific protocols**
Induction of anaesthesia	○	○	○	○
Choice of anaesthetic drugs for colics	○	○	○	○
Fluid therapy during colic anaesthesia	○	○	○	○
Intraoperative prokinetic therapy	○	○	○	○
Assisted anaesthetic recovery	○	○	○	○

36 **Do you have any set surgical protocols for the following at your clinic?**

	Set protocol always followed	**Set protocol in most cases with few exceptions**	**Set protocol sometimes followed**	**No specific protocols**
Pre-surgical checklists	○	○	○	○
Preoperative antimicrobial treatment	○	○	○	○
Closure of the prepuce in male horses	○	○	○	○
Catheterisation of the bladder	○	○	○	○
Draping	○	○	○	○
Methods of resection and anastomosis	○	○	○	○
Method of abdominal closure	○	○	○	○

Method of incisional protection	○	○	○	○

37 **Which of the following surgical equipment (or other materials) is available at your clinic? Please tick all that apply.**

	Available	Regularly Used
GIA stapler	☐	☐
ILA-100 stapler	☐	☐
TA-90 stapler	☐	☐
Active gas suction	☐	☐
Surgical diathermy (monopolar or bipolar)	☐	☐
Visceral retainer	☐	☐
Sodium carboxymethylcellulose	☐	☐

38 **Have you ever had to significantly delay (by more than 30 minutes) colic surgery on a horse due to:**

	Yes	No
Lack of an available theatre?	○	○
Lack of equipment?	○	○
Lack of available staff?	○	○

SECTION D: POSTOPERATIVE CARE

39 **Are any staff required to be present at the clinic out-of-hours? Please tick all that apply.**

☐Intern veterinarian

☐Nurse/technician

☐Surgeon

☐Other veterinarian

40 **Who is responsible for overseeing decision-making regarding postoperative care of colic patients at your clinic?**

☐Intern

☐Resident

☐Ambulatory veterinarian

☐Surgeon who performed surgery on that horse

☐Another surgical clinician covering a certain service (e.g. 'Soft Tissue')

☐Internal medicine or Critical care specialist

☐Other hospital veterinarian

☐Other, please specify

41 **How is handover of postoperative patient care managed?**

○Informal discussion between veterinarians

○Formalised handover time/rounds with scheduled time in the working day

○Other, please specify

42 **Who is responsible for the practical postoperative care of colic patients i.e. performing checks and routine care?**

	Senior surgeon/clinicians	Nurses/technicians	Intern veterinarians	Other veterinarians	Students
Working hours	☐	☐	☐	☐	☐
Out-of-hours	☐	☐	☐	☐	☐

43 **How often are clinical examinations performed on postoperative colic patients in the first 24 hours after surgery as standard (excluding unusual cases that may require more frequent monitoring)?**

- ○Every 12 hours or less frequently
- ○Every 8 - 12 hours
- ○Every 5 - 7 hours
- ○Every 3 - 4 hours
- ○Every 1 - 2 hours
- ○More frequently than every hour

44 **How often is stomach tubing performed on postoperative colic patients in the first 12 hours after surgery?**

- ○Done only if required (based on clinical signs)
- ○Every 4 hours or less frequently
- ○More frequently than every 4 hours
- ○Varies depending on lesion found at surgery
- ○Other, please specify

45 **Which of the following are used routinely (at least once daily) in the early postoperative monitoring of colic surgery patients (first 48 hours after surgery)? Please tick all that apply.**

- ☐Packed cell volume
- ☐Total protein
- ☐Peripheral blood lactate
- ☐Abdominal ultrasonography
- ☐Blood gas analysis
- ☐Electrolyte measurement
- ☐Pain scoring using a defined scale
- ☐Other, please specify

46 **If pain scoring is used at your clinic for colic patients please state which scale is used.**

47 **Do you have any set protocols for any of the following postoperative management factors at your clinic?**

	Set protocol always followed	Set protocol in most cases with few exceptions	Set protocol sometimes followed	No specific protocols
Intravenous fluid therapy	○	○	○	○
Offering of oral fluids	○	○	○	○
Re-feeding	○	○	○	○
Method of [illegible]	○	○	○	○

Method of incision protection	○	○	○	○
Duration of incision protection	○	○	○	○
Prokinetic therapy	○	○	○	○

48 **How many weeks do you recommend horses remain on box/stall rest after colic surgery?**

49 **How many weeks after colic surgery do you recommend horses are able to begin a gradual return to exercise, assuming there have been no complications?**

SECTION E: CLINICAL GOVERNANCE AND AUDIT

50 **Do you undertake any form of internal audit of colic surgery at your clinic?**

○No (please go to question 53)

○Yes, every 12 months or less frequently

○Yes, every 6 - 12 months

○Yes, more frequently than every 6 months

51 **If you answered yes to question 50, who is responsible for carrying out this audit?**

○Senior clinicians

○Other veterinarians

○Nursing/technician staff

○Administrative staff

52 **If you answered yes to question 50, is this information made available to the public, for example on your website or to an external organisation?**

○Yes

○No

53 **Do you conduct follow-up telephone calls to assess progress of discharged patients?**

○No

○Occasionally

○Routinely for every colic surgery discharged from the clinic

○Only at follow up appointments for practice clients

54 **Do you hold regular morbidity and mortality rounds at your clinic?**

○No (please go to question 57)

○Once every 12 months or less frequently

○Every 7 - 11 months

○Every 4 - 6 months

○Every 2 - 3 months

○Monthly or more frequently

55 **Which staff attend morbidity and mortality rounds?**

	Compulsory	Optional	Not invited
Senior clinicians	○	○	○
Nurses/technicians	○	○	○
Intern veterinarians	○	○	○

Other veterinarians	○	○	○
Other support staff	○	○	○
Visitors	○	○	○

56 **How are cases selected for discussion at morbidity and mortality rounds?**

○All deaths and complications discussed

○All deaths and selected complications discussed

○Selected cases as chosen by clinicians

○Other, please specify

57 **Please fill in any notes for any questions that require additional information (for example question 6)**

58 **Please fill in any additional information you would like to provide regarding colic surgery at your clinic**

59 **Please give any thoughts you have on ways we can make clinical audit of colic surgery easier to perform in practice.**

ADDITIONAL SECTION F: COVID-19 PANDEMIC

Q60. Has the COVID-19 pandemic affected the ability of your clinic to offer colic surgery at some point between January and September in 2020?

○No – the provision of colic surgery has been completely unaffected at our clinic.

○

Yes – we have been unable to offer colic surgery at some points during the pandemic due to staffing or other constraints (e.g. some nights have not been covered on the OOH rota).

○

Yes – our ability to offer colic surgery has been greatly reduced for sustained periods (longer than 1 week) during the pandemic.

○Other – please describe.

Q61. Have colic admissions been markedly affected compared to numbers expected to be seen during the COVID-19 pandemic?

○No – colic admissions unaffected (anecdotal)

○No – colic admissions unaffected (based on actual data)

○Yes– colic admissions reduced (anecdotal)

○Yes – colic admissions reduced (based on actual data)

○Yes– colic admissions increased (anecdotal)

○Yes– colic admissions increased (based on actual data)

Q62. In your experience, has the COVID-19 pandemic impacted the likelihood of owners proceeding with colic surgery when indicated?

○No – unaffected.

○Yes – more surgery declined due to economic concerns.

○Other – please describe.

Q63. In your experience, has the COVID-19 pandemic impacted the stage at which horses are referred by referring veterinary surgeons?

○No – unaffected.

○Other – please describe.

○Yes – delayed referrals in some instances.

○Yes – quicker referrals due to decreased capacity to manage colic cases as ambulatory patients.

Q64. Has the COVID-19 pandemic resulted in a more difficult OOH rota for any of the following staff members?

	Yes	No
Interns	☐	☐
Residents	☐	☐
Ambulatory vets	☐	☐
Anaesthetists	☐	☐
Nurses	☐	☐
Surgeons	☐	☐

Q65. Have the number and type of personnel involved in the initial investigation of colic cases been affected?

○Yes – increased number due to absence of owner or lack of student assistants

○Yes – decreased number due to staffing restrictions or social distancing

○No

○Type of personnel involved has changed – Please describe.

Q66. Have the number and type of personnel in theatre for surgical colic cases been affected?

○Yes – increased number due to absence of owner or lack of student assistants

○Yes – decreased number due to staffing restrictions or social distancing

○No

○Type of personnel involved has changed – Please describe.

Q67. Have the number and type of personnel who undertake aftercare of surgical colic cases been affected?

○Yes – increased number due to absence of owner or lack of student assistants

○Yes – decreased number due to staffing restrictions or social distancing

○No

○Type of personnel involved has changed – Please describe.

Q68. Has the COVID-19 pandemic affected the way in which cases are handed over to colleagues?

○No – as before with social distancing face-to-face discussions/rounds

○Yes – fewer people are present at rounds/case handovers

○Yes – rounds/handovers are done using emails or other text messaging/paper formats

○Yes – rounds/handovers are done by video-call

○Other – please describe

Q69. Have you made any changes to clinic protocols relating specifically to colic cases such as colic aftercare (i.e. not general biosecurity)? If yes, please describe.

○Yes - please describe

○No

Q70. Do you have any other comments on how the COVID-19 pandemic has impacted on colic cases or surgery up to September 2020?

Save

APPENDIX TWO: Incidence of primary lesions in INCISE-2

LESION	Africa	Asia	Australasia	Europe	North America	South America	Total
Abdominal haemorrhage - primary	0	0	0	1	0	0	1
Abscess - mesenteric	0	0	0	2	0	0	2
Adhesion - obstructing - caecum	0	0	0	2	1	0	3
Adhesion - obstructing - large colon	0	0	0	12	0	0	12
Adhesion - obstructing - small colon	0	0	0	1	0	0	1
Adhesion - obstructing - small intestine	1	7	1	32	6	0	47
Adhesions - primary	0	0	0	0	1	0	1
Adhesions - incidental	0	1	0	0	0	0	1
Adhesions - panabdominal	0	0	0	2	0	0	2
Bladder - rupture	0	0	1	4	0	0	5
Bladder - neoplasia	0	0	0	1	0	0	1
Bladder - urolithiasis	0	0	0	2	0	0	2
Congenital - Atresia Coli	0	0	0	2	0	0	2
Congenital - Large colon malformation	0	0	0	1	0	0	1
Congenital - Meckel's diverticulum - small intestinal volvulus	0	1	2	3	2	0	8
Congenital - Mesodiverticular band - small intestinal volvulus	0	4	0	11	1	0	16
Displacement - caecal primary	0	1	0	1	0	0	2

Displacement - large colon - left dorsal - NSE	12	23	9	158	32	2	236
Displacement - large colon - intermediate	0	4	1	72	9	6	92
Displacement - large colon - left dorsal	0	4	0	1	1	0	6
Displacement - large colon - right dorsal	9	23	5	254	76	1	368
Diverticulum - ileum	0	1	0	0	0	0	1
Diverticulum - jejunum	0	0	0	1	0	0	1
Enterolith(s) - primary obstructing	0	4	1	1	18	0	24
Entrapment - epiploic foramen	0	0	0	1	0	0	1
Entrapment - Epiploic foramen	3	4	1	185	27	1	221
Entrapment - gastrosplenic ligament	0	0	1	41	5	0	47
Entrapment - lateral ligament bladder	0	0	0	0	1	0	1
Entrapment - mesenteric	0	8	8	41	5	0	62
Entrapment - nephrosplenic ligament	0	1	0	0	0	0	1
Entrapment - omentum	0	0	1	13	5	0	19
Entrapment - other	0	0	0	1	0	0	1
Entrapment - ovary	0	0	1	1	0	0	2
Entrapment - unknown	0	1	2	15	7	0	25
Gas distention primary - caecum	2	0	0	21	2	0	25
Gas distention primary - caecum and large colon	0	0	0	5	2	0	7

Gas distention primary - large colon	2	0	1	10	2	0	15
Gas distention primary - small colon	0	0	0	1	0	0	1
Gas distention primary - small intestine	0	0	0	3	5	0	8
Haematoma - extraperitoneal	0	0	0	1	0	0	1
Haematoma - mesenteric	0	0	1	0	1	0	2
Hepatic - mass	0	0	0	1	0	0	1
Hepatic lipidosis	0	0	0	0	1	0	1
Hernia - Body wall	0	0	0	2	0	0	2
Hernia - Diaphragmatic	1	5	3	15	2	0	26
Hernia - inguinal	0	0	0	2	0	0	2
Hernia - Inguinal	2	3	0	72	6	1	84
Hernia - Inguinal - evisceration	0	0	0	1	1	0	2
Hernia - Umbilical	0	0	2	11	1	0	14
Ileocaecal torsion	0	0	0	1	0	0	1
Ileus - generalised	0	0	0	2	0	0	2
Impaction - large colon - primary	7	9	1	131	20	11	179
Impaction - ascarids	0	0	0	8	1	0	9
Impaction - faecolith / other foreign body	1	9	5	45	17	1	78
Impaction - Ileal	7	1	1	79	12	0	100
impaction - jejunal	0	0	0	1	2	0	3
Impaction - Jejunal	0	0	0	29	3	0	32
Impaction - meconium	0	0	0	5	1	0	6
Impaction - sand	2	7	3	77	25	1	115
Impaction - small colon	14	1	0	47	11	1	74

Impaction - small colon - parasites	0	0	0	1	0	0	1
Impaction primary - caecal	0	0	0	18	3	0	21
Impaction primary - gastric	0	0	0	6	1	0	7
Impation - duodenum	0	0	0	1	2	1	4
Inflammatory - Anterior enteritis / Duodenitis - proximal jejunitis	0	6	1	33	5	3	48
Inflammatory - colitis	0	1	0	16	4	0	21
Inflammatory - colitis - focal eosinophilic	0	0	0	5	1	0	6
Inflammatory - colitis - right dorsal	0	0	0	3	1	0	4
Inflammatory - enteritis - idiopathic focal eosinophilic enteritis (IFEE)	1	0	0	46	3	0	50
Inflammatory - enteritis - diffuse	1	0	2	34	4	0	41
Inflammatory - enterocolitis	0	0	0	1	1	0	2
Inflammatory - focal mass	0	0	4	11	1	1	17
Inflammatory - typhlitis	0	0	0	3	0	0	3
Inflammatory - typholocolitis	0	0	0	3	0	0	3
Intussusception - caecocolic	0	1	0	9	1	0	11
Intussusception - caecocaecal	0	0	2	26	1	0	29
Intussusception - caecocolic	0	0	0	17	0	0	17
Intussusception - colocolic	0	0	0	6	0	0	6
Intussusception - ileocaecal	0	1	1	14	1	0	17

Intussusception - small intestine only	0	1	0	18	3	2	24
Large colon - tear	0	0	0	1	0	0	1
Large colon - unknown	0	0	0	1	1	0	2
Lipomatosis - mesenteric	0	0	0	1	0	0	1
Mesenteric abscess	0	0	0	2	1	0	3
Necrosis - unknown	0	0	0	3	0	0	3
Neoplasia - intestinal - diffuse	1	1	0	3	2	0	7
Neoplasia - intestinal - focal	0	0	0	10	2	0	12
Neoplasia - diffuse	0	0	0	1	0	0	1
Neoplasia - omental	0	0	0	0	1	0	1
Neoplasia - splenic lymphoma	0	0	0	1	0	0	1
Neoplasia - unclassified	0	0	0	4	1	0	5
No abnormalities found	0	0	0	2	1	1	4
Non strangulating infarction - caecum	0	0	0	1	0	0	1
Non strangulating infarction - large colon	0	0	0	13	0	1	14
Non strangulating infarction - small colon	0	1	0	2	0	0	3
Non-strangulating infarction - large colon	0	0	0	0	1	0	1
Non-strangulating infarction - small intestine	0	1	0	12	1	0	14
Not Recorded	2	2	1	49	54	1	109
Obstruction - muscular hypertrophy ileum	0	0	0	5	3	0	8

Obstruction - stricture	2	0	0	5	0	0	7
Obstruction - strictures	0	0	0	0	1	0	1
Other - not reported - caecum	0	0	0	1	0	0	1
Other - not reported - large colon	0	1	0	1	0	0	2
Other - not reported - small colon	0	0	0	1	0	0	1
Ovary - abscess	0	0	0	1	0	0	1
Ovary - haematoma	0	0	0	1	0	0	1
Ovary - neoplasia	0	0	0	1	0	0	1
Pedunculated lipoma - non-strangulating obstruction	0	0	0	1	0	0	1
Pedunculated lipoma - non-strangulating obstruction	0	0	0	2	0	0	2
Pedunculated lipoma - small intestine	1	0	0	0	0	0	1
Pedunculated lipoma - strangulating obstruction	1	1	10	306	89	1	408
Perforation - duodenum	0	0	0	1	0	0	1
Perforation - jejunum	0	0	0	3	0	0	3
Perforation - jejunum (parascaris associated)	0	0	0	1	0	0	1
Peritonitis	1	1	0	9	1	0	12
Primary ileus	2	1	1	6	0	0	10
Primary ileus - Equine grass sickness (confirmed)	0	0	0	4	0	0	4
Primary ileus - Equine grass sickness (suspected)	0	0	0	20	0	0	20

Primary ileus - gastric outflow obstruction	0	0	0	1	0	0	1
Primary ileus - localised	0	0	0	1	0	0	1
Rectum - abscess	0	0	0	1	1	0	2
Rupture GI - caecum	0	0	0	12	1	1	14
Rupture GI - gastric	1	2	0	16	2	0	21
Rupture GI - large colon	0	0	0	7	0	0	7
Rupture GI - rectal tear	0	0	0	1	0	0	1
Rupture GI - small colon	0	0	0	2	0	0	2
Rupture GI - small intestine	0	2	1	2	0	1	6
Rupture GI - small intestine - iatrogenic needle laceration	0	1	0	0	0	0	1
Small intestinal - unknown	0	4	0	4	1	0	9
Small intestinal other - entrapment unknown	0	0	0	1	0	0	1
Small intestinal - necrosis	0	0	0	0	1	0	1
Spleen - Mass	0	0	0	1	0	0	1
Unknown cause	0	1	0	0	0	0	1
Uterus - adhesions	0	0	0	2	1	0	3
Uterus - broad ligament haematoma	0	0	2	0	0	0	2
Uterus - tear	0	1	0	1	0	0	2
Uterus - torsion	0	1	1	18	1	0	21
Vagina - tear	0	0	0	0	1	0	1
Volvulus - caecum	0	2	0	5	1	0	8
Volvulus - large colon - <270°	1	3	3	78	31	7	123
Volvulus - large colon - >=270°	3	23	6	250	80	1	363

Volvulus - small colon	0	0	0	2	0	0	2
Volvulus - small intestine	1	24	7	116	21	1	170

APPENDIX THREE: Incidence of secondary lesions in INCISE-2

LESION	Africa	Asia	Australasia	Europe	North America	South America	Total
Abscess - abdominal	0	0	0	1	0	0	1
Adhesion - obstructing - large colon	0	0	0	1	0	0	1
Adhesions - primary	0	0	2	11	3	0	16
Adhesions - primary; Rupture GI - large colon	0	1	0	0	0	0	1
Adhesions - incidental	1	1	2	14	6	0	24
Adhesions - panabdominal	0	0	1	7	1	0	9
Adhesions - panabdominal; Mesenteric rent - incidental	0	0	0	0	1	0	1
Adhesions - primary	0	0	0	0	1	0	1
Congenital - Meckel's diverticulum	0	2	0	0	0	0	2
Congenital - Mesodiverticular band - incidental	0	0	1	1	2	0	4
Displacement - large colon - left dorsal - NSE	0	1	1	8	2	0	12
Displacement - large colon - intermediate	1	1	0	70	9	0	81
Displacement - large colon - intermediate;	0	0	0	0	1	0	1
Displacement - large colon - left dorsal	0	0	0	1	1	0	2
Displacement - large colon - left dorsal;	0	0	0	1	0	0	1

Diverticulum - jejunum							
Displacement - large colon - right dorsal	0	8	2	80	36	1	127
Displacement - large colon - right dorsal; Peritonitis - septic - ingesta	0	0	0	1	0	0	1
Diverticulum - ileum	0	0	0	1	0	0	1
Enterocutanous fistula	0	0	0	1	0	0	1
Enterolith(s) - incidental	0	0	0	0	2	0	2
Entrapment - mesenteric	0	0	0	1	0	0	1
Entrapment - other	1	0	1	2	2	1	7
Evisceration From Abdominal Wound	0	0	0	1	0	0	1
Gas distension primary - small intestine	0	0	0	0	1	0	1
Gas distention primary - caecum	1	3	0	37	0	0	41
Gas distention primary - large colon	0	0	2	1	0	0	3
Gas distention primary - small intestine	0	0	0	5	1	0	6
Haematoma - mesenteric	0	0	0	3	1	0	4
Haemoabdomen	1	0	2	8	1	0	12
Haemothorax	0	0	0	1	0	0	1
Hernia - Umbilical	0	0	0	1	0	0	1
Impaction - large colon - primary	7	7	3	45	39	1	102

Impaction - large colon - primary; Haemoabdomen	0	0	0	1	0	0	1
Impaction - large colon - primary; Impaction - faecolith / other foreign body	0	0	0	1	0	0	1
Impaction - large colon - secondary	8	11	3	136	32	4	194
Impaction - large colon - secondary; Impaction - small colon	0	0	0	1	0	0	1
Impaction - caecal	0	0	1	4	4	0	9
Impaction - ascarids	0	0	0	7	1	0	8
Impaction - ascarids; Congenital - Mesodiverticular band - incidental	0	0	0	1	0	0	1
Impaction - ascarids; Peritonitis - septic - ingesta	0	0	0	1	0	0	1
Impaction - faecolith / other foreign body	0	0	0	4	2	0	6
Impaction - gastric	1	1	1	20	4	0	27
Impaction - gastric; Impaction - large colon - secondary	0	0	0	0	1	0	1
Impaction - ileal	2	1	1	14	2	0	20
Impaction - Jejunal	0	0	0	10	1	0	11
Impaction - large colon - primary	0	0	0	1	0	0	1
Impaction - large colon - secondary	0	0	0	2	0	0	2

Impaction - sand	0	0	0	27	19	0	46
Impaction - small colon	0	1	0	11	6	2	20
Inflammatory - Anterior enteritis / Duodenitis - proximal jejunitis	0	0	0	8	3	0	11
Inflammatory - colitis	0	0	0	10	3	0	13
Inflammatory - colitis - right dorsal	0	0	0	1	2	0	3
Inflammatory - colitis; Inflammatory - enteritis - diffuse	0	0	0	0	1	0	1
Inflammatory - enteritis - idiopathic focal eosinophilic enteritis (IFEE)	0	0	0	0	1	0	1
Inflammatory - enteritis - diffuse	0	3	0	5	4	0	12
Inflammatory - focal mass	0	0	0	2	0	0	2
Intussusception - small intestine only	0	0	0	1	0	0	1
Lipoma Small Intestine	0	0	0	1	1	0	2
Lipomas In Mesentery SI	0	0	0	0	1	0	1
Lipomatosis - mesenteric	0	0	0	1	0	0	1
Mesenteric rent - incidental	0	2	1	16	7	1	27
Necrosis - unknown	0	0	0	1	0	0	1
Neoplasia - intestinal - focal	0	0	0	3	1	0	4
Neoplasia - gastric	0	0	0	1	0	0	1
Neoplasia - nonintestinal -	0	0	0	2	0	0	2

Non-strangulating infarction - caecum	0	0	0	1	0	0	1
Non-strangulating infarction - large colon	0	0	0	2	0	0	2
Non-strangulating infarction - small colon	0	1	0	0	0	0	1
Non-strangulating infarction - small intestine	0	0	0	6	1	0	7
None	53	146	63	1857	331	32	2482
Not Recorded	0	0	0	32	54	2	88
Obstruction - muscular hypertrophy ileum	0	0	0	1	1	0	2
Other intraluminal obstruction - faecolith	1	0	0	0	0	0	1
Pedunculated lipoma - incidental - small intestine	0	0	0	3	2	0	5
Pedunculated lipoma - non-strangulating obstruction	0	0	0	0	2	0	2
Perforation - ileum; Peritonitis - septic - ingesta	0	0	0	1	2	0	3
Perforation - jejunum	0	0	1	2	0	0	3
Peritonitis	0	3	0	17	6	0	26
Peritonitis - septic - ingesta	1	4	1	40	3	2	51
Peritonitis - septic - ingesta; Impaction - large colon - secondary	0	0	0	1	0	0	1
Peritonitis; Adhesions - primary	0	0	0	1	0	0	1
Primary ileus	1	0	0	7	0	0	8

Primary Impaction - Sand	0	0	0	0	2	0	2
Primary Impaction - Sand; Rupture GI - large colon	0	0	0	1	0	0	1
Renal_ureter - Urolithiasis	0	0	0	0	1	0	1
Rib fractures	0	0	0	1	0	0	1
Rupture GI - caecum	0	0	0	3	0	0	3
Rupture GI - caecum; Peritonitis - septic - ingesta	0	0	0	1	0	0	1
Rupture GI - gastric	0	1	0	2	0	0	3
Rupture GI - gastric; Peritonitis - septic - ingesta	0	0	0	1	0	0	1
Rupture GI - large colon	0	0	0	10	2	0	12
Rupture GI - large colon; Peritonitis - septic - ingesta	0	0	0	0	1	0	1
Rupture GI - rectal tear	1	0	0	1	0	0	2
Rupture GI - rectal tear; Impaction - small colon	0	0	0	0	1	0	1
Rupture GI - small colon	0	0	0	0	1	0	1
Rupture GI - small intestine	0	0	0	1	0	0	1
Rupture GI - small intestine; Peritonitis - septic - ingesta	0	0	0	1	0	0	1
small intestinal inflammatory disease	0	0	0	1	0	0	1
splenomegaly	0	1	0	0	0	0	1
Testicle - Neoplasia	0	1	0	0	0	0	1

Umbilical - omphalophlebitis	0	0	0	1	0	0	1
Uterus - tear	0	0	1	0	0	0	1
Volvulus - caecum	1	0	0	5	4	0	10
Volvulus - caecum; Impaction - sand	0	0	0	0	1	0	1
Volvulus - large colon - <270°	0	2	0	34	11	1	48
Volvulus - large colon - >=270°	0	1	2	9	2	0	14
Volvulus - small colon	0	0	0	3	0	0	3
Volvulus - small intestine	0	1	0	21	0	0	22
Volvulus <270°	0	1	0	18	8	0	27
Volvulus <270°; Rupture GI - large colon; Peritonitis - septic - ingesta	0	0	0	1	0	0	1
Volvulus >=270°	0	0	0	10	1	0	11
Wound; Medial thigh	0	0	0	1	0	0	1