An owner questionnaire and cohort study on equine wounds and their management

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Summary

Traumatic wounds have been described as the second most common reason for out-of-hours emergency veterinary visits in the horse. Sequelae of wound injury can pose a risk to life and return to pre-athletic function and incur significant treatment costs. Existing literature on equine wound healing and management has reported several factors to impact on wound outcome however, this body of research consists predominantly of retrospective studies specific to referral horse populations, expert opinion, and extrapolations from human medicine. The lack of high-quality evidence reported in the literature, particularly relating to concepts and current habits of owner attitudes towards wound management, served as the impetus for this project. The aim of this project was to generate primary evidence on the healing and outcome of wounds in horses, including documenting the attitudes and current habits of owners towards wound management and to perform descriptive and statistical analysis of the presenting signs, treatment and outcomes of these injuries. Data was captured through the use of an online questionnaire and prospective cohort study.

The online questionnaire investigated how those involved in the care of horses would approach and manage seven hypothetical equine wound case scenarios with a focus on any first aid they would apply and factors influencing their decisions to seek veterinary advice. Dissemination was mainly facilitated using social media channels, and a total of 1037 responses were collected. Nearly all (95%) participants had previous experience of a horse under their care suffering from a wound. Over half

of those participating would administer some form of first aid to each case, with approaches to treatment varying between participants. Despite most participants suggesting that the 'depth of a wound' would be the most influential factor in seeking veterinary advice, when presented with a puncture wound over the digital flexor tendon sheath only 22% stated the wound required high priority veterinary treatment. Additionally, owners were poor at both identification of exuberant granulation tissue and recognition that this condition requires veterinary intervention in order to promote healing. This study also identified a positive association between participants who had the horses under their care insured and whether they choose to seek veterinary advice for some case scenarios. Suggesting that the insurance status of a horse acts as a barrier to having access to veterinary treatment. These findings highlight significant gaps in owner knowledge of wounds which could result in their inappropriate management and therefore compromised animal welfare.

A prospective cohort study was launched. Study advertisement, and subsequent participant recruitment, was achieved using social media channels and promotion within UK veterinary practices. A total of 219 wounds met inclusion criteria for this study, with outcome data available for 64% cases. Wounds were most commonly the result of contact with wire/fencing, with most injuries being sustained on the limbs (70%). Owners reported that many injuries involved deeper anatomic structures, such as tendon/ligament (17%), bone (17%) or synovial structures (16%). More than half of participants were reportedly administering some form of first aid however, a number of horses were identified whose

owners had failed to adopt simple prophylactic measures that could mitigate the impact of traumatic wound injury. For example, 8% of horses that had wounds were not vaccinated against tetanus, 16% did not have access to emergency equine transport facilities. This study also found that over half of wounded horses included in this study were not insured for veterinary fees. Statistical analysis identified several factors, many of which have previously not been reported, which significantly impacted the rate of traumatic wound healing in the horse, return to work and cost of treatment. These include, for example, the horse's age (P=0.013), gender (P=0.033), height (P=0.029), insurance status (P=0.04) and whether an owner had access to emergency equine transport facilities (P=0.002).

Studies within this thesis are the first to investigate how horse owners currently approach and manage wounds. This evidence has highlighted factors which could significantly impact wound healing and outcome outside of a referral hospital setting and has identified key areas where further research is required. These findings should be utilised by both the horse owning population and veterinary professionals as valuable prognostic indicators, to determine both the success of wound healing and potential financial costs of treatment. Additionally, the findings have identified key areas where further research and public educational campaigns have the potential to significantly impact wound management practice and animal welfare.

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Contents

Chapter 1: Introduction

1.0 Introduction

The term 'wound' is used to describe an injury to the skin resulting in a breach of the epidermis and/or dermis. In the UK, traumatic wounds represent the second most common condition seen in out-of-hours equine practice (Bowden *et al*., 2017). Recently, Bowden and colleagues (2017) reported wounds accounting for only 19.6% of cases over a three-year period, with one in 25 wound cases being euthanized. This work included out-of-hours cases from two UK equine practices, one referral and one first opinion. In an older report by the United States Drug Agency, the prevalence of 'skin wounds/trauma' for horses over six months of age reached 4.7% and these accounted for 24% of equine deaths/euthanasia (USDA, 2006). Although the USDA mortality figure for skin wounds/trauma is six times higher (24% vs 4%) than the UK study by Bowden *et al.* (2017), the USDA represented the prevalence of wounds across 28 American states collated by 200 enumerators compared to a much smaller population of horses in Bowden's study

Wounds have a significant impact on owners and the equine industry. For example, wounds and lacerations were responsible for the early retirement of 3.6% of all New Zealand thoroughbred racehorses (Perkins *et al*., 2005). They are considered one of the most common conditions treated by equine veterinary surgeons, having a negative financial impact on owners and the equine industry (USDA, 2006). Wounds represent an

important cause of morbidity in the horse. It is important for both veterinary surgeons and owners to have a sound understanding of the aetiology and management of equine wounds to effectively recognise and treat them, minimising their financial and welfare impacts.

2.0. Equine Factors

2.1. Signalment

In humans, it is well recognised that elderly people suffer from impaired wound healing, presenting a large clinical and economic burden for wounds of traumatic, chronic (e.g. diabetic ulcers) and surgical origin (Gosain and DiPietro, 2004). Rodents have been used as a research model for human wound healing (Sussman, 1973)skin from wounds in younger rats (eight months old) was significantly thicker than the skin of older rats (20 months old). Moreover, the wounds from younger animals showed a greater amount of fibrous tissue, translating into a higher total breaking strength. This is in accordance with a more recent systematic review of wounds in rodents of varying ages (Kim et al., 2015). The rate of wound closure (%/day) was slower in senescent compared to younger rodents in all included studies but one. Kim and coworkers (2015) suggested lower rates of epithelization and granulation tissue formation in older animals. Similarly to humans, ageing also affects equine populations. Both veterinary surgeons and owners are having to care for potentially older horses. Traub-Dargatz and colleagues (2006) reported an increase from 3% to 12% of hospital admission for equine patients aged over 15 years old (L. Traub-Dargatz et al., 2006). The effect of ageing on equine wound healing remains largely unreported with the exception of a retrospective study addressing ventral midline coeliotomy complications which reported that horses over 20 years old had significantly greater risks of suffering from incisional complications (Scharner et al., 2017). While there may be similarities between healing

processes in horses and other species such as rodents or humans, there are also some important species differences, for example pituitary pars intermediate dysfunction (PPID) which has been shown to impair equine wound healing (Knottenbelt, 1997).

Sex hormones have been demonstrated in rodents to impact cutaneous wound healing, with male sex hormones (androgens) inhibiting wound healing, and female sex hormones (oestrogens) accelerating repair (Ashcroft *et al*., 1997, Ashcroft and Mills, 2002). Similar findings have been reported in human medicine, for example 74% of cases of dehiscence following laparotomy were males compared to 26% of females (Ramneesh *et al*., 2014). Gilliver and colleagues (2008) reported controversial findings to Ashcroft and colleagues using a rodent model. They reported a difference in wound area three days after surgery between entire male and female mice, with female mice having on average a significantly longer wound width. Interestingly, ovariectomised female mice had a significantly larger wound area compared to their castrated counterparts, with males having significantly more advanced reepithelialisation (Gilliver *et al*., 2008). The differences in wound healing between male and female remains to be determined in the horse population as well as the effects of castration and ovariectomy.

Breed differences between wound healing have been reported in the pig (Gallant *et al*., 2004, Gallant-Behm *et al*., 2006). The red duroc pigs formed skin wounds which were fibrotic, hypercontracted and hyperpigmented, whereas the Yorkshire breed did not (Gallant *et al*.,

2004). The same group also reported that oral mucosal wounds in these same red duroc pigs healed uneventfully, suggesting the genetic component of the red duroc phenotype (Gallant-Behm *et al*., 2006) is restricted to specific wound locations or types of tissue. The effects of an equids breed on their wound healing capability, independent of height, has not yet been established.

2.2. Height

Ponies (<14.2hh) have been reported to exhibit faster rates of healing compared to horses (>14.2hh) (Wilmink *et al*., 1999a). In this experimental study, the wound size had reduced by 76% in ponies compared to 59% in horses nine weeks following injury, despite all wounds being created with equal dimensions at the same anatomical locations. This study has limitations due to its small sample size and only one breed of horse and pony were used. Wilmink and colleagues also reported ponies had higher levels of polymorphonuclear leucocytes and more well aligned fibroblasts (Wilmink *et al*., 1999b). The authors have concluded this initial and more intense inflammation response in ponies compared to horses to be the physiological explanation behind the differences in healing rates. The same group later reported that primary wound closure was achieved in 41% of ponies compared to 26% of horses in a clinical non-experimental study (Wilmink *et al*., 2002). Interestingly, ponies healing rates were still faster than horses, despite having on average more complex wounds, such as tendon rupture and cortical bone exposure. Additionally, secondary complications, such as bone sequestra and wound dehiscence were seen less frequently in ponies despite receiving, on average, reduced NSAID and antibiotic

administration compared to horses (Wilmink *et al*., 2002).

Wounds on horses have also been shown to possess inferior contraction capabilities, compared to similar wounds in ponies (Wilmink *et al*., 2001). Fibroblasts in horse wounds appeared significantly more disorganised compared to the morphological regularity seen in the fibroblasts of ponies. The reduced rate of contraction in horses was suggested as a reason to why their wounds heal slower than ponies. (Wilmink et al., 2002)It remains questionable if the differences between ponies and horses are indeed related to their height, as opposed to their breed. Although Wilmink and colleague's data clearly supports the hypothesis that ponies have improved wound healing compared to ponies, the data was acquired from experimental and retrospective studies. Further evidence is needed from the wider horse population to show if the findings are replicated out in the general horse population that incur a variety of traumatic injuries.

2.3. Body Condition Score

Various nutritional deficiencies have a negative impact on progression through the wound healing process (Stechmiller, 2010). This relationship has been demonstrated in several human studies. Cellular proliferation is essential for wound healing, a process requiring high energy input originating from energy stores in the body. Nutrition has a direct effect on the rate of wound healing, meaning efficient healing requires an individual to be well nourished (Wild *et al*., 2010). The latter review states that people experiencing a period of undernutrition have impaired physiological wound healing processes due to a prolonged inflammatory

phase of healing associated with decreased rate of leukocyte phagocytosis and collagen production. This results in reduced mechanical and tensile skin strength and an increased risk of wound dehiscence.

Obesity has been widely reported to impact wound healing in human medicine. A review focusing on obesity and surgical wound healing highlighted their correlation, stating that obese patients have increased rates of dehiscence and total wound failure (Pierpont *et al*., 2014). The exact physiological mechanisms behind this are complex and are not yet completely understood. There is currently no veterinary literature reporting whether over conditioned horses directly suffer from impaired wound healing.

2.4. Effects of glucocorticoids

Glucocorticoids have long been demonstrated in human medicine to slow or even inhibit wound healing by slowing the migration of inflammatory cells, the formation of collagen and the rate of angiogenesis within a wound bed (Ehrlich and Hunt, 1968). This is in agreement with an experimental study in which 72 rats had standardised wounds inflicted on their backs and were injected subcutaneously with methylprednisolone acetate (Wicke *et al*., 2000). Rats injected with methylprednisolone acetate had significantly lower levels of inflammatory cytokines, such as TGF-β and IGF-I, in the fluid surrounding the wound compared to controls. In human medicine, it is recommended that individuals receiving glucocorticoids at the time of sustaining a surgical or accidental wound should stop the administration due to their inhibitory effects on lymphocyte function and collagen synthesis (Capewell et al., 1990,

Pollack, 1984).

In equine medicine, methylprednisolone acetate is predominantly used as an intra-articular injection for treatment of degenerative joint diseases and is rarely used systemically (McIlwraith, 2010). However, it has been demonstrated that intra-articular injections of other glucocorticoids in the horse can have systemic effects. Indeed, intra-articular injections of triamcinolone acetate into the tarsocrural joints have been shown to reduce the symptoms of equine asthma (Bessonnat et al., 2020). Exogenous glucocorticoids are not only used to treat orthopaedic conditions but also a range of inflammatory conditions in the horse, including those of a respiratory, integumentary, immune-mediated, and neurological nature. Iatrogenic hyperglucocortoidemia is a sequelae of horses undergoing treatment for these inflammatory conditions that receive exogenous glucocorticoids as part of their treatment regimens (Mora Pereira *et al*., 2018). There are no published studies that explore whether systemic or local exogenous administration of glucocorticoids in the horse have an impact on wound healing.

Pars pituitary intermedia dysfunction (PPID) is an endocrine disease affecting geriatric equids predominantly, with epidemiological studies suggesting a morbidity of 30% in horses aged 25 and above (Schumacher and Kemppainen, 1998, Brosnahan and Paradis, 2003). One of the pathophysiological mechanisms of this disease is the endogenous production of glucocorticoids in excess (Johnson et al., 2004). Wounds found on horses with PPID frequently fail to heal, such as

oral wounds reported to transform in ulcerated lesions and integument wounds failing to properly vascularise and granulate (Knottenbelt, 1997). Knottenbelt's statement is however expert opinion and has not been supported with experimental evidence to show that PPID horses have impaired wound healing or how this may be modified by current treatments for PPID. Although there is extensive research in human medicine demonstrating how glucocorticoid use impacts wound healing, studies using an equine model and glucocorticoids commonly used in equine medicine are lacking.

3.0 Wound Factors

3.1. Wound location

Wounds can occur in a variety of areas, including the limbs, trunk and head. The location of a wound may impact the rate of healing as different locations are affected in varying amounts by factors such as degree of movement, soft tissue coverage and vascularisation. The anatomical location of a wound on a horse has been demonstrated in several studies to influence the rate of healing. For example, trunk wounds are reported to heal faster than limb wounds, with several factors contributing to this, for example differences in wound contamination, vascularisation, fibroblast activity and wound contraction (Knottenbelt, 1997, Wilmink, 2016). In the experimental study by Wilmink and Colleagues (2016), standardised full thickness wounds were artificially inflicted on the trunk and limbs of horses and ponies. Trunk wounds were demonstrated to heal faster than limb wounds in both horses and ponies. Between weeks two and four after injury, trunk wounds on ponies exhibited 12% more wound contraction compared to similar limb wounds whilst trunk wounds on horses showed 38% more contraction compared to similar limb wounds. The findings and the physiological explanation are consistent with previous work from the same group, investigating fibroblasts isolated from the proximal and distal hindlimb of horses and ponies by (Wilmink *et al*., 2001). Fibroblasts from the buttocks were found to proliferate faster than limb fibroblasts, meaning they would be able to produce collagen and extra-cellular matrix faster and therefore hasten

wound healing. This study used only used four horses of one breed and four ponies of one breed, all were geldings. This physiological mechanism has not been demonstrated in the general horse population and clinical case studies or trials are lacking, however these findings have been further described in two review papers. One review hypothesised that limb wounds heal slower than trunk wounds due to their location over joints resulting in a high degree of motion (Wilmink and van Weeren, 2004). They proposed this resulted in more frequent disruption to developing granulation beds in limb compared to trunk wounds. Another review using human wound healing as a model for horses, suggested that wound healing on the equine limb is impaired compared to the trunk due to reduced skin elasticity and closer proximity to the ground and its contaminants, (Theoret and Wilmink, 2013). Moreover, the same authors hypothesised that reduced soft tissue coverage and reduced blood flow in limbs could be other physiological reasons contributing to reduced rates of wound healing in limbs compared to trunk wounds. Reduced blood flow in the limbs compared to elsewhere in the body of horses has previously been confirmed (Knighton et al., 1981). Although there is currently limited evidence on differences between limb and trunk wounds, there is consensus that trunk wounds heal faster as they contract faster, have higher blood flow and are subject to less movement. Future studies on the duration of wound healing and incidence of complications therefore need to consider wound location as a significant factor.

3.2. Osseous Involvement

Wounds occurring on the distal limb in horses can involve the bone or expose periosteum due to a thin layer of skin and reduced thickness/layers of fat and muscle. Osteomyelitis and sequestrum formation are potential complications of equine wounds involving bone (Moens et al., 1980). A sequestrum is a fragment of necrotic bone that fails to be resorbed following trauma and is commonly sustained from high impact injuries, such as kick wounds (Dart *et al*., 2016). Sequestra can act as a nidus of infection resulting in chronic non-healing wounds characterized by purulent discharge and dehiscence (Moens *et al*., 1980). A retrospective case study in Australia examined 73 cases of bone sequestration in horses and cattle (Firth, 1987). Sequestration in horses was found secondary to osseous trauma with concurrent wound formation and periosteal infection, with delayed wound healing as the most common clinical feature. The majority (96%) of sequestra on the appendicular skeleton were associated with wounds, supporting findings from another equine study (Clem *et al*., 1988). In both studies, lameness was highlighted as a common complication, with 60% of cases in the study by Clem *et al*, (1988) showing concurrent lameness. In both Clem and Firth's retrospective studies, no details were provided on any initial wound surgery, but they reported that subsequent surgical sequestrectomy following diagnosis had a good prognosis. Delayed treatment could result in persistent lameness and purulent/exuberant granulation tissue formation. The study by Clem *et al*, (1988) included seven breeds of horses, geldings, stallions and mares

ranging in age from four months to eight years but fails to reference any sequestra in ponies or geriatric equids. The study by Firth (1987) did not specify how many horses were assessed compared to cattle, or disclose data outlining the signalment of horses included in the study, preventing the analysis of many important co-factors. A more recent retrospective analysis of traumatic wounds admitted to a referral hospital in The Netherlands did investigate factors that may affect wound healing, and found a significant difference between sequestrum formation between horses and ponies (Wilmink *et al*., 2002). Sequestra formation was noted in only 4% of ponies compared to 31% of horses. In conclusion, there are three retrospective studies exploring sequestration in the horse however none are recent with two over thirty years old. Neither of the studies were conducted in the UK and many important wound healing factors were omitted.

3.3. Synovial Involvement

Traumatic skin wounds in horses may involve deeper synovial structures. Rapid identification of synovial involvement is important as delayed treatment can result in permanently debilitating secondary complications including septic arthritis, degenerative joint disease and capsular fibrosis. These conditions can affect ability to return to pre-injury athletic performance or result in euthanasia (Orsini, 2017a). The potential severity of synovial involvement in wounds was highlighted in a retrospective analysis of 90 cases of tenosynovitis where only 54.2% of horses returned to their previous level of work (Smith *et al*., 2006). Due to the potential severity of synovial wounds, there have been a number of studies looking at factors which may affect prognosis, including

anatomic structures compromised in the wound, the time elapsed between injury and treatment and the number of surgical procedures performed. There have been several retrospective studies assessing outcomes from synovial injuries in referral hospital populations however they contain conflicting evidence on whether a delayed admission impacts outcome (Post et al., 2003, Milner et al., 2014, Findley et al., 2014, Wereszka et al., 2007, Isgren et al., 2020). One study examining 51 cases of septic tenosynovitis found horses treated within 24 hours from the start of clinical signs were 16 times more likely to survive one year compared to horses treated more than 10 days after the onset of clinical signs (Wereszka *et al*., 2007). Findley and colleagues (2014) had similar findings concluding that a delayed hospital admission affected the outcome for solar penetration wounds involving synovial structures by 1.2-fold for every day elapsed between injury and hospital admission. However, a further two retrospective studies focusing on calcaneal bursitis and synovial sepsis found no significant association with time to hospital admission and outcome (Post *et al*., 2003, Milner *et al*., 2014). Milner and colleagues (2014) compared synovial wounds affecting joints, tendon sheaths and bursa and suggested bursal wounds had a worse prognosis than wounds involving joints. These four studies assessed outcomes for different synovial structures, suggesting that the trend 'delayed treatment affects outcome' for wounds with synovium involvement may only be true for particular synovial structures. Further studies are required to ascertain if this is true and if so, for which structures. There is however no data for synovial wounds seen and treated in first opinion/ambulatory practice. Several studies have shown

that synovial wounds with osseous involvement have a worse prognosis than those with synovial involvement only. Septic calcaneal bursitis is a common sequelae of wounds to the plantar tarsal region (Post et al., 2003, Isgren et al., 2020). Post and colleagues (2003) focused on septic calcaneal bursitis and reported involvement of the subcutaneous calcaneal bursa only had an excellent prognosis, with 100% of cases surviving following treatment. Wounds that had further involvement of the tuber calcanei bone had a lower survival rate (44%). A more recent multicentric retrospective study of calcaneal bursitis by Isgren and Colleagues (2020) reported higher survival rates (84%) and identified horses treated with systemic antimicrobials prior to referral were more likely to have a favourable outcome. Findley and colleagues (2014) also reported that concurrent bone and synovial compromise in a traumatic wound had an increased incidence of euthanasia, in this case specific to penetrating foot injuries. Three of the studies also reported that horses requiring more than one surgical procedure for wounds with synovial involvement had a worse prognosis than those requiring only one surgery (Findley *et al*., 2014, Post *et al*., 2003, Milner *et al*., 2014). Current recommendations are that wounds over synovial structures should receive urgent veterinary examination as involvement necessitates diagnostic tests to determine which structures are involved as well as immediate/intensive lavage and antibiotic therapy. Outcome data on various synovial injuries could be used to help veterinary surgeons inform owners of predicted prognosis at the time of injury, allowing owners to make a more informed decision with regards to treatment route they wish to proceed with.

3.4. Neurovascular Involvement

Unilateral palmar/plantar digital nerve transection is described as a common consequence of distal limb wounds and these injuries usually re-innervate with minimal medical intervention and clinical consequence (Moens *et al*., 1980). Wounds with more serious nerve involvement include elbow wounds with radial nerve damage and shoulder wounds with suprascapular nerve involvement (Sweeney), which can cause life threatening neurogenic muscle atrophy or limb dysfunction if the damage is permanent (Hanson, 2008). Facial wounds can result in trauma to cranial nerve VII, the facial nerve. This type of injury can manifest as a deviation/asymmetry of the muzzle, impaired dilatory capacity of the nares causing poor performance and a dynamic respiratory noise during exercise or a drooping appearance of the lower lip (Barber and Stashak, 2017). Vascular damage is a potential sequela to wounds affecting the distal limbs. Significant blood vessels which could be involved in wounds include the saphenous vein, cephalic vein and greater metatarsal artery (Hanson, 2008). Wounds that involve major arteries/veins require immediate haemostasis to avoid significant blood loss, by applying pressure or applying clamps to larger vessels (Schumacher and Stashak, 2017). Surgical anastomoses are often not necessary due to the rapid formation of collateral circulation in the limbs (Hendrix and Baxter, 2005). There is a lack of data on the incidence of neurovascular involvement in equine wounds and how this may influence outcome.

3.5. Tendon/ligament Involvement

The equine distal limb has a thin covering of muscle, fat and skin that predisposes certain tendons and ligaments to damage as a consequence

of wounds to this area, for example interference injuries or wire lacerations. The type of tendon involved (extensor vs flexor), the limb affected and the number of soft tissue structures compromised in a wound are all factors that may impact on prognosis and outcome, therefore tendon involvement can have a variable prognosis for return to work (Foland *et al*., 1991). The type of tendon involved in a wound has been shown to affect outcome in several retrospective studies. Four retrospective studies on extensor tendon lacerations all showed a favourable prognosis on returning to the same level of work prior to injury, ranging from 47% to 74% (Foland *et al*., 1991, Jansson, 1995, Mespoulhes-Riviere *et al*., 2008, Belknap *et al*., 1993). In contrast, two studies of flexor tendon lacerations, reported that 18% and 50% of horses returned to the same level of work (Foland *et al*., 1991, Jordana *et al*., 2011). Perhaps the difference between return-to-work could be the improved medical treatment available to horses that developed in the 20 years between when these studies were published. These findings suggest a more favourable prognosis for wounds involving extensor tendons compared to those involving flexor tendons. Jordana and colleagues reported the more tendinous structures involved in a wound, the higher the likelihood of an unsuccessful outcome. Horses with only one structure had a 36% rate of returning to pre-injury level of work compared to 18% and 4% for wounds involving two or three structures respectively (Jordana *et al*., 2011). The authors suggested that with an increased number of functionally compromised tendinous structures, the more unstable a joint becomes, and the more likely nerves/vessels associated with the joint likely to become damaged. This finding was

replicated in a retrospective study on extensor tendon lacerations where wounds involving the long digital and lateral digital extensor tendons had a 62% chance of returning to the same level of work compared to 80% for wounds involving just the long digital extensor tendon (Belknap *et al*., 1993).

Three retrospective studies have identified that tendon lacerations are significantly more common in the hindlimb compared to the forelimb (Foland *et al*., 1991, Jansson, 1995, Jordana *et al*., 2011). For example, in the study by Jordana *et al*. (2011), injuries to the forelimb and hindlimb accounted for 37% and 63% respectively, but there is no current consensus on how this affects outcome. Foland and colleagues (1991) hypothesised that wounds involving tendons in the forelimb have a higher morbidity as the forelimb support 60% of the horse's weight compared to 40% at the hindlimbs. In contrast to wounds involving synovial structures, there was no significant correlation between time elapsed between treatment and outcome (Jansson, 1995). It is important both vets and owners can recognise wounds that involve tendinous structures as they can require significant surgical management. Despite treatment, the prognosis for return to pre-injury athletic function is variable. Current data is of a small sample size and specific to referral hospital populations, highlighting a need for larger studies which also capture data from primary care practice to ascertain whether findings in referral hospital populations are representative to the general horse population and would help to develop guidelines applicable to first opinion practice.

3.6. Thoracic/abdominal cavity Involvement

Wounds that involve the thoracic and abdominal cavities are relatively uncommon, but are usually penetrating injuries resulting from horses running over/into fixed objects, particularly fence posts or sticks (Hanson, 2008). Deeper involvement of the pleural/peritoneal cavity is rare, but wounds in these regions should still receive urgent veterinary treatment as involvement of these deeper structures is life-threatening. Abdominal wounds which can present with peritoneal contamination are usually located in the deep inguinal region and can be associated with life threatening complications including septic peritonitis or intestinal herniation (Barber, 2017). Wounds to the axilla region are most likely to compromise the pleural space with life-threatening subcutaneous emphysema, pleuritis or pneumothorax as potential complications (Hanson, 2008).

There is very limited evidence on treatment and outcomes for thoracic and abdominal wounds. A case report on an eight-year-old American Quarter Horse with a penetrating ventral abdominal wound is one of the few case reports of its type in the veterinary literature. The horse was successfully discharged from hospital 69 days post injury after undergoing underwent a general anaesthetic for exploratory celiotomy, a standing procedure to remove 12 sequestered costochondral fragments along with maggot debridement therapy and a peritoneal drain (Fontenot *et al*., 2018).

4.0. Treatment

4.1. Hand Preparation

Prior to administering any first aid to the wound, both owners and veterinary surgeons should proceed with hands preparation. Several solutions are available to achieve hand asepsis prior to wound treatment, for example antiseptic solutions such as chlorhexidine and povidone iodine. Alcoholic based hand rubs (ABR) are newer but have been shown to have equal efficacy to traditional hand-scrub techniques (Biermann et al., 2019, da Silveira et al., 2016). Antiseptic solutions and ABRs are both effective in reducing the hands bacterial load to appropriate levels for carrying out surgical procedures, regardless of the hands contamination level prior to scrubbing (da Silveira et al., 2016, Biermann et al., 2019). By wearing gloves for surgical procedures and for wound treatments, an effective protective barrier is established to reduce the introduction of pathogens to a wound bed (WHO, 2018). Hand preparation is important prior to donning gloves, as gloves can perforate allowing finger tips to inoculate a wound bed (Misteli et al., 2009). While it has been shown that glove perforation happens in 27% of equine surgeries (da Silveira et al., 2016) and in up to 66% of large animal surgeries (Biermann et al., 2019), the likelihood of contaminating a wound if the owner or attending veterinary surgeon fails to proceed with careful hand preparation remains to be established. Indeed, there is sparse data on the methods used by both veterinary practitioners and owners to clean or aseptically prepare their hands prior to wound treatment, particularly for veterinary practitioners in first opinion. There is also a lack of data on how owners

prepare their hands prior to administering first aid to wounds that are not attended by veterinary surgeons.

4.2. Clipping Hair

In human medicine, removal of hair is advocated to reduce the risk of surgical site infections, improve adhesiveness of dressings and reduce interference when opposing wound edges (Tanner et al., 2011). This systematic review concluded that shaving was associated with a higher risk of developing infections as opposed to clipping hair, and there was no significant difference between shaving and the use of depilatory cream. This review recommended the comparison of clipping with depilatory creams in future studies. Depilatory creams are rarely used in equine practice due to the nature and thickness of equine hair (Dart *et al*., 2016). Likewise, human medicine data on sterile surgical incisions in people should not be extrapolated to horses suffering from traumatic, likely contaminated wounds. The application of a sterile water-based lubrication gel to the surface of a wound prior to clipping hair prevents cut hairs from contaminating a wound and potentiating infection as the cut hairs are trapped in the gel which is then easily rinsed off the wound surface with water (Dart *et al*., 2016). This has been confirmed in the equine literature and while it is widely recommended, there is no data documenting its use by veterinary surgeons. There is also limited information focusing on site preparation. One experimental study compared bacterial swabs from clipped and non-clipped arthrocentesis sites (Hague et al., 1997). No significant difference in the amount of colony forming units (CFUs) was identified between clipped and non-clipped sites with the number of CFUs for both sites considered

acceptable prior to arthrocentesis. Hague's findings indicate that aseptic preparation of the skin in horses can be achieved without clipping hair when using five minutes contact time with Povidone iodine followed by an alcohol rinse. Povidone iodine and chlorhexidine gluconate were compared in another study for jugular venipuncture of long, clipped or shaved hair in horses (Geraghty *et al*., 2009). Clipping alone with no antiseptic did not result in a significant reduction of CFUs. The coat length (long, clipped, shaved) did not affect the ability of the surgical detergents to reduce bacterial load. While these results relate to the neck, findings may differ for traumatic wounds to limbs and other areas more prone to contamination or where the hair can often be longer, such as feathered distal limbs. Another potential confounding factor is that the bacterial population differs between wounded and non-wounded areas, with one study reporting that chronic wounds contained more *Pseudomonas* spp and healthy (non-wounded) skin flora contained more *Staphylococcus* spp (Westgate et al., 2011). Further studies are needed to assess the efficacy of antiseptic solutions on bacterial populations associated with wounds, for both clipped and non-clipped sites. This could in turn be used to establish evidence-based protocols leading to effective skin preparation prior to wound treatment.

4.3. Patient Skin Preparation

Chlorhexidine gluconate (CHG) and povidone iodine (PI) are surgical detergents used commonly for cleaning the surrounding skin of a wound prior to veterinary treatment (Dart *et al*., 2016). A systematic review in human medicine highlighted only one study which suggested Both chlorhexidine and povidone iodine have been shown equally effective in

reducing bacterial numbers to levels appropriate for surgery on healthy equine skin (Hague *et al*., 1997, Geraghty *et al*., 2009). One experimental study investigated whether application methods for PI influenced its efficacy, where was applied in one of the following four protocols: 10-minute scrub, 5-minute scrub, three 30-second scrubs or a commercial one-step iodophor surgical solution (Zubrod *et al*., 2004). All four methods were effective in reducing the bacterial numbers to appropriate levels for surgery on skin and there was no significant difference between groups. A similar study using CHG found no significant difference in the number of bacteria following a five minute mechanical scrub compared to a non-mechanical scrubbing one (Davids *et al*., 2015). Non-mechanical scrubbing was reported to be 67.8% cheaper as it required less water. The cost benefits coupled with no reduction in efficacy favours the use of non-mechanical scrubbing over mechanical scrubbing. Both studies support the efficacy of PI and CH, however they were performed at surgical sites on healthy, unbroken skin. Caution is warranted for extrapolating of these findings in cases of wounds from traumatic origin with exposed tissues and potential contamination. If antiseptics are in direct contact with the wound bed, they could impair wound healing. Indeed, they have been reported to have cytotoxic effects on keratinocytes, which in unbroken skin is protected by the stratum corneum (Totoraitis *et al*., 2017). In an older study, standardised full-thickness skin wounds were irrigated with differing concentrations of chlorhexidine using a beagle model (Sanchez *et al*., 1988). All wounds irrigated with chlorhexidine exhibited more wound contraction than control wounds irrigated with saline. More

recently, development of a novel alcohol-based skin antiseptic (ABSA) has shown promise as an alternative to chlorhexidine following an experimental study on 25 healthy horses. The ABSA tested, which is currently used in human medicine, was shown to be as equally efficacious in reducing bacterial load whilst reducing the skin preparation time for surgical procedures when compared to chlorhexidine gluconate followed by isopropyl alcohol rinse (Tannahill *et al*., 2018). While the work from Tannahill and colleagues was based on a clipped area of equine abdomen, the applicability of its results in cases of traumatic wound of the equine patient is questionable.

4.4. Debridement

Debridement is a key principle of the inflammatory phase of wound healing. Its function is to remove debris, necrotic tissue and reduce bacterial load, to promote wound healing and reduce the risk of infection (Hanson, 2008). Debridement of equine wounds can be achieved using a number of techniques including surgical, chemical, biological and hydrosurgical (Dart *et al*., 2017). There are a small number of experimental studies which have investigated different debridement methods. In a study comparing the effectiveness of saline lavage, sharp and hydrosurgical debridement at reducing the bacterial load on equine masseter muscle prosections, Skarlina and colleagues found hydrosurgical debridement to be significantly more effective, with a 99.7% reduction in bacterial counts of S*taphylococcus Aureus* (Skarlina *et al*., 2015). Saline irrigation alone, a type of mechanical irrigation, was the least effective. This study used healthy tissue from cadavers inoculated with bacteria and did not assess the ability of techniques to

remove debris or areas of necrosis, or how this impacted healing. The high cost of equipment is a limiting factor in the use and availability of hydrosurgical debridement, which limits its use to referral centres.

Chemical debridement techniques can also used in the management of equine wounds. The effects of enzymatic and autolytic debridement agents in wound dressings on the in vitro breakdown of fibrin in 15 equine blood clots was compared (Pain *et al*., 2006). Autolytic clot debriding agents were 47% more successful than enzymatic agents in breaking down the artificially formed eschar, particularly hydrofibre and gauze dressings. Untreated traditional gauze soaked in saline was also assessed; a form of non-selective mechanical debridement of a wound bed. This method was shown to be one of the simplest and most effective ways to achieve protein breakdown in the blood clot (Pain et al., 2006). In general dressings hydrated in saline were more effective than those hydrated in water at breaking down the blood clots.

Biological debridement of wound beds can be achieved using maggot debridement therapy (MDT), which has additional antimicrobial benefits, particularly effective against antibiotic resistant infections such as Methicillin-resistant staphylococcus aureus and is effective against biofilms (Daeschlein *et al*., 2007). MDT in veterinary practice is a relatively new technique. Sherman and colleagues reported that infections on six horses, expected to require euthanasia because of their injuries were brought under control following the use of MDT and only one animal was euthanized (Sherman et al., 2007). No notable

complications were noted other than mild discomfort during treatment. A more recent retrospective case series of MDT in 41 equids concluded that 93% of cases reached a favourable outcome within a seven day period (Lepage *et al*., 2012). Cases where MDT did not influence outcome suffered from concurrent complications including osseous sequestration or neoplasia (e.g. squamous cell carcinoma/melanoma). Although there are studies looking at individual methods of debridement, very few studies compare different techniques and no clear guidelines exist to suggest when one method is appropriate over another.

4.5. Lavage/Irrigation

In both human and veterinary medicine, irrigation is a corner stone of effective wound management, a prophylactic measure performed to help prevent the development of infection (Schumacher and Stashak, 2017). However, there are no official guidelines relating to delivery method and volume for both professions (Barnes *et al*., 2014, Singer *et al*., 1994). High pressure irrigation is effective in removing bacteria and foreign material. If the pressure is too high, irrigation can become counterproductive causing tissue damage and driving bacteria deeper into the wound bed (Anglen, 2001). The first published study attempting to establish the most appropriate method for irrigation used artificially inflicted and inoculated wounds on a rabbit model (Stevenson *et al*., 1976). High pressure, inexpensive syringe irrigation that successfully removed bacteria from the wound bed was achieved using a 35ml syringe and a 19-gauge needle. These findings were replicated in later study which created pressure curves when human doctors used various irrigation methods (Singer *et al*., 1994). Singer concluded that coupling a

19-gauge needle with either a 35 or 65ml plastic syringe achieved suitable pressures for wound irrigation, whilst costing less than $2 per disposable setup.

The time at which irrigation is performed in relation to the time of wound infliction has been demonstrated in one experimental study to influence outcome. Artificially inflicted wounds involving deeper musculoskeletal structures were inflicted to the distal limb of goats and inoculated with *Pseudomonas* (Owens and Wenke, 2007). The study found that irrigation of wounds at three hours resulted in a 70% reduction in bacterial levels compared to 52% at six hours and 37% at 12 hours. This suggests that earlier wound irrigation could help prevent the development of infection. This study only used a pulsatile lavage system which is unlikely to be widely used in first opinion equine practice. Prospective clinical studies using more widely available irrigation techniques are needed to better define the ideal window of time and method for optimal irrigation and debridement.

4.6. Closure

Primary closure is the direct apposition of wound edges, in the time soon after sustaining a wound, and is most commonly achieved using either sutures, which penetrate the dermis, or staples which do not penetrate the dermis. The criteria for wounds suitable for primary closure include adequate vascularisation, minimal tension and contamination, absence of foreign bodies and an acute presentation. Primary closure is advantageous in comparison to second intention healing having a reduced risk of contamination, faster healing and improved cosmetic

results (Elce, 2017). Introduction of suture material into a wound has the capacity to elicit a foreign body reaction or introduce infection (Setzen and Williams, 1997). Knonig and coworkers reported 20% of monofilament sutures contained levels of detectable biofilm in anexperimental study of chronic non-healing wounds in dogs, cats and horses (König *et al*., 2014). Two samples contained biofilms which were both multifilament suture material from canine tissues. While this evidence alone is not sufficient to suggest higher biofilm formation in multifilament compared to monofilament suture materials. It has previously been reported that biofilm formation favours growth in-between the braided filaments of multifilament sutures compared to monofilament suture materials under artificial conditions (Limbert *et al*., 2013). Konig's work is the only published study on suture material and biofilm formation in equids and only 8% of the tissue samples were from horses. Further research is needed to establish if any trends exist regarding the use of suture material in equine wound appostion that may predispose the development of infection.

Staples and sutures are two materials commonly used to achieve primary closure but there have been few studies assessing which is more appropriate for use in horses. A tissue reflectance spectroscopy device was used to assess how staples and 4-0 subcuticular polyglactin 910 sutures affect blood perfusion at the wound edge in 20 humans following knee replacement surgery (Graham *et al*., 2000). This study found a statistically significant increase in oxygen saturation with increasing distance between staples as they were spaced further apart from 4-

13mm. The use of 4-0 subcuticular polyglactin 910 sutures for wound apoosition in equine practice is unlikely. Oxygen saturation for sutures at the wound edge was equivalent to the mean interstaple space of 6mm. Increased oxygen saturation better perfuses a wound bed to aid healing and help prevent the growth of anaerobic bacteria (Franz *et al*., 2008). A meta-analysis inclusive of 683 orthopaedic patients whose surgical wounds were closed using either staples or sutures concluded that the risk of wound infection was three times greater with staples compared to sutures (Smith *et al*., 2010). There was no significant difference in wound dehiscence between staples and sutures. There were however differences in methodology between the six studies included in the meta-analysis which could be attributed to the diffences in risk of infection between staples and sutures. A more contemporaneous study is needed to support these findings, particularly in horses. Smith's study noted that patients reported increased pain following staple compared to suture removal but this would be difficult to assess in horses.

An experimental study assessed the gross and histological differences in wound closure for 3-0 polyglactin suture, metal staples and absorbable subcuticular staples for standardised surgical wounds in eight pigs (Fick *et al*., 2005). Dehiscence was not reported in any of the closure methods. Aggregate wound healing scores were significantly better for incisions closed with absorbable staples compared to metal staples and sutures. There was no significant difference between metal staples and sutures despite metal staples having marked initial inflammation. The limitations of this study are that only one suture material was tested and the use of

absorbable staples has not been widely reported in equine practice. These studies show both sutures and staples are effective in closing wounds but more primary studies are needed to assess the benefits and drawback of these closure methods in horses.

Suture patterns used to close wounds can be broadly split into continuous and interrupted. A systematic review of theincidence of wound dehisence and surgical site infection (SSI) development in people concluded there was no significant association between SSI development and suture pattern (Gurusamy *et al*., 2014). Differences in methodology between the separate studies makes comparison of results difficult. For example, 96% of cases of wound dehisence were caused by an interrupted suture pattern, however this finding is attributed to the non-absorbable material used in only one study, meaning the original statistic is due to suture materials and not pattern. This study was for surgical abdominal incisions in people. Similar studies on equine ventral midline coelitomies report that complications such as dehisence or incisional exudation are common (incidence of 9-22%) (Scharner et al., 2017, Colbath et al., 2014). These two studies identified that reduced post-operative wound complications were associated with inclusion of the peritoneum when closing the linea alba and closure of the subcutaneous tissues using a two layer modified subcuticular pattern (Colbath et al., 2014). No differences between continuous percutaneous or intradermal patterns have been identified and both are deemed suitable for closure of an equine ventral midline coeliotomy (Scharner et al., 2018). Interestingly, the use of a antibiotic impregnanted suture material did not demonstrate superior efficacy in

reducing the incidence post-operative complications in similar wounds (Bischofberger et al., 2010). Further studies exploring the effect of suture pattern and material are required using a traumatic wound model as oppose to the surgical wounds for which the current evidence is pirmarily based upon.

5.0. Complications with healing

5.1. Exuberant Granulation Tissue

Exuberant granulation tissue (EGT) is a common complication of equine limb wounds, especially those which heal through second intention. EGT is a product of excessive fibroplasia resulting in granulation tissue sitting proud above the level of the skin (Theoret and Wilmink, 2017). EGT reduces the rate of healing by impeding wound epithelisation and contraction (Bertone, 1989). An experimental study investigating the differences in wound healing between horses and rats concluded the healing response in horses was overly excessive (Chvapil *et al*., 1979). Rapid neutrophil infiltration and high collagenase activity in wounds less than one day old in horses, compared to rats, was suggested as the mechanism for impaired healing and EGT formation. EGT is a significant problem in horses, as such several studies have investigated treatments to reduce its development, including bandaging and the use of topical medications. An experimental study investigating the efficacy of four treatments for EGT formation on artificially inflicted wounds on four ponies found that wounds undergoing surgical excision of granulation tissue and cryosurgery produced no EGT whilst wounds that were bandaged or placed in plaster cast produced EGT requiring surgical excision (Fretz *et al*., 1983). Wounds that had a bandage/cast healed on average 23mm/day slower than the excision and cryosurgery wounds. A more recent study investigated the effects of bandaging on artificially inflicted wounds on the metacarpi/tarsi of six horses (Berry and Sullins, 2003). Again, all bandaged wounds required surgical excision of EGT

whilst no un-bandaged wounds formed EGT. Findings from both studies suggest the iatrogenic influence of bandaging wounds is a predisposing factor to EGT formation whilst exposure to air reduces this risk. The mechanism of this is unclear, but hypoxia has been suggested to play a key role in the pathogenesis of EGT formation (Sorensen *et al*., 2014). Bandaging decreases the oxygen concentration on the wound surface, causing hypoxic conditions which stimulates angiogenesis, fibroplasia and EGT formation (Knighton *et al*., 1981). This study used doppler flowmetry to show that limb wounds have reduced blood flow compared to wounds elsewhere on the body, which further reduces the oxygen concentration at the wound surface. The benefit of bandaging/casting wounds is often necessary, for example to enable large deficits to heal by granulation tissue infiltration, or to immobilise a wound over an area with a high degree of motion (Fretz *et al*., 1983). The experimental studies by Fretz *et al*. (1983) and Berry and Sullins (2003) have a number of limitations, including small sample size (ten equids in total). Neither study provided data on the signalment of equids used and wounds were artificially inflicted, which may affect how these results are extrapolated to traumatic skin wounds seen in the general horse population. Fretz's study used a pony model whilst Berry's used a horse model, and differences in EGT formation between horses and ponies has previously been reported. (Wilmink *et al*., 1999a) reported that the EGT of horses was more irregular, remained purulent for longer and persisted for longer compared to the EGT of ponies. A study assessing the different treatment options on both horses and ponies would therefore be beneficial.

Topical medications have also been evaluated to reduce the rate of EGT

formation. An experimental study investigated the effects of two topical antimicrobial treatments, povidone iodine and silver sulfadiazine. There was no significant difference on the rate of wound healing between the different antimicrobial treatments once EGT was managed by surgical excision. A further experimental study used EGT formation as a parameter of healing when comparing the effects of silver sulfadiazine cream (SCC), triple antimicrobial ointment (TAO) and hyperosmolar nanoemulsion (HNE) (Harmon *et al*., 2017). There was a significant (P = 0.007) difference in the number of wounds that required EGT surgical excision among groups, groups SCC and HNE required a significantly higher number of surgical excisions compared to TAO. None of these treatments resulted in more rapid wound closure compared with that for untreated control wounds. This paper states that larger studies of at least 61 wounds would be needed to confirm this significant difference, with 80% power and 95% confidence. This again highlights the need for a larger study to further assess which variables affect EGT formation and which treatments are most effective with consideration of different potential confounding factors, including age and size of the horse.

5.2. Lameness

The degree of lameness arising from a traumatic wound can be indicative of the severity of the injury itself, suggestive of sequelae requiring veterinary treatment and also prognosis (Hubert, 2011). The association with the degree of lameness and outcome has been specifically analysed in one retrospective case series of wounds seen in out-of-hours practice and commented on in a further three retrospective studies on wounds involving synovial structures, sequestra and tendons. A total of 481

wounds were included in the retrospective case series of wounds seen in out-of-hours practice (Firth *et al*., 2017). This study reported a significant relationship between the degree of lameness and outcome. Sixty three percent of horses with mild/moderate lameness had a 'simple outcome' compared to 74% of horses with critical lameness having a 'complicated outcome', which was significantly different using Fishers Exact test. Lameness is not a valuable prognostic indicator for all wounds, for example those involving synovial structures. In a retrospective study of septic calcaneal bursitis progressive lameness can be a clinical sign of the condition, but absence of lameness did not rule out persistent sepsis (Post *et al*., 2003). This study did highlight the association between severity of lameness and prognosis, where seven of the eight horses euthanized were done so because of persistent, debilitating lameness. Lameness can be a long-term debilitating complication of wounds involving bone, tendons, ligaments or synovial structures. In the study by (Clem *et al*., 1988) of osseous sequestration, lameness persisted in 12% (n=8) horses, which will have impacted their prognosis and ability to return to athletic performance. As discussed previously, flexor tendon lacerations are associated with a poorer prognosis than extensor tendon lacerations (Dahlgren, 2017). A retrospective study into extensor tendon lacerations did not give any details on horses being euthanized because of persistent lameness as a result of their injury (Jansson, 1995). In comparison, a similar study into flexor tendon injuries found that 15% (n=16) of horses were euthanized due to persistent lameness (Jordana *et al*., 2011). The comparison between these two studies again alludes to the prognostic value of documenting lameness in the case history. There

are many retrospective studies that mention lameness when assessing the outcomes of equine wounds but all lack specific details on the extent of lameness present. Further studies examining the relationship between lameness at the time of initial injury related to prognosis, and lameness persisting after treatment would be beneficial to truly understand the prognostic value of lameness when it has developed following traumatic wound injury.

5.3. Infection and dehiscence

Infections are a potentially performance limiting and life-threatening complication of equine wound healing, for example due to their risk of development into synovitis or tenosynovitis (Wereszka et al., 2007). To successfully treat infected wounds it is important to investigate and address any physiological, pathological or anatomical factors that are allowing infection to persist and progress; These could include for example, presence of antimicrobial insensitivity in the colonised wound bacteria or a nidus for infection, e.g. foreign bodies, excessive bacterial inoculum or sequestra (Orsini, 2017b). A retrospective study in human medicine highlighted several factors that influenced surgical wound dehiscence. Data from 17,044 laparotomies had a 3.4% incidence of wound dehiscence (Webster *et al*., 2003). Co-morbidities were found to most significantly influence the incidence of dehiscence, for example COPD, pneumonia and superficial/deep wound infections. Dehiscence is a common sequelae of equine wounds particularly those wounds that are closed by primary intention with a high bacterial load, although the incidence of dehiscence has not been directly reported (Wilmink, 2016). All wounds whether surgical or traumatic are contaminated with bacteria.

In the healthy animal, providing the inoculum is of low number/virulence, host defences are usually sufficient to localise and clear any developing infection. Infection can however develop from as little as 10^5 microorganisms per gram of tissue (Hackett *et al*., 1983). These levels were reported in an experimental study on surgical skin wounds to the cervical region of six horses. The potential severity of traumatic wound infection was highlighted where open long bone fractures in horses with wound contamination were 4.59 times less likely to be discharged compared to similar fractures without wound contamination (Ahern et al., 2010). Traumatic wounds, particularly those to the distal limb, may behave differently in response to bacteria, as wound healing may differ from proximal injuries, as detailed previously. Novel treatments such as a single intralesional application of medical grade honey at the time of wound injury has been demonstrated to significantly reduce the signs of infection and reduce the risk of dehiscence (Mandel et al., 2020).

5.4. Tetanus

Tetanus, or 'locked-jaw', is a fatal, but preventable, neurological disease found in the horse characterised by progressively worsening muscular stiffness and spasming (Aleman *et al*., 2018). The disease is caused by the production of neurotoxins from the bacteria *Clostridium Tetani*; the spores of which are found in the soil, particularly where contaminated with faecal matter. Horses are commonly infected following the inoculation of any sized wound with spores found in the soil (Jeffcott and Mair, 1998). In a retrospective study of 20 cases of equine tetanus in a referral hospital population, only 10% had no previous history of a recent traumatic wound. The onset of clinical signs for the other 90% of cases

occurred a mean of nine days after injury (ranging from 2-21 days) (Green *et al*., 1994). Tetanus can be easily prevented if owners choose to routinely and appropriately vaccinate their horses with a tetanus toxoid (Paillot *et al*., 2017). Green's retrospective study quoted a mortality rate of 75% with all of the non-vaccinated horses dying (Green *et al*., 1994). A similar, more recent retrospective study of 31 cases of equine tetanus quoted a mortality rate of 68% and stated that no animals included in the study had been appropriately vaccinated (van Galen *et al*., 2008). In this study, the younger a horse was, the more likely it was to have a negative outcome. For any wounded horse, a tetanus toxoid booster should be given if the animal has not received a booster within the previous 12 months. If the animal has never been vaccinated for tetanus then it should receive the booster and an injection of tetanus antitoxin at a separate injection site (Dart *et al*., 2017). There have been reports of a lack of efficacy of the tetanus vaccine of four horses in a retrospective evaluation of 155 equids suffering from tetanus (van Galen et al., 2017). This study also reported that two foals died of tetanus despite being administered appropriate anti-toxoid at birth. Despite Van Galen's findings of failed efficacy, these cases remain in a minority meaning it remains important to prophylactically vaccinate animals instead of solely relying on the antitoxin as animals can be infected by cuts that go unnoticed by the owner.

6.0. Aim and objectives

Aim: The aim of this study was to generate primary evidence on the healing and outcome of wounds in horses, including how owners' approach and manage wounds either prior to or in the absence of veterinary treatment.

Objectives:

- To document owners' confidence and ability in recognising different types of wounds and factors influencing their decisions to seek veterinary advice/treatment
- To better understand what first aid measures owners adopt when faced with different types of equine wounds
- To develop and distribute electronic and hard copy data capture systems suitable for owners to report recently healed wounds and also document currently ongoing healing wounds
- To perform descriptive analysis of the presenting signs, treatment and outcomes of wound injuries in horses
- To identify any factors which have a significant impact on the duration of healing, cosmetic or functional outcome and survival

Chapter 2: Survey on the Concepts and Current Habits of Horse Owners When Approaching and Managing Hypothetical Wound Case Scenarios

7.0. Materials and Methods

7.1. Ethical Review

This study, run in collaboration between The British Horse Society (BHS) and The University of Nottingham (UoN), was approved by the University of Nottingham's School of Veterinary Medicine and Science Ethics Committee. Data collection and anonymity was conducted in accordance with the 2018 Data Protection Act and the British Educational Research Association's revised ethical guidelines for educational research (2004).

7.2. Summary

An online survey was developed to assess the concepts and current habits of how people involved in the care of horses, approach and manage different wound case scenarios. The areas covered included participants' demographic, previous experience with wounds, relevant qualifications, factors that would influence their decision to seek veterinary advice, when they would seek veterinary advice and any first aid measures administered. Participants were also asked how they would approach and manage each of seven different wounds if the injury

occurred on a horse under their own care. Links to complete the survey was disseminated to the target population through BHS social media channels. Data was transferred into a spreadsheet and coded to allow for simple descriptive and statistical analysis (IBM SPSS Statistics for Windows 2017, IBM Corp, version 25.0. Armonk, NY: IBM Corp). Binomial logistic and multinomial regression models were applied to how the participant's demographics, previous experience and qualifications affected how they chose to treat each wound and seek veterinary advice.

7.3. Sample Population

The online survey was designed to collect data on how owners/carers approach and manage different types of equine wounds and what factors influence their decision to seek veterinary advice. The survey was available between 18/03/19 and 15/05/19. The target population was UK residents who currently or who have previously had a role in caring for a horse, pony, donkey or mule. The survey aimed to collect responses not only from horse owners but any person who had a major role in caring for a horse, for example those loaning/sharing a horse, grooms and yard owners etc. Participants were recruited using a convenience sample method through social media.

7.4. Survey Development

This overall research project was named 'The Equine Wound Project' (EWP), with this survey forming the first element of the project. An online survey titled 'Equine Wound Management: Approach to Hypothetical Case Scenarios' was developed using the online platform Jisc Online Surveys. This was piloted as taking between 20 and 30 minutes to complete. A

copy of the online survey can be found at Appendix I. The main body of the survey presented seven different equine wound cases following a section capturing data on participant demographics, previous experience and opinions on wound management. Each case included a description of the mechanism of injury, a picture of the wound and a diagram of a horse marking the anatomic location of the wound. Participants were asked to answer subsequent questions honestly, as if the wound was on a horse under their care. Each case included questions on how confident participants would feel about managing the wound/seeking veterinary advice and what, if any, first aid measures they would administer. Each case included in the survey assessed how participants would approach and manage different elements of equine wound management. Cases and questions were selected and designed following a review of the current relevant medical and veterinary literature. Data was collected using both open and closed questions. Only questions in the section titled 'consent' were made compulsory to ensure informed consent was acquired and so respondents were not deterred from not completing the survey if there were some answers they would prefer to omit. The survey structure, details of each case scenario including the picture used, picture source and what each case aimed to assess can be found in Table 7.1. Descriptors under case numbers, for example 'puncture wound' for Case 1 are included for the purpose of this thesis so that readers could more easily refer back to each case scenario. They were not included in the actual survey. A diagram indicating the anatomic location of the wounds was supplied in the description of each case scenario so that owners were clear which area of the horse the wound affected. These seven diagrams

have been combined into one diagram for the purpose of this thesis (Figure 7.1)

Section Title	Number of Questions	Data Collected
Introduction	0	Provided information on why this survey has been developed, outlined the survey structure and asked participants to answer honestly, stated ethical approval and provided researcher contact details. Informed owners/carers about the prospective study detailed in Chapter 12.
Consent	1	Participants could not continue past here unless they agreed with the conditions of participation
Participant information (including participant demographics, experience and opinions on decision-making and resources)	11	Gender, age, country of residence, previous experience with horses, current horse ownership/role, professional equine qualifications*, previous human/veterinary medical training*, vaccination/insurance status of any horses under their care, previous experience with equine wounds, factors influencing decision to seek veterinary advice*/[1], which areas of equine wound management they would benefit most from further education*/[2] and which format they would prefer educational resources to be delivered*
Seven wound case scenarios, each given a separate page	10-12 (x7)	Owner opinions of which tissues they believed were involved in the wound*, whether they believed the wound required veterinary treatment[3], owner confidence in managing the wound and seeking veterinary advice[4], any first aid measures they would administer* (e.g. cleaning, medicating, bandaging), how they would rest the horse, and any further comments.
Prize Draw	1	Details of prize draw

*Indicates a question where participants could indicate more than one answer per questions

[1]Participants were asked to score from 0-10 how 12 different factors would influence their decision to seek veterinary advice if a horse under their care presented with a wound, with '0' not influencing their decision at all and '10'

the most important factor influencing their decision. The mean scores for each factor were calculated and ranked to identify the top five most important factors.

[2]Participants were presented with six different aspects of wound management and asked which areas they were not confident about and would benefit from further advice and education. The total number of responses for each factor were totalled and then ranked.

[3]Participants were asked to indicate what level of treatment they believed the wound required, ranging from 'No treatment' to 'High priority/emergency veterinary treatment'.

[4]Participants were asked how confident they would feel about managing each wound if they were faced with the same injury on a horse under their own care. The term 'management' was described in the question as including the wound's treatment, cleaning, medication and bandaging. A scale was provided where '0' equated to not confident at all and '10' equated to 100% confidence. Using the same scale, participants were also asked how confident they would feel about deciding whether each wound required veterinary treatment.

Case Number	Picture Included	Picture Source	Additional Questions included	What this question aimed to assess
1 'Puncture wound'		http://myhorse forum.com	How would you prepare your hands prior to administering first aid?	Ability to recognise potential severity of puncture wounds over a synovial structure
2 'Kick wound'		www2.aofoundation.org	If the horse was lame would it influence your decision to call a vet?	Effect of lameness on decision-making

3 'Minor Flank wound'		Equine Wound Project Prospective Study	Included a picture of the wound once it had healed and asks study participants to score the cosmetic outcome	Horse owner management of minor wounds Owner assessment of cosmetic outcome
4 'Bleeding wound'		https://horselifeandlove.blogspot.com	How would you stop this wound from bleeding?	Owner haemostasis techniques
5 'EGT wound'		Equine Wound Project Prospective Study	Can you name the complication this wound is presenting with?	Owner ability to recognise presence and significance of EGT[1]
6 'Obviously Severe wound'		Equine Wound Project Prospective Study	Wound would heal but would require at least 12 months off work, how would you proceed with treatment?	Owner ability to recognise obviously severe wounds Owner opinions towards euthanasia
7 'Infected wound'		www.horseforum.com	Do you think this wound is infected?	Owner ability to recognise presence and significance of obviously infected wounds

[1] Participants were asked if they could correctly name the complication that this wound was presenting with, with the correct answer being exuberant granulation tissue or similar. Responses such as 'proud flesh' or 'excessive granulation' were considered correct.

Table 7.1 – Survey Structure. This table details the structure of the online survey. The first half details the questions included, their order and the data they captured. The second half of the table details the seven case scenarios, including the picture used, its source, additional questions included and what the scenario aimed to assess.

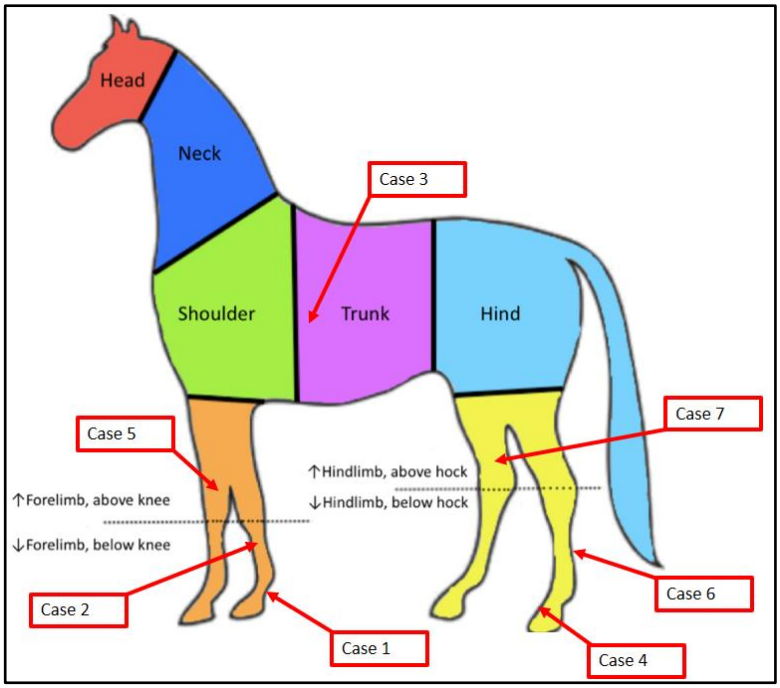

Figure 7.1 – Anatomic location of the seven case scenarios. This diagram details the anatomic location of the seven case scenarios. A copy of this diagram was included in each case description and contained only the location of the wound specific to that case.

Prior to being made publicly accessible, this online survey was piloted with three equine vets and two horse owners, who all had affiliations with the UoN. The British Horse Society also piloted the survey amongst several office staff, all of whom were horse owners. Following piloting, a number of changes were made to the survey to ensure that it was suitable and ready for data collection. Changes included rewording of questions and introductory paragraphs to make it clear exactly what was being asked of participants and removal of three questions that were deemed not relevant to this study.

7.5. Survey Dissemination

Awareness and links to this online survey were disseminated

predominantly using social media, specifically Facebook, by both the BHS and UoN. Information and a link to complete this survey was also hosted on the BHS webpage (Figure 7.2), articles were included in two BHS E-news articles and in The British Horse Magazine. All promotional material was drafted and final approval given by researchers at UoN. Both Facebook posts were shared onto the 'Nottingham Equine Colic and Wound' Facebook page and also shared amongst 62 equine focused Facebook groups which between them had a total of 1,014,828 members (data accurate when accessed 02/05/19). These groups were found after searching Facebook using the following search terms 'Equine', 'Equines', 'Horse' or 'Horsey' Additional groups were then found following suggestions automatically generated by Facebook. Additionally, all participants in the prospective cohort study that was part of this project, detailed in Chapter 10, were emailed a link to, and details of this survey.

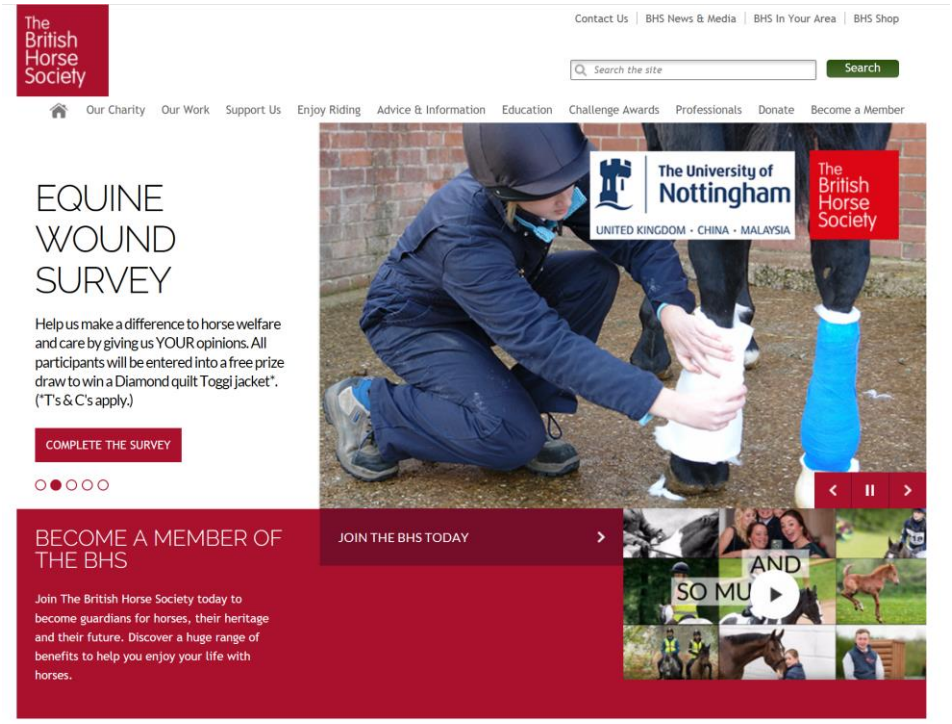

Figure 7.2 – Screen shot of British Horse Society website. This is a screenshot of the homepage of the British Horse Society Website, accessed on 05/03/2019. It depicts a promotional rolling banner aiming to encourage visitors to the website to complete this online survey. Clicking on this banner would direct people to the survey link.

7.6. Data Analysis

Jisc Online Surveys automatically compiled all of the responses into an online spreadsheet. This data were transferred from the online spreadsheet to an excel spreadsheet (2016, Microsoft Corporation, WA, USA). All data entries were then manually checked and cleaned; corrupt, inaccurate, and incomplete records were detected and corrected or deleted where appropriate. Data from the Excel spreadsheet were then transferred into an IBM SPSS statistics spreadsheet. Once all of the data had been transferred into IBM SPSS, descriptive analysis was performed for each question by using the 'descriptive statistics' function. Using the 'Crosstabs' function, chi-square analysis was performed to compare whether variables extracted from the participants demographics made them more or less likely to select different management options for each wound case.

The IBM SPSS Statistics data set was forwarded onto the Digital Research service team (DRST), University of Nottingham. The DRST applied a combination of logistic and multinomial logistic regression models to assess whether eight independent variables relating to the participants' demographics, qualifications, experience in caring for horses and previous experience with wounds had evidence of association with how they choose to treat each wound case. IBM SPSS statistics was again the software used to analyse the data. Four dependent variables were assessed that related to the treatment of the wounds including (1) treatment level, (2) washing the wound with antiseptic, (3) application of medications and (4) application of a bandage.

8.0. Results

A total of 1799 responses were received to this survey, with 1037 respondents completing all 11 sections, giving a 58% completion rate. Only responses that completed all 11 sections of the survey were included for data analysis (n=1037). Many participants chose to omit answers for different questions meaning out of the total pool of included responses, a different proportion of them completed various questions.

8.1. Participant Information

Females comprised the majority of participants (98.2%, n=1018/1037). The mean age of participants was 37.9 years, ranging from 16 to 80 years (n=1002). The study population composition was 88.5% (n=1035/1037) UK based. The USA, New Zealand and Ireland were the first, second and third largest countries contributing participants outside of the UK.

Nearly half of participants had no equine qualifications (49.7%, n=497/999). The proportion of participants with one qualification was 27.5% (n=275/999), with two qualifications was 15.1% (n=151/999) and with three or more qualifications was 7.6% (n=76/999). The most common equine qualification held by participants was a British Horse Society qualification (n=317/1037). The majority of participants did not hold any form of professional medical qualification (79.4%, n=823/1037). Nurses were the most common medical professionals completing this survey (5.2%, n=54/1037).

Those who currently owned a horse and had sole responsibility for emergency decision making made up the majority of participants (86.5%, n=894/1034). The proportion of participants who did not own a horse but had a major role in emergency decision making for a horse or horses they provide day to day care for through loaning/sharing, was 4.4% (n=46/1034). The proportion of participants that did not own a horse but had a major role in emergency decision making for a horse or horses they provide day to care for as part of an equestrian business, for example a yard manager, trainer, breeder groom was 4.6% (n=48/1034). The proportion of participants who did not currently own, care for or have a major role in making emergency decisions for a horse was 4.5% (n=47/1034). The modal number of horses that participants had a role in emergency decision making for was one horse (n=32.5%, 329/1012), ranging from zero to 210 horses with a mean value of five horses.

The majority of participants (82.2% (n=814/990)) had all horses under their care up to date with the tetanus vaccination. The proportion of participants that were caring for horses which were not up to date with their tetanus vaccine or were unsure if they had been vaccinated was 12.6% (n=125/990), 7.6% (n=75/990) of participants were caring for horses which had never been vaccinated for tetanus, full results can be seen in Table 8.1. Chi-squared statistical analysis found no evidence of association when exploring whether respondents holding any equine or medical qualifications would affect the likelihood of the horses under their care being appropriately vaccinated for tetanus.

	Never been vaccinated (n=)	Vaccination is out of date (n=)	Vaccination is up to date (n=)	Unsure (n=)
All of the horses under their care	30	34	814	10
Some of the horses under their care	45	75	78	6

Table 8.1 – Tetanus vaccination status of participant's horses. This table details the tetanus vaccination status of horses under the care of survey participants.

The proportion of participants that had no horses under their care insured for veterinary fees was 41.6% (n=404/971) whilst 36.6% (n=355/971) of participants had all of the horses under their care insured. The modal value of insurance cover for veterinary fees was £5000 ranging from less than £1000 to over £10000 (n=534). Chi squared analysis identified that participants who held a BHS qualification showed evidence of association with having horses under their care insured for veterinary fees (P=0.04, Odds ratio (OR)=1.38, 95% Confidence interval (CI) 1.79-10.3).

8.2. Previous Experience of Wounds

Nearly all participants (94.5%, n=976/1033) stated that they had experience of a horse under their care suffering from a wound of traumatic origin. A further 79.3% (n=754/951) said they have had experience with a horse under their care suffering from a traumatic wound that required veterinary treatment or more than two weeks' worth of management.

The most influential factor if a participant discovered a horse under their care had suffered from a wound injury, ranked on a scale of 1-10 where '0' would not influence their decision at all and '10' was the most important factor influencing their decision to seek veterinary advice if they, was 'Depth of wound'. Full results for this question are displayed in Table 8.2. When asked if there were any other additional factors not previously listed that would influence participants decisions to seek veterinary advice, the most common response were those with a theme pertaining to a change in behaviour of the horse (n=52/306).

Factor	Mean Score	Modal Score	Proportion of participants who had not previously considered this factor	Number of participants who chose to answer this question
Depth of wound	9.1	10 (n=648)	0.3% (n=3)	1034
Location of wound	8.6	10 (n=546)	0.4% (n=4)	1033
Amount of bleeding	8.1	10 (n=450)	0.5% (n=4)	1031
Size of wound	7.9	10 (n=410)	0.4% (n=4)	1029
Degree of lameness (if it were a limb wound)	7.2	10 (n=297)	1.7% (n=18)	1030
Participants previous experience with wounds	6.5	10 (n=224)	2.6% (n=27)	1033
Advice from other horse owners	2.8	0 (n=224)	14.0% (n=114)	1031
Age of horse	2.5	0=312	18.3% (n=188)	1029
Time of day horse injured itself (e.g. have to phone vet out-of-hours)	2.3	0 (n=388)	14.0% (n=144)	1029
Cost of treatment	2.1	0 (n=371)	14.4% (n=148)	1028

Work horse is currently in	1.9	0 (n=358)	19.9 (n=205)	1029
Horse temperament	1.8	0 (n=359)	21.7% (n=223)	1027

Table 8.2 –This table details and ranks, by mean, 12 different factors that would influence participants decisions to seek veterinary advice should a horse under their care suffer from a traumatic wound.

The aspect of equine wound management participants indicated they would benefit most further education was 'When and/or what medications, creams or powders to put on a wound surface' (29.7%, n=308/1036), full results for this question are displayed in Table 8.3. Chi-square analysis of participants holding different equine and medical qualifications showed evidence of significance with participants holding a nursing qualification and those who indicated they would benefit from further education about how long wounds take to heal (P=0.025, OR=0.4, 95% CI 0.18-0.89) and what to do whilst waiting for the vet (P=0.027, OR=0.34, 95% CI 0.14-0.87). There was also evidence of significance for participants who were veterinary nurses and those who indicated that they would benefit from further education about what to do whilst waiting for the vet (P=0.002, OR=0.15, 95% CI 0.03-0.6).

Aspect of wound management	Number of participants (n=1036)	%
When and/or what medications, creams or powders to put on a wound surface	308	29.7
How long different wounds take to heal	275	26.5
When and/or what bandages to put on a wound	251	24.2
What to do whilst waiting for the vet	230	22.2
How to clean a wound	138	13.3
When to call a vet	96	9.3

Table 8.3 – Areas participants would like further education. This table details and

ranks six different aspects of equine wound management that study participants have indicated they would benefit from further education about.

8.3. Case 1 – Puncture wound

Case 1 presented a small puncture wound over the area of the digital flexor tendon sheath. When asked how participants would prepare themselves prior to administering first aid, washing hands with a disinfectant (e.g. chlorhexidine (CH) or povidone iodine (PI)) was the most common response (49.8%, 516/1037). This was followed by wearing medical grade gloves (47.0%), washing hands with soap and water (29.8%), applying an alcohol-based hand rub (7.3%), not washing hands (6.6%) and washing hands with water only (5.1%).

All participants said that they would clean this wound. The most common method of cleaning this wound was using an antiseptic such as CH (76.9%, n=260/338), followed by using cooled boiled water (25.1%, n=85/338) and then using tap/hosepipe water (18%, n=61/338). When asked if there were any additional cleaning methods, not previously listed, participants would employ to clean the wound, the most common response was one that indicated using water with added salt.

The majority of participants said that they would apply a topical medication, cream or powder to the surface of this wound (57.3%, n=199/347), 34.3% (119/347) said they would not apply any whilst 8.4% (n=29/347) of participants indicated they were unsure. A free text box was provided so that those that would apply topical medications could provide further details on exactly what they would apply, which was complete by 188 of the 199 eligible participants. Responses were

grouped based on phrases quoted in Table 8.4, including those with a similar spelling.

Phrase	Number of Responses
'Cream'	45
'Powder'	37
'Spray'	37
'Honey'	25
'Sudocreme'	23
'Gel'	21
'Purple/blue spray'	20
'Antiseptic'	16
'Silver' / 'Flammazine'	14
'Antibacterial'	14
'Antibiotic'	8
'Dermagel'	8
'Barrier'	6
'Camrosa'	5
'Intrasite'	2
'Aloe vera'	1

Table 8.4 – Topical medications Case 1. This table details and ranks the most common topical medications participants stated they would apply to this case scenario. Response numbers were found after searching this free text answer using key terms.

The majority (56.0%, n=195/348) of participants said they would not apply a bandage to this wound. The three most commonly used bandaging products as mentioned in a free text box were 'poultice' (n=24/110), 'gauze' (n=22/110) and 'Animalintex' (n=21/110).

Only participants holding a veterinary medicine qualification demonstrated significance when comparing with those participants who indicated synovial structures were or were possibly involved in this wound (Chi-square, P=0.026, OR = 7, 95% CI 0.94-52.02). Logistic

regression using owners who cared for only one horse as a reference category, demonstrated owners with three horses under their care were more likely to apply a bandage to this wound (P=0.033, OR = 2.4, 95% CI 1.1-5.3). Owners with five or more horses were more likely to apply a bandage to this wound (P=0.002, OR = 2.8, 95% CI 1.5-5.3). There was no evidence of significance when comparing owners who care for two or four horses. Further logistic regression models did not demonstrate any significance between participants with previous wound experience, age and the likelihood they would wash this wound with antiseptic or apply medications.

8.4. Case 2 – Kick wound

Case 2 presented a wound to the metacarpal region; in the case description it was stated the wound was likely caused by a high impact kick. Only a minority of participants (0.5%, n=3/631) said that they would not clean this wound. The majority of participants said they would clean this wound with an antiseptic (68.1%, n=430/631) followed by using cooled boiled water (28.8%, n=182/631) and then tap or hosepipe water (27.7%, n=175/63).

The majority (63.1%, n=403/631) of participants said they would apply a topical medication, cream or powder to the surface of this wound, 27.9% said they would not apply any, whilst 9.1% of participants were unsure. Table 8.5 details the most common responses when participants were asked which topical medications, if any, they would apply to this wound, completed by 188 of the 403 eligible participants.

Phrase	Number of Responses

'Spray'	86
'Cream'	78
'Gel'	58
'Powder'	54
'Antiseptic'	50
'Sudocreme'	41
'Purple/blue spray'	38
'Honey'	36
'Silver' / 'Flammazine'	29
'Antibiotic'	20
'Dermagel'	17
'Antibacterial'	15
'Intrasite'	8
'Barrier'	6
'Camrosa'	4
'Aloe Vera'	0

Table 8.5 – Topical medications Case 2. This table details and ranks the most common topical medications participants stated they would apply to this case scenario, including those of a similar spelling. Response numbers were found after searching this free text answer using key terms in Microsoft Excel.

The majority (52.8%, n=336/644) of participants chose not to apply a bandage to this wound. The most commonly used bandaging products as mentioned in a free text box were 'non-stick' (n=46/219), followed by 'gauze' (n=38/219) and 'Animalintex' (n=23/219).

The proportion of participants stated that if this horse exhibited lameness on the affected limb it would influence their decision to seek veterinary advice was 49% (n=507/1035). The second most common response was 'It would depend on how lame the horse was' (n=30.1%, n=312/1035) followed by 'I would call the vet for this wound regardless of the presence of lameness' (16.7%, 173/1035) and 'the presence of lameness would

not have influenced my decision to call a vet' (3.8%, n=39/1035). A statistical significance was observed between participants who have their own horses insured and whether they chose to call the vet for this wound (Chi-square, P=0.027, OR=1.36, 95% CI 1.04-1.77).

Chi-square analysis demonstrated evidence of significance when comparing those that hold a medical/equine qualification and indicating whether this wound involved bone (P=0.023). Specific analysis of each qualification separately only identified those that held a BHS qualification (P=0.014, OR=1.5, 95% CI 1.08-1.95) or were training to be a nurse (P=0.019, OR=0.52, 95% CI 0.30-0.91) to be significant.

8.5. Case 3 – Minor flank wound

Case 3 presented several small superficial wounds located on the flank of a horse. Only a minority of participants said that they would not clean this wound (2.8%, n=24/866). The most common method of cleaning this wound involved using an antiseptic such as chlorhexidine (65.8%, n=570/866), followed by using cooled boiled water (35.4%, n=307/866) and then tap/hosepipe water (16.7%, n=145/866).

The majority (67.5%, n=431/639) of participants said they would apply a topical medication, cream or powder to the surface of this wound, 26.4% (n=169/639) said that they would not apply any whilst 6.1% (n=39/639) were unsure. Table 8.6 details the most common responses when participants were asked which topical medications, if any, they would apply to this wound, completed by 558 of 600 eligible participants.

Phrase	Number of Responses

'Cream'	153
'Spray'	152
'Antiseptic'	93
'Sudocreme'	88
'Gel'	71
'Powder'	69
'Purple/blue spray'	66
'Silver' / 'Flammazine'	65
'Dermagel'	26
'Antibiotic'	20
'Honey'	20
Aloe Vera	19
'Antibacterial'	16
'Barrier'	12
'Camrosa'	4
'Intrasite'	2

Table 8.6 – Topical medications Case 3. This table details and ranks the most common topical medications participants stated they would apply to this case scenario, including those with a similar spelling. Response numbers were found after searching this free text answer using key terms in Microsoft Excel.

The majority of participants indicated that they would not apply a bandage to this wound (67.5%, n=600/889).

The majority said the cosmetic outcome of this wound was 'adequate' (83.9%, n=866/1032), followed by 'excellent' (9.7%, n=100/1032) and then 'unacceptable' (6.4%, 66/1032), when provided with a picture of the same wound after the edges had completely apposed.

8.6. Case 4 – Bleeding wound

Case 4 presented a wound on the dorsal fetlock and asked how participants would act considering the wound was actively 'dribbling'

blood. The majority of participants said they would apply pressure (71.5%, n=739/1033), this was predominantly achieved by applying pressure with a bandage (26.9%, n=417/752), by using a towel (26.9%, 202/752), cotton wool (7.4%, 56/752) and then hands (1.6%, n=12/752). Fifty (4.8%) participants specified they would apply some form of tourniquet. The proportion of participants that would not do anything in response to the bleeding was (16.5%, n=170/1033).

8.7. Case 5 – EGT wound

Case 5 presented a chronic equine wound that exhibited exuberant granulation tissue as a complication of healing. When asked what complication this wound was suffering from, the majority of participants correctly identified 'exuberant granulation tissue' or similar (63.2%, n=526/832), 25.7% (n=213/832) were incorrect or stated they did not know the answer. A proportion of respondents eluded to the correct answer but were not entirely correct, providing answers such as 'granulation tissue' but did not state that it was excessive or proud (11.1%, n=92/832).

Chi-square analysis demonstrated evidence of significance when comparing owners which had their own horses insured and participants which chose to seek veterinary attention for this wound (P=0.01, OR=1.49, 95% CI 1.1-2.02).

8.8. Case 6 – Severe de-gloving wound

Case six presented a severe de-gloving wound and asked several questions exploring respondent's opinions towards euthanasia. The case

profile states that there was a possibility this wound could be successfully treated but would require at least 12 months off work and the horse may not return to the same level of work. The majority (52.9%, n=549/1037) said they would continue with treatment, 19.1% (n=198/1037) said they would consider euthanasia, 14.7% (152/1037) said they required more information on the cost of treatment with 2.1% (22/1037) saying they would euthanize the horse immediately.

The modal response, when asked what the maximum amount of time participants would allow for the wound to heal before considering euthanasia, was one with a theme pertaining to the idea that the decision to euthanize depends on other factors (28.3%, n=263/928). The most common factor mentioned relating to the quality of life or any pain felt by the horse. The second most common response was where participants stated there was no maximum amount of time (19.1%, n=177/928), followed by less than six months (13.7%, n=127/928) and then 6-12 months (15.1%, n=140/928).

8.9. Case 7 – Infected wound

This case presented a wound that had recently dehisced following primary closure and was now displaying symptoms of bacterial infection including 'a whitish/green discharge'. The majority correctly indicated that this wound was infected (96.8%, n=995/1028).

8.10. Case 1-7 Grouped Data

The majority of participants agreed that 'Skin' was involved in each of the seven cases. For the other tissue types, there was variation as to

whether participants could reach a consensus (≥50%) on which tissues were involved in each wound. For example, participants reached a consensus for case 2 that the tissues 'Muscle' and 'Joint, tendon sheath and bursa' were not involved but no consensus was reached for 'Tendon/ligament' and 'Bone'. The full results for which tissues participants believed to be compromised in each wound case are displayed in Table 8.7.

Case	Tissue	Responses	Yes %	No %	Possibly %
1	Skin	1031	98.8	0.1	1.1
	Muscle	901	35.0	35.8	29.2
	Tendon/Ligament	982	21.7	17.1	61.2
	Joint, tendon sheath or bursa	951	20.8	22.1	57.1
	Bone	912	10.4	45.5	44.1
2	Skin	1030	98.9	0.3	0.8
	Muscle	871	21.6	52.9	25.5
	Tendon/Ligament	952	16.7	27.3	56.0
	Joint, tendon sheath or bursa	877	7.8	53.2	39.0
	Bone	961	15.8	35.0	49.2
3	Skin	1036	99.2	0.3	0.5
	Muscle	947	27.3	30.4	42.2
	Tendon/Ligament	850	0.4	96.6	3.1
	Joint, tendon sheath or bursa	854	0.2	97.3	2.5
	Bone	862	0.8	93.3	5.9
4	Skin	1035	99.5	0.1	0.4
	Muscle	930	42.2	30.9	27.0
	Tendon/Ligament	975	33.5	11.9	54.6
	Joint, tendon sheath or bursa	980	30.5	14.3	55.2
	Bone	949	16.5	33.3	50.2
5	Skin	1030	99.4	0.1	0.5
	Muscle	965	46.0	22.7	31.3
	Tendon/Ligament	894	9.3	53.4	37.4
	Joint, tendon sheath or bursa	873	6.6	63.1	30.2
	Bone	869	3.6	74.7	21.7
6	Skin	1035	99.6	0.0	0.4
	Muscle	991	76.1	17.5	6.5
	Tendon/Ligament	1028	84.2	0.6	15.2
	Joint, tendon sheath or bursa	993	65.2	10.6	24.3

	Bone	1026	75.6	1.9	22.5
7	Skin	1027	98.7	0.3	1.0
	Muscle	976	54.1	10.7	35.2
	Tendon/Ligament	921	13.7	32.8	46.5
	Joint, tendon sheath or bursa	910	13.6	40.2	46.2
	Bone	893	6.0	56.8	37.2

Table 8.7 – Tissue involvement. This table summarises which tissues participants indicated they believed were involved in each case scenario.

Participants felt most confident managing the minor flank wound and least confident about managing the de-gloving wound. Participants felt most confident seeking veterinary advice for the de-gloving wound and least confident for the puncture wound. Full results for how confident owners indicated they would feel about managing each of the seven cases and their confidence in seeking veterinary advice results are summarised in Table 8.8.

Case	Question	Responses	Mode Score	Mean Score	Mean Score Ranked
1	Management	1030	8	6.6	4
2	Management	1033	10	7.6	2
3	Management	1032	10	8.6	1
4	Management	1035	10	5.9	6
5	Management	1026	10	6.7	3
6	Management	1034	0	3.8	7
7	Management	1032	10	6.3	5
1	Veterinary	1030	10	7.7	6
2	Veterinary	1027	10	7.9	5
3	Veterinary	1030	10	8.6	3
4	Veterinary	1029	10	8.9	2
5	Veterinary	1023	10	8.0	4
6	Veterinary	1030	10	9.6	1
7	Veterinary	1027	10	8.9	2

Table 8.8 – Participant confidence in management and seeking veterinary advice. This table details the mean and modal scores of how participants indicated how confident they would feel about managing and seeking veterinary advice for each case scenario. '1' pertained to not confident at all and '10' pertained to 100% confident.

Wounds that received the most responses for needing high priority

veterinary care was 'Case 6', followed by 'Case 4' and 'Case 7'. Wounds that received the most responses for requiring first aid, full results for which are summarised in Table 8.9.

Case	Total Responses	Treatment level		Yes (%)	
1	1035	No vet	No Treatment	0.1	34.2
			First aid from the owner only	34.1	
		Vet	Low priority/non-urgent veterinary treatment	45.1	**65.8**
			High priority/urgent veterinary treatment	20.7	
2	1035	**No vet**	No Treatment	0.4	**63.4**
			First aid from the owner only	63.2	
		Vet	Low priority/non-urgent veterinary treatment	30.3	36.4
			High priority/urgent veterinary treatment	6.1	
3	1036	**No vet**	No Treatment	5.8	**93.2**
			First aid from the owner only	87.4	
		Vet	Low priority/non-urgent veterinary treatment	6.2	6.9
			High priority/urgent veterinary treatment	0.7	
4	1034	No vet	No Treatment	0.0	3.3
			First aid from the owner only	3.3	
		Vet	Low priority/non-urgent veterinary treatment	21.3	**96.7**
			High priority/urgent veterinary treatment	75.4	
5	1028	No vet	No Treatment	5.2	22.5
			First aid from the owner only	17.3	
		Vet	Low priority/non-urgent veterinary treatment	67.2	**77.5**
			High priority/urgent veterinary treatment	10.3	
6	1037	No vet	No Treatment	0.0	0.1
			First aid from the owner only	0.1	
		Vet	Low priority/non-urgent veterinary treatment	0.6	**99.9**
			High priority/urgent veterinary treatment	99.3	
7	1034	No vet	No Treatment	0.1	2.9
			First aid from the owner only	2.8	
		Vet	Low priority/non-urgent veterinary treatment	52.0	**97.1**
			High priority/urgent veterinary treatment	45.1	

Table 8.9 – Treatment level. This table details which treatment levels participants in this study indicated they believed each wound case scenario required. Results that are presented in bold represent the majority answer for each wound injury.

Chi-squared analysis was used to see if those participants which were unsure about how to rest each case were seeking veterinary advice. There was statistical significance for Case 1 (P=0.005, OR = 0.55, 95% CI 0.31-0.82), Case 2 (P=0.004, OR=1.89, 95% CI 1.22-2.93), Case 6 (P<0.001) and Case 7 (P<0.001, OR=0.22, 95% CI 0.1-0.5). Full results for how participants chose to rest their horses immediately following injury are displayed in Table 8.10.

Case	Total Responses	Treatment Level	% Yes
1	1023	Box rest	63.4
		Light work	24.2
		Same level of work	2.3
		Unsure	10.0
2	1022	Box rest	42.5
		Light work	42.3
		Same level of work	6.6
		Unsure	8.7
3	1014	Box rest	22.3
		Light work	40.8
		Same level of work	22.5
		Unsure	14.4
4	1033	Box rest	93.7
		Light work	1.4
		Same level of work	0.1
		Unsure	4.8
5	1013	Box rest	60.8
		Light work	22.2
		Same level of work	4.6
		Unsure	12.3
6	1030	Box rest	96.1
		Light work	0.3
		Same level of work	0.0
		Unsure	3.6
7	1023	Box rest	81.3
		Light work	8.9
		Same level of work	0.4
		Unsure	9.4

Table 8.10 – Treatment level. This table details how participants choose to rest each case scenario.

Chi-square analysis compared first aid measures study participants would apply (broadly split into application of disinfectant, medications or bandages), and whether participants indicated whether that they would benefit from further education in that area of equine wound management for how to clean wounds, use of medications and bandaging. For example, seeing if there is evidence of difference between participants who said they would benefit from further education about medications and those participants who chose to apply medications. P results for this analysis can be found in Table 8.12, bold values are those which are

significant (P<0.05).

Case Number	Total Responses	Action	% Yes
1	626	Wash with a disinfectant	44.1
		Apply any medications	18.7
		Apply a bandage	5.1
2	342	Wash with a disinfectant	46.8
		Apply any medications	8.2
		Apply a bandage	24.9
3	144	Wash with a disinfectant	26.4
		Apply any medications	7.6
		Apply a bandage	34.7
4	924	Wash with a disinfectant	16.9
		Apply any medications	1.5
		Apply a bandage	55.1
5	645	Wash with a disinfectant	32.6
		Apply any medications	10.4
		Apply a bandage	31.3
6	536	Wash with a disinfectant	19.8
		Apply any medications	1.3
		Apply a bandage	20.0
7	902	Wash with a disinfectant	48.1
		Apply any medications	4.8
		Apply a bandage	19.0

Table 8.11 – Owner first aid measures. This table details the proportions of participants that choose to administer different first aid measures either prior to or in the absence of veterinary treatment. First aid was broadly divided into washing the wound and the application of topical therapeutics or bandage.

Area of education	Case 1	Case 2	Case 3	Case 4
How to clean wounds	0.488	0.542	**0.019**	0.189
Use of medications	**0.018**	0.685	**0.002**	0.634
Use of bandages	0.113	**P<0.001**	0.207	0.487

Table 8.12 – Education statistical analysis. This table details the P values for chi-square analysis comparing areas owners specified they would benefit from further education and whether they still choose to carry out these first aid measures. Data fields highlighted in bold indicate a significant value where P is less than or equal to 0.05.

Chi-square analysis was performed evaluating whether there was any evidence of significance between seven independent variables relating to the participants demographics, qualifications and equine experience and how they chose to treat each wound. Table 8.13 summarises the P values

for this analysis. Data fields highlighted in bold indicate significance ($P<0.05$). These factors were inputted into a logistic regression model to identify any significance on outcome for binary outcomes (application of antiseptic/bandage/medications). A multinomial logistic regression model was used to identify any significance between these factors and the level of treatment participants believed each wound required. Data for significant variables identified through modelling are summarised in Table 8.14 which includes odds ratios (OR), confidence intervals (CI) and relative risk ratios (RRR). Data on first aid measures owners chose to administer to each wound (cleaning, medicating and bandaging), was only available for Cases 1-4. Post Case 4 responses were in too low in number to permit analysis.

Case number	Outcome	Participant age	Resident in the UK	Number of horses participant cares for	Equestrian qualifications	Medical qualifications	Previous experience with equine wounds	Previous experience with equine wounds requiring >2 weeks management
Case 1	Antiseptic	**0.003**	0.110	0.724	0.354	0.528	**0.025**	0.376
	Medication	0.0601	0.170	0.418	0.613	0.171	**0.007**	0.287
	Bandage	0.538	**0.009**	**0.002**	0.619	0.140	0.547	0.503
	Treatment	**<0.001**	0.133	0.280	0.180	0.362	0.089	0.629
Case 2	Antiseptic	**<0.001**	0.283	0.201	0.839	0.823	0.127	0.503
	Medication	0.115	**0.012**	0.959	0.824	0.079	0.281	0.418
	Bandage	0.950	**0.008**	0.414	0.784	0.246	0.623	0.971
	Treatment	0.207	0.088	0.954	0.599	0.650	0.054	**0.034**
Case 3	Antiseptic	0.320	0.723	0.585	0.824	0.499	0.055	0.723
	Medication	0.301	**0.007**	0.838	0.140	0.150	0.952	0.740
	Bandage	0.301	**0.007**	0.838	0.140	0.150	0.952	0.740
	Treatment	0.179	0.462	0.062	0.071	0.264	**<0.001**	**0.032**
Case 4	Antiseptic	0.864	0.761	0.390	0.420	0.107	0.740	0.253
	Medication	0.061	0.960	0.630	0.322	0.296	N/A	0.211
	Bandage	0.698	0.509	0.135	0.328	0.741	0.648	0.176
	Treatment	**0.022**	0.089	0.410	0.750	0.178	0.351	0.133
Case 5	Treatment	0.506	**0.048**	**0.008**	0.942	0.626	**0.029**	0.137
Case 6	Treatment	0.059	0.090	0.447	0.746	0.168	0.252	0.560
Case 7	Treatment	**0.044**	**0.001**	0.613	0.147	0.090	0.059	0.717

Table 8.13 – Statistical analysis of first aid measures. This table details the P values for chi-square analysis comparing aspects of the participant including their demographics, qualifications and previous experience against the first aid measures they choose to implement. Data fields highlighted in bold indicate a significant value where P is less than or equal to 0.05.

Outcome Measure	Variable		Reference Category	Stats
Case 1				
Washes wound with an antiseptic	Participants with experience of a horse under their care suffering from a wound		Participants with no experience of a horse under their care suffering from a wound	OR 0.21 (95% CI 0.29-0.76, P=0.005)
	Participants aged 40-59		Participants aged 0-39	OR 0.47 (95% CI 0.29-0.76, P=0.002)
	Participants aged 60 or over		Participants aged 0-39	OR 0.22 (95% CI 0.07-0.76, P=0.016)
Applies a topical medication	Participants with experience of a horse under their care suffering from a wound		Participants with no experience of a horse under their care suffering from a wound	OR 0.16 (95% CI 0.04-0.58, P=0.006)
	Participants aged 60 or over		Participants aged 0-39	OR 0.24 (95% CI 0.08- 0.81, P=0.022)
Applies a bandage	Participants with three horses under their care		Participants with one horse under their care	OR 2.4 (95% CI 1.1-5.3, P=0.033)
	Participants with five or more horses under their care		Participants with one horse under their care	OR 2.8 (95% CI 1.5-5.3, P=0.002)
Treatment level participant indicates this wound requires	First Aid	Number of years participant has been involved in the care of horses	N/A[2]	RRR 0.02 (95% CI 0.00-0.0.04, P=0.016)
	Low Priority veterinary treatment	Base level		

	High priority veterinary treatment	Number of years participant has been involved in the care of horses	N/A[2]	RRR 0.04 (95% CI 0.02-0.06, p<0.001)
		Participants with one equestrian qualification	Participants with no equestrian qualifications	RRR 0.67 (95% CI 0.24-1.09, P=0.002)
		Participants with one medical qualification	Participants with no medical qualifications	RRR -0.48 (95% CI -0.88 - -0.06, P=0.024)
		Participants caring for three horses	Participants caring for one horse	RRR -0.68 (95% CI -1.34 - -0.04, P=0.038)
Case 2				
Washes wound with an antiseptic	Participants aged 40-59		Participants aged 0-39	OR 0.59 (95% CI 0.42-0.84, P=0.003)
	Participants aged 60 or over		Participants aged 0-39	OR 0.35 (95% CI 0.17-0.70, P=0.003)
Applies a topical medication	Participant is a UK resident		Participants who are not UK residents	OR 0.47 (95% CI 0.26-0.88, P=0.018)
	Participants with one medical qualification		Participants with no medical qualifications	OR 0.62 (95% CI 0.40 – 0.95, P=0.03)
Applies a bandage	Participant is a UK resident		Participants who are not UK residents	OR 0.51, (95% CI 0.31-0.85, P=0.009)
Treatment level participant indicates this wound requires	First aid	Base level		
	Low priority veterinary treatment	Participants with experience of a horse under their care suffering from a wound requiring long term management	Participants with no experience of a horse under their care suffering from a wound requiring long term management	RRR 0.61 (95% CI 0.44 – 0.84, P=0.013)
	High priority veterinary treatment	No variables were found to be significant in multinomial modelling		
Case 3				

Washes wound with an antiseptic	Participants with experience of a horse under their care suffering from a wound	Participants with no experience of a horse under their care suffering from a wound	OR 0.52 (95% CI 0.26 – 1.02, P=0.057)
Applies a topical medication	Participant is a UK resident	Participants who are not UK residents	OR 0.42 (95% CI 0.23 – 0.75, P=0.003)
	Participants with two or more equestrian qualifications	Participants with no equestrian qualifications	OR 1.54 (95% CI 1.03 – 2.29, P=0.036)
	Participants with two or more medical qualifications	Participants with no medical qualifications	OR 0.54 (95% CI 0.32 – 0.93, P=0.025)
Applies a bandage	Participant is a UK resident	Participants who are not UK residents	OR 0.42 (95% CI 0.23-0.75, P=0.003)
	Participants with two or more medical qualifications	Participants with no medical qualifications	OR 0.54 (95% CI 0.32 – 0.93, P=0.025)
Treatment level participant indicates this wound requires[1]	Number of years participant has been involved in the care of horses	N/A[2]	OR 1.03 (95% CI 1.01 – 1.06, P=0.012)
	Participants with one equestrian qualification	Participants with no equestrian qualifications	OR 0.39 (95% CI 0.21 – 0.74, P=0.004)
	Participants with two or more medical qualifications	Participants with no medical qualifications	OR 0.31 (95% CI 0.12 – 0.80, P=0.016)
	Participants with experience of a horse under their care suffering from a wound requiring long term management	Participants with no experience of a horse under their care suffering from a wound requiring	OR 0.47 (95% CI 0.24 – 0.89, P=0.021)

			long term management	
	Participants with three horses under their care		Participants with one horse under their care	OR 0.36 (95% CI 0.15 – 0.87, P=0.023)
	Participants aged 60 or over		Participants aged 0-39	OR 0.20 (95% CI 0.07 – 0.53, P=0.001)
Case 4				
Washes wound with an antiseptic, applies medication, applies a bandage	Logistic regression modelling did not highlight any variables that were significant			
Treatment level participant indicates this wound requires	First aid	No variables were found to be significant in multinomial modelling		
	Low priority veterinary treatment	Participants with one medical qualification	Participants with no medical qualifications	RRR 0.41 (95% CI -0.00 – 0.83, P=0.05)
		Participants aged 60 or over	Participants aged 0-39	RRR -1.35 (95% CI -2.31 - -0.39, P=0.006)
	High priority veterinary treatment	Base level		
Case 5				
Treatment level participant indicates this wound requires	First aid	No variables were found to be significant in multinomial modelling		
	Low priority veterinary treatment	Base level		
	High priority veterinary treatment	Number of years participant has been involved in the care of horses	N/A[2]	RRR 0.97 (95% CI 0.95-0.99, P=0.016)
Case 6				
Treatment level participant indicates	Logistic regression modelling did not highlight any variables that were significant			

this wound requires[1]				
Case 7				
Treatment level participant indicates this wound requires	First aid	Number of years participant has been involved in the care of horses	N/A[2]	RRR 0.53 (95% CI 0.22 – 1.26, P=0.016)
	Low priority veterinary treatment	Base level		
	High priority veterinary treatment	Participants with one equestrian qualification	Participants with no equestrian qualifications	RRR 1.42 (95% CI 1.07 – 1.87, P=0.038)
		Participants with one medical qualification	Participants with no medical qualifications	RRR 1.42 (95% CI 1.08 – 1.86, P=0.034)
[1]Due to the small count of high priority veterinary treatment which made the proportions incomparable, low and high priority were combined into one category 'veterinary treatment' a logistic regression modelling performed instead of multinomial. *[2]This is a continuous variable so there is no reference category.*				

Table 8.14 – Statistical modelling of first aid measures. This table details all factors that highlighted significant P values through logistic and multi-level regression modelling, including odds ratios, relative risk ratios, confidence intervals and P values. P was considered significant when less than or equal to 0.05.

9.0. Discussion

9.1 Summary of main results

The aim of this study was to generate primary evidence on the healing and outcome of wounds in horses, focusing on how owners' approach and manage wounds. The survey of first owners' opinions and experienced showed that wounds were a common problem, with 95% of participants having experienced a wound in their horse, and 79.3% had experience of wound that required veterinary or long-term treatment. The study population included horses that did not receive routine vaccination (13% cared for horses that were not vaccinated for tetanus) and were not insured (67% of horses). Case studies were used to evaluate owners' approaches and highlighted variation in how owners' cleaned, medicated and bandaged wounds. The majority of owners (67%) did not recognize that a puncture wound over a synovial structure required veterinary attention, and a similar proportion did not recognize wound healing complications (excessive granulation tissue) which required veterinary attention. This survey highlighted the need for further education and guidance for horse owners around recognizing and managing wounds, including when veterinary intervention is required.

9.2. Study Methodology

There are currently no published studies on how owners' approach and manage wounds, either prior to or in the absence of veterinary treatment. The survey style and dissemination methods have been successfully used to capture data for veterinary research in many previous studies (Field *et al*., 2017, Hotchkiss *et al*., 2007, Mellanby and

Herrtage, 2004). The use of online surveys in scientific research has a number of advantages, including the ability to collect both qualitative and quantitative data, ease and low cost of development and dissemination and the efficient automated collation of data (Ponto, 2015, Wright, 2017). Other methods such as telephone interviews and paper questionnaires, are time consuming, costly and do not have the same capacity to utilise visual aids. Surveys have previously been used to successfully capture data directly from horse owners specific to equine health conditions. This study yielded a similar response rate compared to these studies (Bowden et al., 2020, Bowden et al., 2019, Bambra et al., 2017).

There were some potential biases inherent in using surveys for data collection. Study participants would require access to some form of computer, tablet or phone and the internet. The use of an online survey allowed for participants to express opinions anonymously, allowing some participants to express their true opinions more comfortably then compared to other data capture methods. This does however mean that opinions and responses are not collected from those who do not have access to the internet (Wright, 2017). To overcome this, a future study that distributed hard copy data capture forms with free-post return envelopes, in conjunction to an online survey, could be beneficial. It is possible that there is a selection bias for people completing the survey who have previous experience of treating equine wounds meaning results may not be reflective of the general population. To prevent further response bias from those with an interest in equine wounds, perhaps a

survey that presented different emergency equine conditions, such as colic or acute lameness, with wound case scenarios amalgamated in amongst others would be advantageous. Those completing the survey may also be subject to recall and acquiescence bias as the survey asks them to recall on previous experiences rather than reporting objective data. Overcoming this would require assessment of how horse owners' approach and manage real life equine wounds. Therefore, hypothetical case scenarios are the best approximation we can get.

9.3. Main findings

Owner first aid

In all seven cases, over half of participants chose to administer some form of first aid, including washing the wound, applying medications and applying bandages. This is despite participants stating the area of equine wound management they would benefit most from was knowing which topical therapeutics to apply and when. This survey highlighted variation in how participants were cleaning, medicating, and bandaging wounds, including the techniques and products used, which in many cases contradicts currently published evidence.

This study identified several variations in horse owners' first aid approaches to wounds, and also raises some concerns. These included the use of antiseptics for wound lavage and topical wound treatments. Nearly half (48%) of participants first aid approach involved cleaning a wound with Hibiscrub, the active ingredient of which is chlorhexidine gluconate (CH). When used appropriately, CH can significantly reduce the bacteria load of a wound and by extension the risk of infection, but high

concentrations of CH can be cytotoxic (Dart *et al*., 2017). In human wound antisepsis, there is now more a shift towards using povidone iodine over CH, due to reduced risk of anaphylaxis, reduced cytotoxicity and the reduced risk of producing resistance in microbes (Kramer *et al*., 2018). This calls into question whether veterinary wound antisepsis should follow the same protocol. Methods to utilise CH when cleaning wounds can vary greatly between those administering first aid, based on delivery method, volume and concentration. In human medicine, evidence based guidelines have been developed to help standardize practice for cleaning of surgical wounds (Barnes *et al*., 2014). These concluded that a 0.05% solution of CH was appropriate for reducing the risk of infection. When used in higher concentrations than 0.05%, CH can cause contact dermatitis acting as an irritant and eliciting pain (Toholka and Nixon, 2013). In this study data was not collected on how, or if, participants would dilute a disinfectant solution. It is possible many horse owners are unaware of how to appropriately dilute and administer antiseptics when cleaning wounds. Evidence based guidelines on how to clean equine wounds, including the solution used and delivery method would be beneficial to both vets and owners. To produce evidence-based guidelines similar to those produced by Barnes, (2014), further studies are needed to ascertain whether traumatic equine skin wounds behave the same as human wounds in response to various antiseptic treatments, and therefore establish if the conclusions from human literature would be transferrable.

Participants were uncertain about how to use topical medications, and

this was the aspect of wound management that participants indicated they would most like further education on. Despite this, in some of the case studies, more than half of participants chose to apply some form of topical medication. Many topical treatments, particularly those readily available without prescription, have not gone under scientific testing to ascertain if they are effective and when they are appropriate for different wounds (Jacobsen, 2017). Only recently have evidence-based clinical practice guidelines for veterinary practitioners on the use of topical therapeutics been developed (Freeman et al., 2020). Notable findings Freeman's paper include the appropriate use of silver sulfadiazine, which should only be used in the treatment of infected or contaminated wounds and it's use in acute wounds can be cytotoxic. Silver sulfadiazine was one of the most commonly mentioned topical products that participants said they would use in Cases 1-4, all of which were acute in nature. In human medicine silver sulfadiazine has been described as an inadvisable and obsolete topical therapeutic, due to its cytotoxicity and risk of absorptive side effects (Kramer *et al*., 2018). This highlights one example of the use of topical medications by owners that could potentially be impeding wound healing and is against some of the current evidence.

Manuka honey was consistently one of the most commonly used products by study participants for cases 1-4, however whether it use is efficient and cost effective requires further investigation. The evidence on use of honey in veterinary wounds was that it improves the rate of healing in earlier phases of wound repair (up to 21 days) but there is limited evidence on its impact on overall wound healing (Bischofberger et al.,

2011, Bischofberger et al., 2013). In this survey participants only indicated whether they used 'Manuka honey' and not a specific brand. Whether this was of medical grade quality as the studies on its use are based upon remains unknown. There is little evidence-based guidance for vets on topical wound therapeutics and none for owners. This online questionnaire demonstrated many owners are choosing to administer topical medications which may not be supported by current evidence. This highlights the need for the development of evidence-based guidelines to help inform decisions as the only published evidence-based guidelines are targeted at equine veterinary practitioners and not horse owners.

Significant evidence of difference was identified between participants who had their own horses insured and whether they choose to seek veterinary treatment for wounds which were neither minor or severe ('Case 2' and 'Case 5'). This could be interpreted to suggest that owners who do not have the horses under their care insured are less likely to call the vet for more minor wounds. One potential explanation for this could be that the cost of veterinary treatment poses a barrier for horses with minor wounds, potentially impacting animal welfare.

Puncture wounds and synovial structures

Another key finding of the study was the difficulties that owners have in recognising the potential severity of puncture wounds. Despite participants stating 'depth of wound' would be the most influential factor affecting their decision to call a vet, when presented with a small, but

potentially deep puncture wound over the digital flexor tendon sheath over a quarter (28%) of participants stated it did not involve any synovial structures, a similar number stated this wound did not require veterinary treatment (34%) and less than a quarter stated this wound required 'high priority/emergency veterinary treatment'. At skin level puncture wounds can appear innocuous but have the potential to pose a great threat to life and return to pre-athletic function if they compromise deeper synovial structures. These wounds require fast and aggressive treatment to ensure the best chance of an optimal outcome and a delay in treatment can negatively impact survival and return to pre-athletic function (Ludwig and van Harreveld, 2018, Findley et al., 2014, Isgren et al., 2020, Orsini, 2017a). Horses that have been referred for treatment of synovial sepsis are 4.75 times more likely to survive if they present with a visible wound (Milner *et al*., 2014). This suggests that wounds with a smaller surface area can be difficult for owners or vets to recognise and are therefore more likely to receive delayed veterinary treatment or referral. This difficulty in identifying these types of wounds was highlighted in this survey. This could explain why owners are not so proficient at recognising the significance of severe puncture wounds as the wound can be difficult to recognise at the skin level or due to their small surface being misinterpreted as innocuous at presentation.

In this current study, older participants, those with a medical or equine qualification or those who had more experience caring for horses were significantly more likely to identify that the synovial wound needed veterinary treatment. These trends have not yet been reported in the

literature and suggest horse owners with more experience or a relevant qualification are likely to recognise the potential severity of puncture wounds. Participants ranked depth of wound as the most influential factor that would affect their decision to seek veterinary advice which shows that participants are aware that deep puncture wounds are dangerous but when applied to a hypothetical case scenario there appears to be a barrier for some participants applying this knowledge. This finding around experience and education is unsurprising but results from this survey helps identify where knowledge levels are lower among the horse owner demographic and where educational campaigns could be targeted to have the greatest impact.

Exuberant granulation tissue

Although not a medical emergency wounds presenting with EGT require veterinary treatment, usually surgical excision, to promote healing (Theoret and Wilmink, 2017, Fretz *et al*., 1983). Despite this, 26% of participants were not able to identify EGT, and 23% said that this case did not require veterinary treatment. When the two responses were considered together, there was no statistical association between those who correctly identified EGT and those who specified this wound required veterinary treatment. This suggests that participants who can correctly identify EGT may still not aware of how to appropriately manage it, and therefore both these aspects should be targeted for owner education. Whether the participant was resident in the UK, the number of horses they cared for, and the participant's previous experience of caring for wounded horses were all identified as factors that significantly increased

the likelihood of them identifying EGT as requiring veterinary treatment. These results could be used to target educational resources at the most appropriate demographic, and again identifies the need to help owners with less experience.

Interestingly chi-square analysis highlighted evidence of difference between participants who had their own real-life horses insured and whether they indicated Case 2 (kick wound) and Case 5 (EGT wound) required veterinary treatment. Both of these wound case scenarios did not pose a significant risk to life or return to pre-athletic function but equally would benefit from veterinary treatment. Interpretation of this statistical significance could suggest the insurance status of a population of horses may be a barrier for them accessing veterinary treatment for wounds which are neither minor nor severe.

One aim of this study was to identify gaps in the knowledge of horse owners to produced targeted educational resources that owners would utilise to positively impact on the health and welfare of horses. The findings have identified areas where there were knowledge gaps or inappropriate treatment and actions. It also identified areas where owners were responding appropriately, and these included obviously severe and infected wounds. These results can be used to inform how future educational campaigns can be targeted to have the greatest impact, namely a management of puncture wounds and EGT.

9.4. Next steps

There are no currently published evidence-based guidelines for first aid

and management of equine wound management for horse owners. This study has identified a need for evidence-based guidelines to recommend various first aid measures including the appropriate cleaning, medicating and bandaging of various wound types, with a particular focus on puncture wounds and EGT. Despite there being extensive research in human medicine on wound management techniques, experimental studies using an equine model are required to ascertain whether findings in human medicine are applicable to horses. The use of surveys captures data on participant opinion and recall data. The use of real time cases and data to determine whether owners use similar approaches in actual equine wound cases are required to assess what the impact is on the healing and complications of wounds. Methods to capture this data could include the use of either retrospective or prospective studies where owners report how they approached and managed a wound case scenario to a horse under their care. These types of studies are require a greater investment of time to yield similar response numbers and a large number of case scenarios would be required to be reported to ensure conclusions would be representative due to the large variation in the types of wounds horses can sustain.

9.5. Conclusion

This is the first study to investigate horse owners approaches and decision making for equine wounds. It identified several key areas where owners would benefit from future educational campaigns. These include a small but relevant proportion of participants who were caring for unvaccinated and un-insured horses, applying appropriate first aid measures, specifically how participants chose to clean and medicate

wounds. Improved identification of the importance of puncture wounds and those complicated with EGT requiring veterinary intervention would also be beneficial. This study has formed the important foundations of recognising areas of wound management that require further research and should be targeted for owner education. It represents the important first step in planning impactful resources that have the potential to improve the health and welfare of countless horses.

Chapter 3: Prospective Cohort Study

10.0. Materials and Methods

10.1. Ethical Review

This prospective study was approved by the University of Nottingham's School of Veterinary Medicine and Science Ethics Committee. Data collection and anonymity was conducted in accordance with the 2018 Data Protection Act and the British Educational Research Association's revised ethical guidelines for educational research (2004).

10.2. Summary

The second element of this project was the development and launch of a prospective study, designed to collect data on traumatic equine wounds. Owners/carers of equids whose animal was currently suffering from or who had recently suffered from (within the previous 12 months) any form of traumatic wound were asked to submit data. Two separate data capture forms were designed to be completed, capturing data from initial injury through to the time the wound had completely healed. Questions included were designed to capture data on factors that are believed to influence wound healing following a review of the current literature relevant to equine wound management. The study was disseminated to the sample population at equine shows/events, through magazine/E-news articles, using social media and by recruiting the help of equine vet practices. Data was compiled into a spreadsheet (Excel 2016, Microsoft Corporation, WA, USA) for data cleaning and then transferred to IBM SPSS Statistics (IBM SPSS Statistics for Windows 2017, IBM Corp,

Version 25.0. Armonk, NY: IBM Corp), allowing for various descriptive and statistical analysis.

10.3. Sample Population

A prospective nine-month study (01/10/18 – 31/06/19) was designed to collect owner reported data on traumatic equine wounds. The target population was UK equid owners/carers whose equid was currently suffering from, or who had recently suffered from (within the last 12 months), any form of traumatic wound. Participants were recruited using a snowball sampling method.

10.4. Development of Data Capture Systems

Two separate data capture forms were developed to collect data throughout the wound healing process, from initial injury through to a time that the owner believed the wound to have completely healed, with the exception of any scarring. Links to the forms were hosted on a publicly accessible BHS webpage. The title of each form and details of when they were to be completed by study participants are described below:

- **Form 1:** *"Details of equine, initial wound assessment and initial first aid/veterinary treatment"* To be completed once at the time of initial injury.
- **Form 3:** *"Wound outcome"* To be completed once when the owner believed the wound to have completely healed (scarring may be present).

Additional forms were also developed, the first was titled 'Form 2a – Owner treatment/periodic update on wound healing' which could be completed frequently throughout the wound healing process. The second was titled 'Form 2b – Veterinary treatment' which was to be completed

anytime the wound received veterinary treatment excluding any received in the first 24 hours following injury. Data from these forms was not evaluated or reported in this thesis.

Forms were developed in two formats, online using Google Forms and also as Adobe PDF forms. The Adobe PDF Forms were initially developed using PowerPoint (2016, Microsoft Corporation, WA, USA) and once complete were exported as PDF files. The questions and layout of the Adobe forms mirrored that of the online forms. The PDF files were made into interactive fillable forms using the 'Fill & Sign' tool in Adobe Acrobat Reader DC, (2019). Copies of the adobe PDF Forms can be found in Appendix II. The adobe PDF forms could be completed on a computer/phone/tablet and submitted using the electronic submit button, which automatically delivered them to a mailbox specifically created for this project (equinewoundproject@nottingham.ac.uk). Alternatively, the PDF forms could be emailed directly to this mailbox. The PDFs could also be printed off to be completed manually, then returned either by emailing scanned copies or by post. Questions on each form were designed to capture data on factors that were believed to influence wound healing following a review of the current relevant veterinary and medical literature surrounding wound management. Each form contained both open and closed questions. Table 9.1 outlines the layout and various sections each form contains, including the number of questions and what data the questions hoped to collect.

Section Title	Number of Questions	Information collected
Form 1		
1) Introduction and consent	1	Introductory paragraph outlining the study which provided a link to further information (https://www.bhs.org.uk/our-work/welfare/wounds-project/more-information). Participants could not continue unless they consented to the conditions of participation. By giving consent here, participants also gave consent for the wound outcome form.
2) Photograph submission	1	Option to upload photographs of the wound, including the date any photos were taken.
3) Details of horse	19	Signalment, country of residence, coat condition, temperament, BCS[1], level of work, insurance/vaccination status[2] etc.
4) Details of wound	9	Date/time of injury, mechanism of injury, location[2], contamination, tissues involved, lameness[3] etc.
5) Initial wound treatment	1	Survey logic to direct owner/carer to relevant section depending on whether they called a vet or administered first aid.
6) Owner first aid	14	Date/time of first aid, hand preparation, haemostasis, wound cleaning, medications, bandaging[4] etc.
7) Veterinary treatment	18	Date/time of treatment, sedation, confidence in seeking veterinary advice/treatment, haemostasis, cleaning, medications, bandaging, additional procedures, cost limitations etc.
8) Euthanasia	2	Was euthanasia required as a result of the wound?

[1]Participants were asked to indicate the BCS of their horse using an infographic scale developed by the National Equine Welfare Council, who gave permission for the EWP to use the same scale in this study. The scale ranged from '0-very poor' to '5-very fat', with a corresponding diagram for each point on the scale. In this study the number and descriptors were omitted leaving just the diagram of each horse so as not to cause participants to be biased in their response by selecting a BCS they believe their horse should be as oppose to what it actually is.
[2] An appropriate vaccination status was defined when the owner specified the 'vaccine is up to date'. An inappropriate vaccination protocol was defined when the owner specified their horse 'has never been vaccinated', 'has been vaccinated but the vaccine is out of date' and 'unsure of vaccination status'.
[3] To help owners determine the location of their horse's wound a diagram was supplied, which divided the anatomy of the horse into nine sections.
[4] A lameness scale was designed for owners to safely assess at the time of injury, whether their horse was exhibiting any lameness should the wound have occurred on a limb (n=153). The scale was different to a traditional veterinary lameness scale, excluding trotting, to prevent owners over exercising horses on a potentially compromised limb.
[5] A heavy bandage was described as applying pressure to the wound with several layers of different material whilst a light bandage was described as simply covering the wound with a single material layer.

Form 2		
1) Introduction and consent	1	Ensures participants have completed 'Form 1' and therefore given consent.
2) Photograph submission	1	Same as for 'Form 1'
3) Details of horse	3	Signalment of horse. This is included again so that different form submissions can be matched to each case.
4) Wound outcome		How long took to heal, euthanasia required, satisfied with rate of healing, return to work, lameness, cosmetic outcome, complications, limitations, what resources would like about wound management, how heard about study
5) Prize Draw	1	Yes/no

Table 10.1 – Form structure. This table details the structure and order of questions included in the two data capture forms that were analysed as part of this study. This includes 'Form 1' which collected data on the horse's signalment and initial injury. 'Form 2' collected data on wound outcome.

The initial template of data capture forms used in this study came from a 12 week research project carried out as part of a Bachelor of Veterinary Medical Sciences (BVMedSci) degree completed by the same lead researcher in the previous year. This initial research project was titled 'Development of pro formas that capture data on the aetiology, treatment and outcome of equine wounds'. This project differs to the EWP as it did not focus on data analysis but instead the development of appropriate forms that would capture data suitable for analysis. This project also intended to collect data from veterinary practitioners and not horse owners. Prior to being made publicly accessible, the forms were piloted with three equine vets and two horse owners who had affiliations with UoN. The BHS also piloted the forms amongst several office staff, all of whom were horse owners. Following piloting, a number of changes were made to both the online and adobe forms to ensure they were appropriate for data collection. Changes made included rewording of questions and introductory paragraphs so that participants would better understand what was asked of them for different questions. A question on whether the owner had access to emergency equine transport was also added.

10.5. Participant Recruitment

The BHS kindly designed and hosted a webpage specifically (Figure 10.1) for the EWP which contained all the relevant information on the study, including links to the online forms, case studies, prize draw details, researcher contact details and a link to the survey discussed in Chapter 9.0. All content hosted on the BHS website was initially developed and final versions approved by researchers at UoN. Dissemination of the EWP

to horse owners/carers was carried out by both UoN and the BHS; methods included promoting the study at various equine shows/events, magazine/E-news articles, social media posts and involvement of equine vet practices.

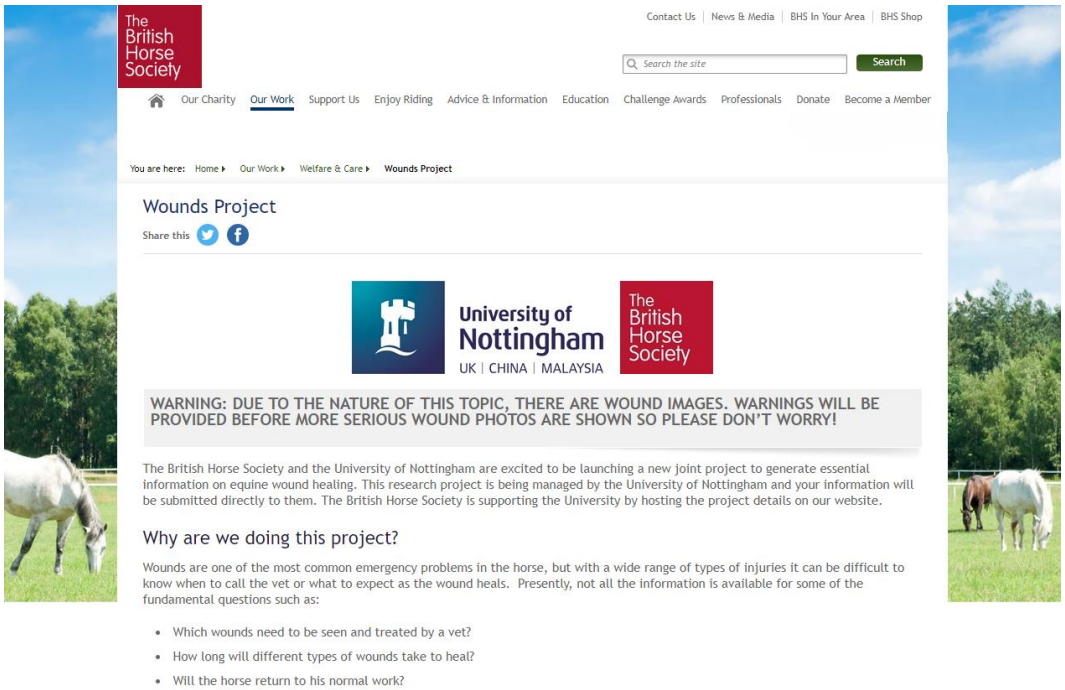

Figure 10.1 – Screenshot of British Horse Society Website. This figure shows a screenshot taken of the BHS website (accessed 05/03/19). This specific page shown is the homepage that was designed specifically for this wounds project.

Shows and Events

A5 flyers detailing the study aimed at recruiting the target population were designed and 5000 copies printed. A similar design was printed on three 800mm wide x 2m high roller banners. Throughout the data collection period the BHS had a charity stand at several equine events/shows across the UK (Figure 10.2) displaying roller banners and distributing flyers, details of the names and dates of events attended can be found in Table 10.2. One roller banner remained permanently on display at the BHS headquarters in Warwickshire. Staff working on the stand when greeting horse owners/carers made them aware of the EWP and encouraged them to participate and raise awareness of the project. The BHS also attended the British Equine Veterinary Association (BEVA) congress, attendees were equine vets and not horse owners. Therefore, an advisory document for vets outlining the study were handed out with flyers to encourage their support, which is further discussed in section 9.5.4.

Figure 10.2 – Photo of wound roller banner at a mobile castration clinic. This picture was taken at one of the BHS mobile welfare clinics, to the right of the image you can see the roller banner promoting the equine wound project prospective cohort study.

Name of Event	Date of Event
BEVA Congress	*12/09/18 – 15/09/18*
Horse of the Year Show	03/10/18 – 07/10/18
Lorinery Conference	06/11/18
Your Horse Live	*09/11/18 – 11/11/18*
Student Equine Veterinary Association Congress	*24/03/19*
Badminton Horse Trials	*01/05/19 – 05/05/19*
Royal Windsor Horse Show	*08/05/19 – 12/05/19*
Bolesworth International Horse Show	*12/06/19 – 16/06/19*
Royal Highland Show	*20/06/19 – 23/06/19*
Royal Norfolk Show	*26/06/19 – 27/06/19*
Great Yorkshire Show	*09/07/19 – 11/07/19*
Royal International Horse Show	*24/07/19 – 28/07/19*

Table 10.2 – Equine events attended to promote this study. This table details the names and dates of equine events attended by the BHS where the prospective study was promoted to horse owners.

Magazine Articles and E-News

Articles outlining the project were published in several magazines and included in various electronic newsletters. Two template news articles detailing the project were written, one was designed for publications that targeted veterinary practitioners and the other for publications that targeted horse owners/carers. Magazines and organisations were

approached by both UoN and the BHS following previous affiliations and asked if they were prepared to include an article on the EWP. Those that said they would cover the EWP were sent one of the template news articles, depending on their target audience. The templates contained extensive study detail so that each publication could condense and alter the content as they saw fit, whilst remaining fully informed of the study's operations. Details of publications that produced an article on the EWP can be found in Table 10.3, including the date of publication.

Publication Title	Date of Publication
BHS Magazine	*01/09/18* *01/03/19* *01/04/19*
BHS E-News	*Monthly (10/18–07/19)*
Equine Science Update E-news	*01/10/18*
Horse Talk New Zealand Magazine	*01/10/18*
Vet Times	*05/10/18* *22/10/18*
Vet Nurse Times	*22/09/18*
Vet Record	*19/10/18*
Redwings Wound Advice Campaign	*17/01/19*
National Pony Society Newsletter	*01/03/19*
Southern Horse Magazine	*01/03/19*
Heavy Horse World Magazine	*01/03/19*
Rider Magazine	*01/04/19*

Table 10.3 – Publications that included promotional articles on this study. This table details the names and dates of various publications that included a promotional article in order to increase awareness of this study to horse owners and veterinary professionals.

Social Media

Social media was also used as an additional channel to disseminate both awareness of this study and project updates to the sample and target population. Facebook was the main social media platform used. Monthly Facebook posts were posted on 'The British Horse Society' Facebook page (https://www.facebook.com/TheBritishHorseSociety/). Posts were drafted by the BHS and reviewed by UoN prior to being posted. All posts were

accompanied by the hashtag #Welfarewednesday. The BHS Facebook posts were then shared into 62 equine focused Facebook groups which between them had a total of 1,014,828 members (data accurate when accessed 02/05/19). These groups were found after searching Facebook using the following search terms 'Equine', 'Equines', 'Horse' or 'Horsey'. Additional groups were then found following suggestions automatically generated by Facebook. Regular updates on the project and posts to encourage participation in the study were also posted on 'The Nottingham Equine Colic and Wound Project' Facebook page (https://www.facebook.com/nottinghamcolic/). The admin of the Facebook Group 'Horsebay', which had over 90,000 members, made contact to help promote the wound project by changing the groups cover photo to one detailing the EWP (Figure 10.3).

Figure 10.3 – Cover photo for Facebook group. This picture is a copy of what was used as a cover photo for the Facebook group 'Horsebay' which had over 90,000 members (accurate when accessed 16/09/19).

Involvement of Equine Vets

All of the UK Equine Veterinary Practices were contacted to ask for their support in disseminating awareness of the EWP to their clients. This list was obtained from a previous third year veterinary students research project dissertation at UoN. This was achieved firstly by sending out a

mass email and later by posting letters and flyers to the same practices. Practices email and postal addresses were extracted from their respective publicly accessible websites and compiled manually into a excel spreadsheet.

A mass email was sent on 06/11/18 from the EWP email address to all UK equine veterinary practices. The email contained a brief summary of the project; it stated that vets could request as many flyers as they would like, free of charge, by replying to this email. Flyers could be distributed to owners when vets were called to see a wounded horse. They could also be displayed at yards or in practice reception areas. The email reassured vets that they themselves did not have to collect any data and that no data was collected on the attending vet/practice. The email had attached the veterinary advisory document on the project along with a PDF copy of the flyer. Replies to this email requesting flyers were forwarded onto the BHS who were responsible for posting them out.

The postal addresses of each practice from the electronic spreadsheet were mail merged (Word 2016, Microsoft Corporation, WA, USA), in order to generate a sticky label for each address that were transferred onto envelopes. Each envelope contained the veterinary advisory document and an A5 copy of the flyer. The advisory document was altered to contain additional wording stating if practices would like to get involved then they should email equinewoundproject@nottingham.ac.uk to request free flyers. Letters were posted on 17/12/18.

A second letter was sent out to the list of signed up practices on 15/04/19 reminding them of the project and to ask for their continued support in recruiting cases over the final few months of data collection.

Additional

Additional measures used in attempt to recruit study participants include the following:

- The BHS promoted the project in a presentation of their organisation's work in welfare education at Your Horse Live, 10/11/18.
- A client evening on equine wound management was held at Oakham Veterinary Hospital on 12/12/18. Details of the EWP and flyers were distributed to attending horse owners/carers.
- All of the 171 registered packs of hunting foxhounds were contacted via email through The Hunting Office Website. Due to the nature of the sport of hunting horses are at a higher risk of suffering wounds. Each hunt was asked if they would raise awareness of the study among their members.
- Three BHS Conventions were held throughout spring 2019. All delegate bags contained a wound flyer, with a total of 1200 delegates receiving wound flyers.
- The study was listed on 'SciStarter', a publically accessible online database of similar citizen science research projects.
- The 'Equine Register', DEFRAs central equine database, was contacted to see if they could assist in disseminating awareness of the EWP to its members. However, due to the infancy of this

organisation and timescales associated with data collection, the equine register was unable to assist.

10.6. Data Analysis

All adobe PDF forms that were received via email or by post were manually inputted as new entries via Google Forms, meaning all data was now stored in the same online database. Manual cleaning of the data was performed so that corrupt, inaccurate and incomplete records were detected and corrected or deleted where appropriate.

Data from the Excel spreadsheet was then transferred into an IBM SPSS statistics spreadsheet. Once all data had been transferred into IBM SPSS, descriptive analysis was performed for each question by using the 'descriptive statistics' function.

Appropriate analytical and statistical tests were performed through IBM SPSS statistics to assess whether 28 independent variables from the horse's signalment, aetiology of injury and treatment had evidence of association with wound outcome. Statistical tests used included bivariate Pearson correlation test, chi-square and non-parametric tests including Kruskall-Wallis H and Mann-Whitney U. Dependent variables were: (1) healing time (days), (2) return to work (weeks), (3) ability to return to the same capacity of work prior to injury and (4) total cost of treatment. Significance evidence of association was defined as P of less than or equal to 0.05.

11.0. Results

A total of 251 horse owners completed 'Form 1', which collected data on the horse signalment, nature of injury and initial treatment. The majority of cases (n=190/219) were submitted using the online platform 'Google Forms', 26 cases were submitted via email and two cases were returned post. Thirty-two responses were excluded from data analysis due to owners duplicating information (n=16), submitting data on retrospective cases (n=15) or on wounds of a surgical origin (n=1). Information on wound outcome ('Form 3') was received for 155 cases. However, 16 responses were excluded due to form duplication (n=5) or submission of retrospective cases (n=11). Therefore, a total of 219 wound case studies were included in this study with outcome data available for 139 (63.5%). The majority of cases (n=190/219) were submitted using the online platform 'Google Forms', 26 cases were submitted using the electronic adobe PDF forms via email and two cases were returned post.

11.1. Details of Horse

The majority of horses in this study were resident in the United Kingdom (95.3%, n=201/211) and had an average age of 12.4 years (range, 1-30 years). Sixty-one percent of horses were geldings (n=134/219), with the most frequent breeds being thoroughbred (25.8%, n=55/213), warmblood (15.5%, n=33/213) and Irish sport horse (15.0%, n=32/213). The height of horses within this study varied (Figure 11.1) with a modal height of 16-16.3 hands being reported.

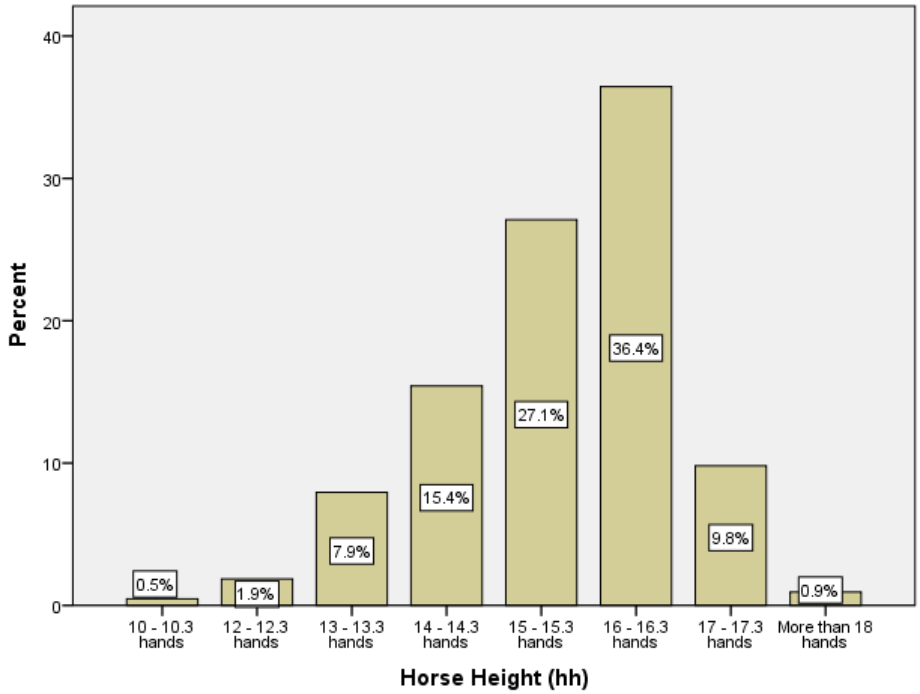

Figure 11.1 – Bar chart of horse height. This bar chart depicts the proportion of horses included in this prospective cohort study that were classified into different height categories.

Owners reported a variety of body condition scores (BCS) (Figure 11.2), with a score of '3' being the modal body condition score given to horses (47.0%, n=103/219).

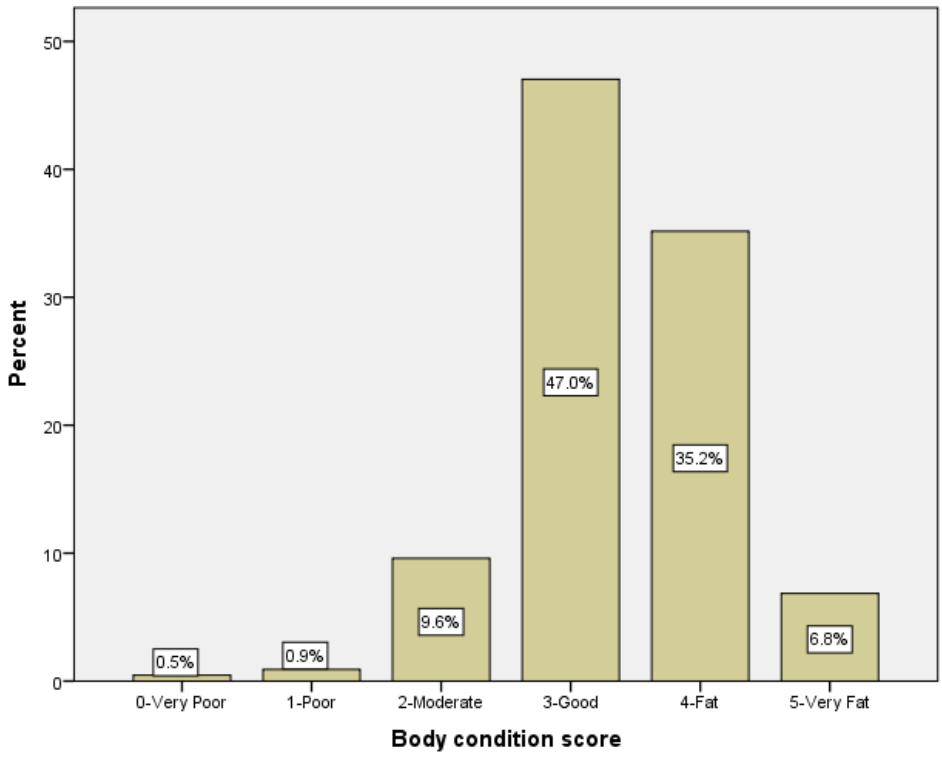

Figure 11.2 – Bar chart of horse body condition score. This bar chart depicts the proportion of horses included in this prospective cohort study that were classified into different body condition score categories.

At the time of injury, the majority of horses had unclipped coats (92.1%, n=196/213) and were assessed as being 'moderately clean' (68.9%, n=151/219) by their owners. When asked to provide information about their horses temperament, the majority of owners reported their horse was 'average – horse is safe enough to be handled by most people but will sensibly spook at certain stimuli' (56.6%, n=124/219) with 19.6% (n=43/219) indicating their horse was 'highly strung – horse cannot be safely restrained for simple procedures, e.g. being shod, without prior sedation'. The proportion of horse's which had an up-to-date appropriate vaccination protocol for influenza was 84.2% (n=181/215) and for tetanus was 89.5% (n=196/214). The proportion of horses working at a 'light' level of work was 47.0% (n=103/219), with only 4.1% (n=9/219) exercising at a 'heavy' level of work. Light work was defined as 'exercised three or four times weekly', heavy work was defined as 'training/competing at the peak of their physical abilities, e.g. thoroughbred racehorses'. Seven horses (3.2%) in this study had been diagnosed with pars pituitary intermedia dysfunction (PPID), whilst two study participants (0.9%) were unsure as to whether or not their horses had been previously diagnosed with PPID.

Participants were asked if they would have access to equine transport facilities should their horse require emergency referral or hospitalisation, for which 16.4% (n=36/219) said they would not have access. Over half of participants did not have their horse's insured for veterinary fees

(52.1%, n=114/219). The modal policy value for the insured horses was £5000-£5999 (n=41/78), ranging from £1000-£1999 to >£10000 worth of cover.

11.2. Details of Wound

Participants were asked what time of day they first noticed the wound on their horse, 42.0% (n=92/219) said they first noticed the wound in the afternoon (12pm-6pm), followed by the morning (6am-12pm) (41.6%, 91/219), evening (6pm-12am) (14.6%, n=32/219) and then night time (12am-6am) (1.8%, 4/219). Most wounds occurred on the limbs (69.9%, n=153/219) with the majority of these occurring on the hindlimb (57.5%, n=88/153). Wounds to the limb were more likely to be distal to the carpus/tarsus. Full results of the anatomic regions wounds affected are displayed in Table 11.1.

Anatomic Location	Number of responses (n=)	%
Head	27	12.3
Neck	4	1.8
Shoulder	26	11.9
Trunk	13	5.9
Hind	13	5.9
Forelimb (above carpus/knee)	28	12.8
Forelimb (below carpus/knee)	43	19.6
Hindlimb (above tarsus/hock)	18	8.2
Hindlimb (below tarsus/hock)	79	36.1

Table 11.1 – Anatomic location of wound. This table details the proportion of wounds in this study which affected different anatomic locations on the horse. Horse anatomy was broadly split up into nine sections and had a supplied diagram to help participants identify which region the wound affected.

Participants were asked to indicate which tissues they believed were compromised in their horse's wound. The full results for this question can be seen in Table 11.2.

Tissue Type	Number of responses	Yes (%)	No (%)	Unsure (%)

	(n=)			
Skin	218	98.6	0.9	0.5
Muscle	184	42.9	44.0	13.0
Tendon/ligament	169	16.6	72.2	11.2
Bone	164	16.5	76.2	7.3
Joint, tendon sheath or bursa	166	15.7	72.3	12.0

Table 11.2 – Tissues involved in each wound. This table details the proportion of wounds in this study which compromised different tissue types.

The most common cause of horses getting injured in this study were some form of field injury (e.g. wire/fencing injury), followed by kick injuries and then stable injuries. Full results for wound aetiology can be seen in Table 11.3, for which 217 participants completed data on this question.

Cause of wound	Number of responses (n=)	%
Field injury	84	38.4
Kick	33	15.1
Unknown	23	10.5
Stable injury	19	8.7
Fall	10	4.6
Gate catch injury	8	3.7
Puncture/penetration	8	3.7
Overreach injury	8	3.7
Other	7	3.2
Horsebox injury	5	2.3
Self-irritation	4	1.8
Bite	4	1.8
Dog bite	2	0.9
Road traffic accident	2	0.9

Table 11.3 – Wound cause. This table details the most common causes of wounds in this study.

In the 24 hours following injury, the majority of horses who had suffered from a limb wound were exhibiting some degree of lameness (64.7%, n=99/153). Full results of how participants scored their horse's lameness are displayed in Table 11.4.

Lameness Score	Number of responses (n=)	%
Sound	54	35.3
Cannot see lameness at walk but is sometimes there under certain circumstances such as turning	31	20.3
Cannot see lameness at walk but is always there under certain circumstances such as turning	14	9.2
Bearing less weight on the affected limb	40	26.1
Non-weight bearing	14	9.2

Table 11.4 – Lameness score. This table details the how lame participants indicated their horses were at the time of wound injury. Trunk wounds were excluded from this study.

Participants were asked to indicate if the wound was contaminated when they first noticed it, the results of which can be seen in Table 11.4; all 219 participants completed this question.

Contamination	Number of responses (n=)	%
No obvious contamination	101	46.1
Dirt/soil contamination	93	42.5
Faeces contamination	6	2.7
Contamination with another substance	16	7.3
Obvious infection	19	8.7

Table 11.5 – Wound contamination level. This table details the proportion of participants that indicated how contaminated their horse's wounds were at the time of initial injury.

11.3. Initial Wound Treatment

The proportion of participants who reportedly administered first aid and called the vet within the first 24 hours following injury was 42.5% (n=94/219). A further 32.4% (n=71/219) called the vet immediately without performing first aid, whilst 24.2% (n=53/219) gave first aid only. Two participants did not give any initial first aid or call for the vet within the first 24 hours.

11.4. Initial First Aid Given by the Owner

Two thirds (n=146) of study participants administered some form of first aid within the first 24 hours after noticing the wound. When asked how they prepared their hands prior to administering any first aid to the wound, three participants stated that they did not touch the wound. Most owners washed their hands with a disinfectant such as chlorhexidine gluconate or povidone iodine (26.6%, n=38/143) followed by washing hands with water only (25.9%, n=37/143), not washing hands (25.2%, 36/143), washing hands with soap (15.4%, 22/143), wearing medical grade gloves (13.3%, n=19/143), applying an alcohol based hand rub (2.1%, 3/143).

The majority (65.2%, n=92/141) did not have to stop any bleeding. The most common method of stopping any bleeding was by applying pressure using a bandage (14.2%, n=20/141) followed by applying pressure with another material (9.9%, 14/141), applying pressure with cotton wool (9.2%, 13/141) and applying pressure with hands (3.5%, 5/141). Table 11.6 displays the top five measures study participants adopted in order to clean their horse's wound. All 146 participants completed this question.

Cleaning method	Number of responses (n=)	%
Washed with tap/hosepipe water	37	16.9
Washed with chlorhexidine	29	13.2
Flushed with a hosepipe	21	9.6
Washed with sterile saline	14	6.4
Flushed with a syringe	11	5.0

Table 11.6 – Owner methods to clean wound. This table details which measures study participants commonly adopted in order to try and clean each wound.

Table 11.7 displays the top five most common topical medications, creams and powders study participants choose to apply to their horse's wound. All 146 participants completed this question of which one third specified they would not apply any medications (n=73).

Topical medication	Number of responses (n=)	%
Purple/blue spray	20	9.1
Sudocrem	14	6.4
Silver ointment/flamazine	11	5.0
Veterinary wound powder	10	4.6
Manuka honey	7	3.2

Table 11.7 – Most common topical therapeutics applied by the owner. This table details the top five most commonly applied topical therapeutics applied to wounds in this study.

The majority of participants choose not to apply a bandage (63.8%, n=90/141), 22.7% (32/141) applied a 'heavy bandage' and 13.5% (19/141) applied a 'light' bandage. The most common material used as a primary contact layer was Melolin (59.0%, n=23/39). The materials Gamgee, Primapore, gauze and Allevyn each had two respondents choosing this material as their primary contact layer.

11.5. Details of any Veterinary Treatment

Most study participants indicated that they 'had no doubt this wound needed veterinary attention' (52.7%, n=106/201), followed by 'I was confident this wound needed veterinary attention' (28.4%, n=57/201), 'Equally unsure on whether to call the vet or not' (9.5%, n=19/201) and 'I was not confident as to whether this wound required veterinary attention' (9.5%, n=19/201). Of the horses that did receive veterinary treatment within the first 24 hours following injury (n=164), the majority did require sedation for treatment (65.9%, n=108/164). Over three

quarters of vets did not have to stop any bleeding (78.7%, n=129/164). The most common methods of achieving haemostasis were by the use of surgical instruments/materials (6.7%, n=11/164), applying pressure using a bandage (6.7%, n=11/164) and applying pressure with cotton wool (2.4%, n=4/164). Table 11.8 displays the different methods that vets adopted in order to clean the wounds. All 164 participants completed this question.

Cleaning method	Number of responses (n=)	%
Clipped hair prior to cleaning	107	65.2
Washed with sterile saline	70	42.7
Washed with chlorhexidine	65	39.6
Flushed with a syringe	55	33.5
Scrubbed with swabs	38	23.1
Scrubbed with cotton wool	24	14.6
Washed with tap/hosepipe water	15	9.1
Did not clean wound	11	6.7
Washed with another solution	9	5.5
Flushed with a hosepipe	9	5.5
Washed with iodine	8	4.9

Table 11.8 – Methods vets used to clean wounds. This table details which measures veterinary practitioners commonly adopted in order to try and clean each wound.

Half of the wounds in this study were left to heal by second intention (50.0%, n= 80/160). The most common method of primary closure was suturing the entire wound closed (19.4%, n=31/160), followed by suturing part of the wound closed and leaving part open to drain 16.3%, n=26/160), both suturing and stapling the wound (6.9%, n=11/160), stapling the entire wound closed (5.6%, n=9/160) and stapling part of the wound closed and leaving part open to drain (1.3%, n=2/160). Over half of vets choose not to apply any topical medications, creams or powders (52.4%, n=86/164). Table 11.9 displays the top five most commonly applied medications by vets.

Topical medication	Number of responses (n=)	%
Manuka honey	20	12.2
Silver ointment/flamazine	17	10.4
Dermagel	7	4.3
Intrasite	3	4.3
Purple/blue spray	3	1.8

Table 11.9 – Most common topical therapeutics applied by the vet. This table details the top five most commonly applied topical therapeutics applied to wounds in this study by veterinary practicioners within the first 24 hours.

The proportion of vets who did not apply a bandage was 47.2% (n=77/163), 47.2% (n=77/163) applied a heavy bandage and 4.9% (n=8/163) applied a light bandage. 'Melolin' was the most common material used as a primary contact layer (n=34/78), followed by 'Allevyn' (n=10/78). The majority (98.1%, n=158/161) of vets administered some form of systemic medication when treating a wounded horse. Of these, 77.0% (n=124/161) were administered a systemic antibiotic, 68.9% (n=111/161) a systemic anti-inflammatory and 60.9% (n=98/161) received both. Most wounds did not require any further procedures (61.6%, n=101/164). Hospitalisation was the most common further procedure required (15.2%, n=25/164), followed by radiography (14.6%, n=24/164), surgery (9.1%, n=15/164) and ultrasonography (7.3%, n=12/164).

11.6. Wound Outcome (descriptive analysis)

Outcome data was provided for 139 horses. Wounds took on average 117.3 days (range, 1-698 days) to heal, healing was defined as the period when the wound had completely closed, with the exception of any

scarring (n=102/139). Three horses (2.2%) requiring euthanasia as a direct result of their injury.

Thirty five percent (n=49/139) of owners said the wound healed faster than they expected, 31.7% (n=44/139) said the wound healed at the rate they expected, 17.3% (n=24/139) said the wound healed slower than they expected and 15.8% (n=22/139) said they did not know what to expect.

The proportion of horses that were never out of work as a result of the wound was 12.6% (n=17/135). The proportion of horses who had already returned to the same capacity of work prior to the wound having completely healed was 46.7% (n=63/135). The proportion of horses who are predicted to the same capacity of work in the future was 15.1% (n=33/135). A proportion (8.1%, n=11/135) of horses in this study are not predicted to return to the same level of work as a direct result of the wound they suffered. Ten participants in this study were unsure if their horse would return to the same level of work and one horse had already retired at the time of injury. Ninety-six respondents completed data on how long it took for their horse's wounds to completely heal, excluding the presence of any scarring. The mean number of weeks it took for horses to return to the same capacity of work prior to injury was 10.5 weeks (range, 1-75) (n=96/139). Once limb wounds had completely healed, with the exception of any scarring, most horses were described as sound (78.9%, n=71/90).

The proportion of participants scored the wounds cosmetic outcome as

'Excellent, scar is faint or not visible' was 47.7% (n=62/130), followed by 'Adequate, scar is clearly visible but not exceedingly wide or large' (46.9%, n=61/130) and 'Unacceptable, scar is wide, unsightly or exceedingly large' (5.4%, n=7/130).

The mean cost of treatment was £1592.02, ranging from £0 to £7000 with a median value of £900 (n=97/139). In a free text box, eight participants commented on the cost of treatment incurred from increased livery fees as a result of having to box rest horses. Participants were asked if there were any factors that limited their horse's treatment, the three most common responses were 'finances' (10.1%, n=14/139), 'horse temperament' (10.1%, n=14/139) and 'facilities' (4.3%, n=6/139).

11.7. Wound Outcomes (statistical analysis)

The following variables had no significant impact on wound outcome using the outcome measures described below ($P>0.05$): Country horse was resident in, BCS, tetanus vaccination status, influenza vaccination status, history of PPID, coat length/cleanliness at time of injury, wound contamination, whether owner administered any first aid, primary closure vs second-intention healing and closure with staples vs sutures. The following sections detail the variables that did have a statistically significant ($p \leq 0.05$) impact on wound outcome, a summary of these results can be found in Table 11.10.

Outcome Measure	Factors demonstrated to significantly impact outcome
Number of days taken for the wound to heal with the exception of any scarring	- Horse age - Tendon/ligament involvement - Received veterinary treatment - Received antibiotics - Ultrasonography performed
Did the horse return to pre-athletic function	- Horse age - Bone involvement
Number of weeks taken for a horse to return to pre-athletic function	- Horse gender - Height of horse - Limb involvement - Tendon/ligament involvement - Synovial involvement - Lameness - Received veterinary treatment - Received antibiotics - Received anti-inflammatories - Hospitalisation - Received surgery
Total cost of treatment (£)	- Access to emergency equine transport - Insured - Tendon/ligament involvement - Bone involvement - Synovial involvement - Lameness - Received veterinary treatment - Received antibiotics - Received anti-inflammatories - Radiographs performed - Ultrasound performed - Hospitalisation required

Table 11.10 – Factors demonstrated to significantly impact wound outcome. This table details which independent variables relating to owner demographics, experience, wound aetiology and treatment were shown to significantly impact wound outcome. Significance was defined when statistical testing produced a P value less than or equal to 0.05.

Variable 1	Variable 2	U value	P value	Additional information	Graph Included
Age of horse	Whether the horse returned to the same capacity of work prior to injury	887.5	0.013	The median age for horses returning to work was 12.3 years and for horses not returning to work was 20.0.	N/A
Was the horse a mare or gelding	Whether the horse returned to the same capacity of work prior to injury	752.0	0.003	The mean time it took for mares to return to work was 12.6 weeks and for geldings was 9.5 weeks.	Figure 11.3
Height of horse	Whether the horse returned to the same capacity of work prior to injury	1079.0	0.029`	The mean time it took for horses under 14.3hh to return to work was 6.4 weeks and for horses over 14.3hh was 11.8 weeks.	Figure 11.4
Did the wound occur on a limb	Whether the horse returned to the same capacity of work prior to injury	771.0	0.019	The mean time it took for horses with limb wounds to return to work was 12.1 weeks and for non-limb wounds was 7.7 weeks.	Figure 11.5
Was the horse insured for	Total cost of	1190.5	0.040	The mean cost of treatment	N/A

veterinary fees	wound treatment			for insured horses was £1866.3 and for uninsured horses was £1147.51.	
Did the horse have access to emergency equine transport	Total cost of wound treatment	541.0	0.002	The mean cost of treatment for horses who did have access to emergency equine transport was £1682.82 and for those who did not was £701.62.	N/A
Did the wound involve tendon/ligament	Number of days taken for a limb wound to heal	97.9	0.001	The mean time it took for wounds to heal involving tendon/ligament was 183.1 days and for those not involving tendon/ligament was 105.4 days.	Figure 11.6
Did the wound involve tendon/ligament	Number of weeks it took for horses to return to work for limb wounds	54.5	<0.001	The mean time it took horses to return to work with wounds involving tendon or ligament was 19.1 weeks and for wounds not involving tendon or ligament was 8.3 weeks.	Figure 11.7
Did the wound involve tendon/ligament	Total cost of treatment for limb wounds	157.5	0.002	The mean total cost of treatment for wounds involving tendon or ligament was £2856.5 and	N/A

				for wounds not involving tendon or ligament was £1308.5.	
Did the wound involve bone	Total cost of treatment for limb wounds	123.0	0.007	The mean cost of treatment for wounds involving bone was £2598.33 and for those not involving bone was £1211.64.	N/A
Did the wound involve a synovial structure	Number of weeks it took for horses to return to work for limb wounds	69.0	0.026	The mean time it took for wounds involving synovial structures to return to work was 15.4 weeks and for those not involving synovial structures was 9.6 weeks.	Figure 11.8
Did the wound involve a synovial structure	Total cost of treatment for limb wounds	158.0	0.021	The mean cost for wounds involving a synovial structure was £2705.27 and for those not involving a synovial structure was £1356.28.	N/A
Did the wound receive veterinary treatment	Number of days taken for the wound to heal	665.0	0.011	The mean number of days it took to heal for wounds receiving veterinary treatment was 132.8 and 71.9 for those that did not.	N/A
Did the wound receive veterinary	Number of weeks it took	432.5	<0.001	The mean number of weeks it took	N/A

treatment	for horses to return to work			for horses to return to work that received veterinary treatment was 12.0 and 5.8 weeks for those that did not.	
Did the wound receive veterinary treatment	Total cost of treatment	336.5	<0.001	The mean cost of treatment for wounds receiving veterinary treatment was £1719.0 and £600 for those that did not.	N/A
Did the wound receive systemic antimicrobial therapy as part of its treatment	Number of days taken for the wound to heal	911.5	0.018	The mean time taken for wounds to heal receiving antibiotics was 147.7 days and for those not receiving antibiotics was 84.3 days.	N/A
Did the wound receive systemic antimicrobial therapy as part of its treatment	Number of weeks it took for horses to return to work	636.0	<0.001	The mean time it took horses receiving antimicrobial therapy was 13.2 weeks and for those who did not was 6.9 weeks.	N/A
Did the wound receive systemic antimicrobial therapy as part of its treatment	Total cost of treatment	784.0	<0.001	The mean cost of treatment for horse's receiving antibiotics was £1741.93 and for those not receiving antibiotics was £1095.12.	N/A
Did the wound receive systemic anti-inflammatories as part of its	Number of weeks it took for horses	758.8	0.004	The mean time it took horses receiving anti-inflammatories was 12.8	N/A

treatment	to return to work			weeks and 7.8 weeks for those who did not.	
Did the wound receive systemic anti-inflammatories as part of its treatment	Total cost of treatment	1073.0	0.013	The mean cost of treatment for horse's receiving anti-inflammatories was £1599.29 and £1347.44 for those who did not.	N/A
Was the horse radiographed as part of the wound treatment	Total cost of treatment	290.5	<0.001	The mean cost of treatment for horse's having radiographs was £2913.33 and for those not having radiographs was £1275.92.	N/A
Did the horse receive an ultrasound as part of the wound treatment	Number of days taken for the wound to heal	149.0	0.048	The mean time taken for wounds to heal receiving ultrasonography was 218 days and 111 days for those not receiving ultrasonography.	N/A
Did the horse receive an ultrasound as part of the wound treatment	Total cost of treatment	100.5	0.001	The mean cost of wounds undergoing ultrasonography was £3471.43 and for those not undergoing ultrasonography was £1364.31.	N/A
Was the horse hospitalised as part of the wound treatment	Number of weeks it took for horses to return to work	255.5	0.036	The mean time it took for hospitalised horses to return to work was 15.2 weeks and for	N/A

				those not hospitalised was 9.9 weeks.	
Was the horse hospitalised as part of the wound treatment	Total cost of treatment	174.0	<0.001	The mean cost of treatment for hospitalised horses was £3539.13 and for non-hospitalised horses was £1153.28.	N/A
Did the horse receive surgery as part of the wound treatment	Number of weeks it took for horses to return to work	133.5	0.038	The mean time it took for horses undergoing surgery to return to work was 24.3 weeks and 9.6 weeks for those not undergoing surgery.	N/A

Table 11.11 – Mann-Whitney U value for factors demonstrated to significantly impact wound outcome. This table details which variables significantly impact wound outcome based on results for Mann-Whitney U testing where a P value was produced less than or equal to 0.05.

Figure 11.3– Box and whisker plot comparing horse gender and the time it took to return to work. This box and whisker plot compares the gender of a horse and the time it took for them to return to work. Mares were returning work significantly longer than geldings.

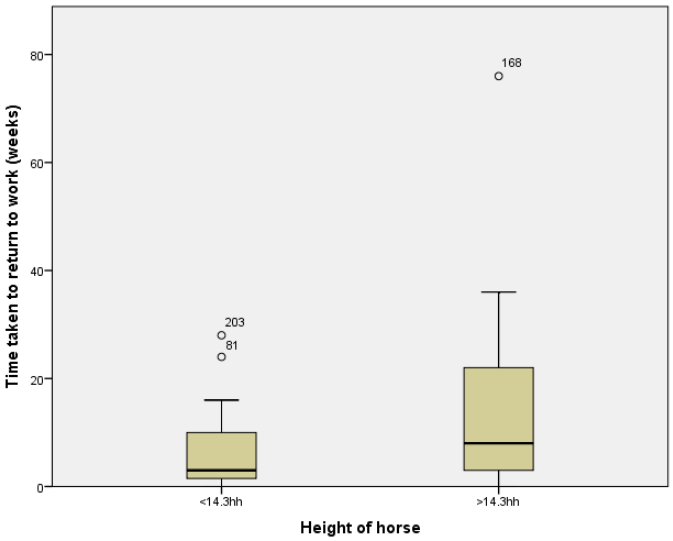

Figure 11.4– Box and whisker plot comparing horse height and the time it took to return to work. This box and whisker plot compares the height of a horse and the time taken for them to return to work. Horse over 14.3hh were taking significantly longer to return to work than those under 14.3hh.

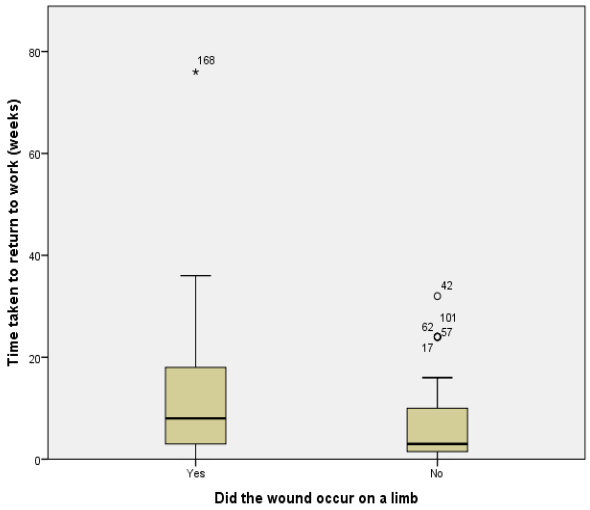

Figure 11.5– Box and whisker plot comparing whether wounds occurred on the limb and the time it took to return to work. This box and whisker plot compares limbs that do and do not occur on the limb and the time taken for horses to return to work. Limb wounds took significantly longer to return to work than non-limb wounds.

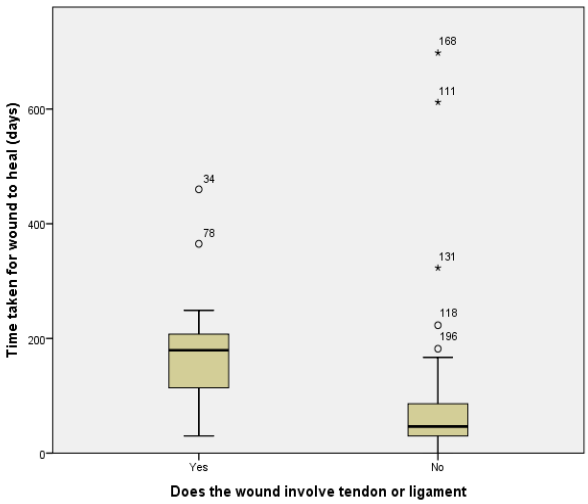

Figure 11.6– Box and whisker plot comparing wounds that do and do not involve tendon/ligament and the total time it took for these wounds to heal. Wounds involving tendon/ligament took significantly longer to heal than those that did not.

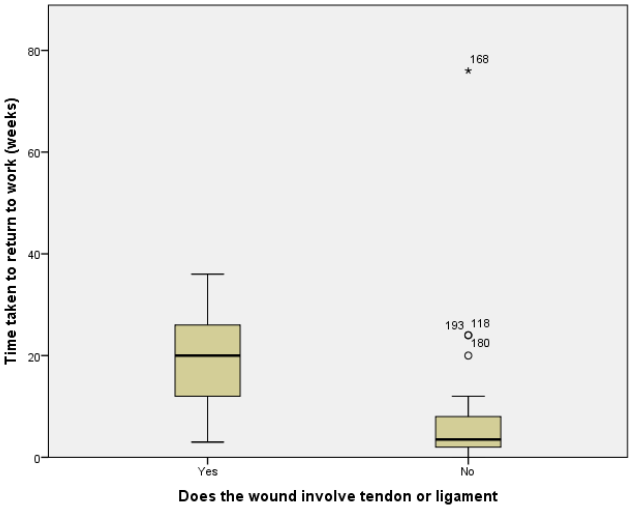

Figure 11.7– Box and whisker plot comparing wounds that do and do not involve tendon/ligament and the time taken for the animal to return to work. Wounds compromising tendon/ligament took significantly longer to return to work than wounds not involving tendon/ligament.

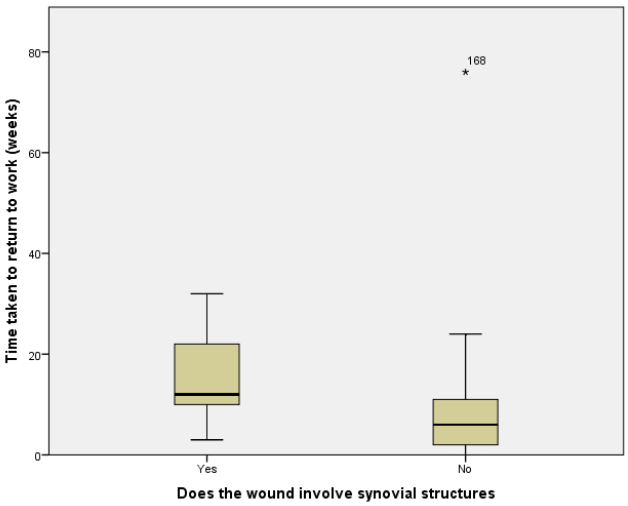

Figure 11.8– Box and whisker plot comparing wounds that do and do not involve synovial structures and the time taken for the animal to return to work. Wounds compromising synovial structures took significantly longer to return to work than wounds not involving tendon/ligament.

Horse age

A bivariate Pearson correlation test demonstrated significant (P=0.047) between the age of the horse and whether the horse returned to the same capacity of work prior to injury (Figure 11.3).

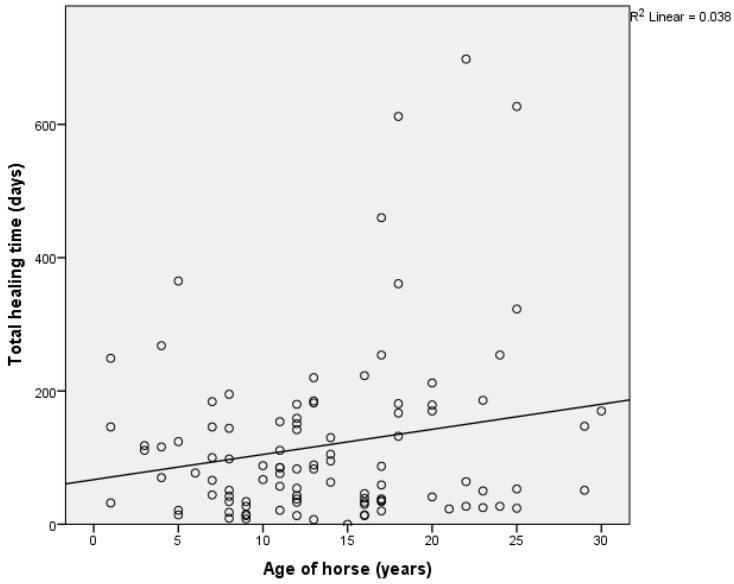

Figure 11.9– Scatter graph plotting age of horse against the total time it took for wounds to heal. This scatter graph demonstrates a significant positive correlation, shown by the line of best fit, between the age of the horse and how long it took for the wound to heal.

Bone involvement

Chi-square analysis showed significance when comparing whether a horse returned to the same capacity of work following injury and whether limb wounds wound involved bone (P=0.031).

Lameness

There was a significant difference between the five categories of lameness a horse was exhibiting at the time of wound injury and the time taken to return to the same capacity of work prior to injury (Kruskal-Wallis H test, chi-square=10.8, df=2, P=0.028). The median time it took for horses to return to work when graded '1-horse is sound' was four weeks (interquartile range 2.0-10.8). The median time it took for horses

to return to work when graded '5-horse cannot bear weight on the affected limb' was 18 weeks (interquartile range 6.8-30.0). This significance is not evident when performing the same analysis on just limb wounds.

Chi-square analysis showed significance between whether a horse was described as being sound at the time of injury and whether it returned to the same capacity of work (P=0.017).

There was a significant difference between the five categories of lameness a horse was exhibiting at the time of wound injury and the total cost of treatment (Kruskal-Wallis H test, chi-square=11.2, df=4, P=0.025). The median cost of treatment for horses graded '1-horse is sound' was £518 (interquartile range 164-1850) and for horses graded '5-horse cannot bear weight on the affected limb' was £2500 (interquartile range 1650-5263). This significance is not evident when performing the same analysis on just limb wounds.

12.0. Discussion

12.1. Summary of main results

The aim of this study was to generate primary evidence on the healing and outcome of wounds in horses, including how owners' manage wounds either prior to or in the absence of veterinary treatment. A small but relevant proportion (8%) of horses were not vaccinated for tetanus, 16% of horses did not have access to emergency equine transport and over half of horses were not insured for veterinary fees (52%). Most wounds occurred on a limb (70%) with half of these occurring on the hindlimb (56%) and most on the distal limb (73%). The mean time taken for wounds to heal was 117.3 days. The mean time taken for horses to return to work was 11 weeks, and 8% of horses were not predicted to return to the same capacity of work prior to injury. The mean total cost of treatment was £1592.02, and one in ten cases stated that medical treatment were limited by cost.

Factors that significantly impacted healing time (days) included the age of the horse, whether the wound involved tendon/ligament and whether the wound received veterinary treatment. Factors that significantly impacted whether a horse returned to pre-athletic function included the age of the horse and the level of work the horse was working at prior to injury. Factors significantly impacting the time taken for a horse to return to pre-athletic function included the horse's gender, the horse's height, whether the wound occurred on a limb and whether the wound compromised any tendon/ligament or synovial structures. Factors

demonstrated to significantly impact the total cost of treatment included whether the owner had emergency access to equine transport facilities, whether the horse was insured, whether the wound involved tendon/ligament/bone/synovial structures, whether the horse was lame at the time of injury and whether the wound required veterinary treatment.

12.2. Study methodology

The majority of data captured in this cohort study was prospective in nature, with the remaining proportion of data being retrospective by a maximum of twelve months. Data was captured directly from owners making it unique in comparison to the current body of literature which consists predominantly of retrospective studies specific to referral hospital populations. Data has not yet been reported for wounds seen in primary care practice or those treated in the absence of a veterinary practitioner.

Prospective studies can be advantageous over retrospective studies as questions can be tailored to collect data specific to the research aims and objectives. With retrospective studies, data can be incomplete as the information collected may not be specific to the research questions or aims (Song and Chung, 2010). Prospective studies present difficulties in recruiting enough suitable cases to permit analysis, especially in the presence of time constraints. For this study, recent retrospective data (cases that had occurred within previous 12 months) were permitted for analysis. This was to increase the amount of data captured whilst mitigating inaccuracies in owner reporting compared to say wounds that

occurred more than 12 months previously.

There are a number of studies that have investigated factors affecting wound healing in *in vitro* conditions. *In vivo* studies are however required to determine whether these factors have any clinical impact on wound healing. There are currently few published studies that directly assess how different factors associated with equine wounds impact outcome and those that do, lack data on potentially significant variables. For example, the largest currently published retrospective study into equine wound healing by (Wilmink *et al*., 2002) assessed outcome based on the success of primary closure and incidence of sequestrum formation for 511 horses. These variables were likely selected as they could easily be extracted from clinical histories, however other key outcome data, such as return to work and time taken for the wound to heal is not reported. Some details on signalment were also omitted. For these reasons and despite the risks of a low sample size and increased time and effort of collecting data, a predominantly prospective study design with owner involvement was chosen. This study designs enabled data on variables that could potentially impact outcome to be collected and reported across a variety of clinical wounds, including those that may not receive veterinary treatment.

A key difference between this study and previous equine wound studies is that data was owner reported. Owners are likely to have more time to complete forms in comparison to vets; Study engagement and participant retention can be a significant barrier to vets reporting data, as discovered

in a previous unpublished research project dissertation by the same author. It is likely owners would report data on their horse signalment accurately, but some might struggle when reporting medical data. There are disadvantages to analysing owner driven data, for example in human literature, nutrition has been discussed to impact wound healing (Stechmiller, 2010, Wild *et al*., 2010). A question was therefore included asking owners to body condition score their horse, giving a gross indication of a horse's nutritional status. A previous study assessed how horse owners body condition scored their horses found 53.3% were consistently underscoring their horses and that there was poor agreement of the body condition scores assigned by the owner and by the researcher (Stephenson *et al*., 2011). A reason for this could be that owners would select a body condition score they believe their horse should be and not what it is. It is possible this trend could be replicated across other aspects of this study. The advantages of using owner reported data compared to vet reported data were believed to outweigh the disadvantages, particularly when examining the quality of the results from a study that employed similar methodology assessing the incidence and clinical signs of laminitis (Pollard *et al*., 2019). This study comprised entirely of owner reported data, which was commented on to be advantageous as it captured information on cases that were not seen by veterinary practitioners. Using owner driven data also had additional benefits as it allows outcome data, for example when or if the horse returned to work, which normally wouldn't be recorded in clinical histories which many retrospective studies extract their data from.

Several data capture formats were developed to increase response rates, including electronic PDF forms, and submission of online questionnaires through the platform 'Google Forms'. Using an online questionnaire is advantageous due to low cost, ease of dissemination, use of visual aids and efficiency of capturing and collating both qualitative and quantitative data (Ponto, 2015, Jones *et al*., 2013). There are limitations to using an online questionnaire, for example access to a computer is required. By providing alternate ways for potential participants to submit data, this is likely to increase the total number of cases received and mitigate the impacts of selection bias against participants with limited access to the internet or a computer/phone/tablet.

Selection bias may be present in this study due to awareness being disseminated predominantly through the British Horse Society's social media and email channels. Actions were taken to mitigate this bias by raising awareness of the project through other channels including veterinary practices and by distributing hard copy leaflets at equine shows/events. When interpreting any statistical findings, it is important to bear in mind that the sample size is small and may not be representative. This should not invalidate findings, but instead warrant further research to fully explore them.

12.3. Main findings

Measures to mitigate the impact of traumatic wound injury

This study highlighted the risk to life traumatic wounds can pose, where 2.2% of cases resulted in euthanasia. A study of out-of-hours cases seen in primary care equine practice reported similar euthanasia rates for

wound injuries (4%) (Bowden *et al*., 2017). The reasons for euthanasia were not explored in detail in this study, but it was interesting to note that some preventative measures were not in place. Tetanus in the horse is a fatal, but preventable, neurological disease caused by the infiltration of *Clostridium Tetani* spores from soil/faecal matter into a wound (Aleman *et al*., 2018). Prevention is achieved by adopting an appropriate vaccination protocol. A proportion of horses in this prospective study had an absent or inappropriate vaccination protocol for the tetanus toxin (8.4%), similar to statistics reported in a survey of UK horse owners (9.2%) (Hotchkiss *et al*., 2007). The UK horse population is estimated to be in the region of 1,000,000 animals (Boden *et al*., 2012). It can be extrapolated that there are approximately 84,000 horses in the UK that are not vaccinated for tetanus. Vaccination is also one of the few prophylactic measures horse owners can, and should, adopt in order to minimise the consequences of traumatic wound injury. Vaccination for tetanus comes at a low cost to the owner (<£50) and are only required every other year, unless injury occurs, which again helps to keep costs low (Paillot *et al*., 2017). Further studies are required to understand what barriers are preventing such a large proportion of horses having access to a tetanus vaccination.

Three quarters of wounds required veterinary treatment in this study, of these 15.2% required hospitalisation and therefore access to equine transport facilities. A similar number of study participants (16%) stated that they would not have access to emergency equine transport facilities. An information leaflet targeted at horse owners produced by the 'REACT

now to beat colic' campaign discusses the importance of having a contingency plan in place so horses have 24/7 access to emergency equine transport should they require referral/hospitalisation as a result of colic (Freeman et al., 2019). This preparedness should apply not only for colic but also for wounds and other emergency conditions. A delay in referral of wounds involving synovial injuries has been demonstrated to have a negative impact on outcome and return to pre-athletic function (Ludwig and van Harreveld, 2018, Findley et al., 2014, Isgren et al., 2020, Orsini, 2017a). This should be considered particularly important when considering the high incidence of wounds in this cohort study that involved a synovial structure (15.7%). A lack of emergency equine transport, which applied to three in 20 study participants, could negatively impact on animal welfare and pose an important barrier to achieving a good prognosis.

As well as having a plan on how to transport a horse for referral and hospitalisation, it is as equally important to have a financial plan in place to afford potential veterinary bills. Insurance policies present an affordable way for owners to cover the cost of expensive and unexpected vet fees (Wingfield Digby *et al*., 1980). The average cost of treatment for wounds receiving veterinary attention in this study was £1718.97; one in ten cases said their horse's medical treatment were limited by cost and over half of cases did not have their horse insured for veterinary fees (52.1%). Insured horses and those with access to emergency equine transport had a statistically higher total cost of treatment. One potential explanation for this could be that insured horses, or those with access to

emergency transport, could access more or higher quality veterinary treatment by being able to either afford it or transport the horse to hospitalisation facilities. Several factors were shown to significantly increase the cost of treatment, all of which had a high incidence rate amongst the study population, including involvement of tendon/ligament, bone or a synovial structure. The presence of lameness at the time of initial injury was another factor demonstrated to result in a significant increase of total cost. These factors highlight the need for owners to be financially prepared for the possibility of a horse under their care suffering from a traumatic wound, whether that be through insurance policies or other contingencies. Future studies should aim to explore barriers to horse owners taking out insurance policies and assess what proportion of the horse owning population are financially capable of affording emergency veterinary treatment in the absence of insurance.

Factors influencing outcome

Eleven factors were demonstrated to have a significant impact on the time taken for a horse to return to the same capacity of work prior to wound infliction. For example, ponies were shown to return to pre-athletic function significantly faster than horses, by an average of 5.4 weeks. This supports findings from previous experimental studies that demonstrated faster wound healing in ponies compared to horses (Wilmink *et al*., 1999a, Wilmink *et al*., 1999b). A further retrospective study by (Wilmink *et al*., 2002) demonstrated that ponies have higher rates of successful primary closure and lower incidences of bone sequestra. Wilmink and colleagues' studies classified a pony as being

below 14.2hh in height and not 14.3hh as used in this cohort study. Despite this minor difference in methodology, this is the first study that has demonstrated the difference in wound healing based on horse height outside of referral hospital and experimental populations. This is also the first study to highlight a difference in the time taken to return to pre-athletic function based on a horse's height. Wound location was demonstrated to have a significant impact on time taken to return to work. Wounds located on a limb took on average 4.4 weeks longer to heal than wounds not located on a limb, supporting findings from previously reported studies (Wilmink, 2016). Limb wounds have been demonstrated to heal slower than trunk wounds due to increased skin tension, poor vascular supply and location over moving joints that disrupt healing. Wounds that involved tendon or ligament were demonstrated to increase the time taken to return to pre-athletic function by an average of 10.8 weeks. Unlike previous studies, this study did not differentiate between which tendinous structures were compromised in a wound, for example flexor or extensor tendons as owners would be unlikely to report this data consistently and accurately. Previous studies that have differentiated between tendinous structures all ultimately demonstrated a risk of return to pre-athletic function (Foland *et al*., 1991, Jansson, 1995, Mespoulhes-Riviere *et al*., 2008, Belknap *et al*., 1993, Jordana *et al*., 2011). These five studies were again retrospective and specific to referral hospital populations. Outcome was based on a horse's ability to return to the pre-athletic but how long this took was not reported. Involvement of synovial structures was similarly demonstrated to increase the time taken to return pre-athletic function by an average of 5.6 weeks. This supports

previous studies of synovial sepsis that all demonstrated a risk of return to pre-athletic function (Smith *et al*., 2006, Wereszka *et al*., 2007, Findley *et al*., 2014, Post *et al*., 2003, Milner *et al*., 2014). Again, these studies were retrospective and specific to referral hospital populations. They assessed outcome based on ability to return to pre-athletic function and survival. A previous retrospective case series of 481 wounds found a significant relationship between the severity of lameness present at the time of injury and outcome (Firth *et al*., 2017). Findings from this study do support that of Firth's, with sound horses returning to work on average 14 weeks faster than those graded '5 non-weight bearing'. Knowing that a horse's height, wound location, tendon/ligament/synovial involvement, and the presence of lameness at the time of injury impact the time taken and/or ability of a horse to return to pre-athletic function is important. By assessing these factors at the time of wound injury, they could serve as valuable prognostic indicators aiding in estimating how long a horse would be expected to return to work. These factors could also be used to identify 'critical cases' and help owners to quickly decide whether a wound requires veterinary treatment.

One unexpected finding from data analysis was that mares took significantly longer to return to work than geldings. Stallions were excluded from analysis due to low sample size. No data was collected on whether mares were in foal at the time of injury or put in foal as a result of the injury. There is currently nothing in the literature to support exactly why this may be but one hypothesis could be that mares have been demonstrated to be more anxious, aggressive and reactive than

geldings (Duberstein and Gilkeson, 2010). As a result ovariectomy surgery is becoming an increasingly accessible option for owners who are dealing with mares in oestrous to try and combat this undesirable 'mareish behaviour', such as unwillingness to respond to rider instruction (Crabtree, 2016). The unpredictable behaviour of a mare compared to a gelding might put them at higher risk of suffering from a severe wound that takes a longer time to return to work. Perhaps the true trend however is not between geldings and mares but instead between neutered and entire individuals of the same sex. These findings warrant further research to establish if these finds are repeatable and if so the reasons for it by collecting further indication on whether animals are pregnant.

The age of the horse was demonstrated to significantly impact whether the animal would or would not return to pre-athletic function. The median age of horses not returning to work was 20 years and of horses returning to work was 12 years. Although this finding is not unexpected, there are a number of possible explanations, which require further investigation. Older horses were also shown to have significantly longer wound healing times compared to younger horses (Figure 11.3). The impacts of increasing age on impaired wound healing has been well reported in human medicine and studies using rodent models (Gosain and DiPietro, 2004, Kim *et al*., 2015). The equine population is ageing and therefore there is also an increasing prevalence of PPID, a disease believed to negatively impact wound healing (L. Traub-Dargatz et al., 2006, Knottenbelt, 1997). Knowing that older horses are likely to suffer from

impaired wound healing and increased recovery times this help owners more accurately plan the rehabilitation period following injury.

12.4. Next steps

This study ran over only a 10-month period and as a result had a small sample size. The logical next steps would be to run a larger prospective study to ascertain whether these results are reproducible and accurate. This study population was 95% UK horses, future studies to establish how wound healing trends between different countries would be desirable. This study also contained no data for donkeys or mules, of which there have been no previous wound studies on. Outcome data was missing for 36.5% of cases and the only method of contacting study participants was by email. Perhaps to increase the amount of outcome data received in a future study it would be advisable to do so via the use of follow up telephone interview. Follow up telephone interviews have been used in several other studies of equine disease processes with potentially long latency periods (Niemelä *et al*., 2016).

Two further forms were developed in conjunction with this study that collected information when wounds received veterinary treatment following the initial 24 hours after injury and also as periodic updates when owners administered first aid. Analysis of this data was not performed in this study due to time constraints. Photographs of the wounds were also submitted with each online form, but time constraints again did not permit analysis as part of this thesis. Future analysis of these forms and photographs could prove beneficial.

To ascertain whether gender really does impact on a horses ability to return to work as findings from this study suggest, an experimental study that produces standardised artificial wounds on a small population of mares and geldings could be employed, emulating methodology used by (Wilmink *et al*., 1999a). Ideally this experimental study would produce standardised wounds on both stallions, geldings, mares and ovariectomised mares to establish if there is a gender and/or sex hormone difference between wound healing and ability/time to return to work.

Reporting previously undiscovered trends in research is important but what is more valuable is how these findings are utilised. For example, a campaign resulting from this study could aim to improve the uptake preventative measures owners can carry out to mitigate the impacts of traumatic wound injury including appropriate tetanus vaccination and having access to emergency equine transport facilities. To ensure any future campaigns to educate owners were successful, first focus groups would be required with stakeholders and the target population to identify any barriers to change, and the optimal routes of dissemination, to make campaigns as impactful as possible (Leung and Savithiri, 2009).

12.5. Conclusion

This is the first study to report on the type of wounds, wound healing times and time taken to return to work across the general UK horse population. This provides important evidence to enable horse owners and vets to plan treatment and rehabilitation programmes, and estimate the time and costs involved. Several factors were identified to significantly

impact various aspects of wound outcome, based on the time taken for the wound to heal, ability/time to return to pre-athletic function and the total cost of treatment. Most of these have not previously been reported in clinical studies. Important factors identified included age of horse, height of horse, lameness at time of injury, location of wound and tendon/ligament/synovial/bone involvement. These factors when assessed at the time of wound injury could serve as useful prognostic indicators and help decide which treatment route to follow. A significant proportion of horse owners did not have measures or options in place that could potentially mitigate the impact of wound injuries, specifically tetanus vaccination, insurance and access to emergency equine transport facilities. Addressing these measures has the potential to positively impact on the health and welfare of thousands of horses suffering from both wounds and other emergency conditions. Due to the small sample size of this study a larger and longer running prospective study is advised to further our understanding and to also ascertain whether these findings are repeatable. A larger study is warranted based on the significance of results from this study.

Chapter 4: Final Discussion, Future Recommendations and Conclusions

13.1. Study Conclusion

The body of literature specific to equine wound management consisted predominantly of expert opinion and retrospective studies specific to referral hospital populations. There are currently no published studies on equine wounds managed outside of a referral hospital environment, no prospective studies and no published data on how owners' approach and manage wounds either prior to or in the absence of veterinary treatment. These gaps in the literature were identified in a previous unpublished research project dissertation by the same author as this study (Birnie *et al*., 2017). The literature has consistently identified that traumatic equine wounds are the second most common emergency condition in the horse with potentially severe sequelae (Firth *et al*., 2017, Boynova *et al*., 2018). Nearly all participants completing the online questionnaire in this current study had experience of a horse under their care suffering from a wound (95%). The current lack of evidence served as the impetus for this piece of research; The primary aim of which was to generate evidence on the healing and outcome of wounds in horses, including how owners choose to approach and manage wounds. This was achieved firstly by the development and dissemination of an online survey suitable for anyone involved in the care of horses to complete. It presented seven wound case scenarios and asked participants how they would approach and manage each injury with respect to first aid measures they would apply

and their decision-making process in seeking veterinary advice. The second element of this project was a cohort study comprised entirely of owner driven data. Descriptive analysis was performed on the presenting signs, treatments and outcomes of these wound injuries. Statistical analysis was also performed to establish if any independent variables relating to the horse's signalment, cause of injury and treatment significantly impacted outcome.

Both the survey and cohort study identified a large proportion of study participants were choosing to administer first aid within the first 24 hours following injury, many of the measures applied could be classified as inappropriate when compared to the current literature. There is currently limited evidence-based guidance available on the application of first aid measures to equine wound injuries; The only resource of its kind is currently unpublished and targeted at veterinary surgeons and not horse owners. It is important that both horse owners and veterinary surgeons have a standardised and synergistic approach to managing equine wounds as both are involved in the recovery of horses following wound injury. The need for further research that can underpin the development of separate evidence-based resources targeted at both of these stakeholders has the potential to positively impact the outcome of horses suffering from traumatic wounds and therefore their health and welfare by avoiding inappropriate first aid and management techniques. Seven factors relating to the participants demographic and previous experience were demonstrated to have a significant evidence of association on the first aid measures they would apply. This data can help to develop

tailored approaches for future educational campaigns to different groups within the target population. For example, this study suggested that those participants that were older, had more horses or more years involved in the care of horses were treating wounds more appropriately, therefore targeting educational campaigns at organisations involved in equine qualifications and developing resources aimed at more inexperienced owners could be more impactful.

Recognising the potential severity of the wound and the need to call a vet was identified as an important area for future education. Despite participants stating depth of wound as the most influential factor affecting their decision to seek veterinary attention, when presented with a puncture wound over the digital flexor tendon sheath less than a quarter of owners recognised that it required high priority veterinary treatment. Seventeen percent of wounds in the cohort study involved a synovial structure. When extrapolating data from the survey this suggests that potentially over three quarters of horses in the cohort study with synovial involvement were not receiving veterinary treatment in an appropriate time frame. Further extrapolation of this data to the national horse population identifies a concerning number of horses that might not be receiving appropriate veterinary treatment for potentially career and life-threatening injuries. At skin level puncture wounds may appear minor, involvement of deeper structures is a great risk to life and return to pre-athletic function if not treated promptly. Delayed treatment of synovial wounds has been demonstrated to increase the risk of mortality by 4.75x. This was also significantly affected by whether the

horse had an identified skin wound at presentation (Milner *et al*., 2014). Milner hypothesised that if there is a clearly visible skin wound owners are more likely to recognise the severity of the injury than if it were small and innocuous. With a high proportion of synovial injuries in equine wounds in the prospective cohort study and generally poor recognition of the significance of puncture wounds in the online questionnaire, this has been identified as a key area for future owner education.

This study identified poor uptake of several methods that owners could employ to mitigate the impact on their horse's health and welfare of any potential future wound injury. These included the uptake of tetanus vaccination (8.4% of participants were not appropriately vaccinated, this figure was higher at 20% in the online questionnaire), insurance for veterinary fees (over half of horses were not insured and 10% of horses treatment options were limited by cost) and putting a plan in place to have 24/7 access to emergency equine transport should a horse require referral for wound injury. The online questionnaire demonstrated not having insurance as a barrier to receiving veterinary care and the prospective cohort study identified a high proportion of horses who were not insured and whose treatment options were limited by cost. Having the horse insured was associated with an increased likelihood of seeking veterinary advice for wounds of a less severe nature in the online questionnaire. The costs associated with wounds could be significant, the average total cost of wound treatment in the prospective study was £1592.02, and the acute nature of wounds means that veterinary treatment and costs have to be found immediately often in emergency situations. The results of this study are important to inform a future

public campaign that should focus on increasing the uptake of owner prophylactic measures to mitigate the impact of traumatic wounds on outcome.

This is the first study to report descriptive and statistical data for wounds seen across the general UK horse population. Most wounds occurred on the limb (70%). More than one in ten wounds involved tendon or ligament (17%), bone (17%) or a synovial structure (16%). Wire/fencing injuries were the most common cause of wound infliction. Several factors were shown to significantly impact wound outcome that have not previously been reported. Outcome was broadly divided into healing time, return to work and cost of treatment. Factors shows significantly affect these included horse age, gender, height, insurance status and access to emergency equine transport facilities, wound location, tissues involved, lameness at time of injury and treatment received. Recognising these factors as having a clinical impact is important to help identify prognostic indicators for both vets and owners. With further data these could be used to help estimate how long it would take the animal to return to work and the total cost of treatment. This can help to identify 'critical cases' requiring urgent veterinary intervention and help owners make a more informed decision about which treatment path they would prefer to go down based on evidence-based outcome data. Further research is required to establish if these factors are indeed significant by capturing repeatable findings in a larger study. A larger study could help identify why they are significant and the cofounding variables and interactions that can affect them.

A previous evidence-based campaign entitled 'REACT now to beat colic' had similar aims to this study, with the equine emergency condition in question being colic and not wounds. This campaign received the 2019 RCVS impact award due to having a 'significant impact on equine welfare, public awareness and the veterinary profession' (RCVS, 2019). A proportion of the research underpinning this campaign comprised of owner driven data (Bowden *et al*., 2019). Bowden's PhD thesis had similar findings, highlighting the importance of all those involved in the care of horses being able to recognise disease and when instigation of veterinary treatment is required. There are still potential issues when collecting owner driven data however it is essential to include horse owners when developing and disseminating educational campaigns, specifically on health conditions as they 'are the gatekeepers of animal welfare' (Bowden, 2018).

This project is the first to gain an insight into how those involved in the care of horses' approach and manage wounds. It is also the first to explore and successfully report factors significantly impacting outcome for wounds outside of referral hospital populations. Several key areas have been identified where further research could have a significant impact on wound management practice and animal welfare. Findings have formed the essential first step in capturing data to inform evidence-based decisions on equine wounds. Through collaboration with The British Horse Society, the data and legacy of this research project will form the foundation of a future campaign which has the potential for widespread

impact on equine health and welfare.

14.0. Bibliography

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15.0. Appendices

Due to the nature of the methods used within this Masters of Research, the appendices were unable to be included within the final document. Please use the following link to access these documents if required: https://uniofnottm-my.sharepoint.com/:b:/r/personal/svyrb2_nottingham_ac_uk/Documents/Equine%20wound%20management%20MRes%20appendices/Appendix%20I%20-%20Copy%20of%20online%20survey.pdf?csf=1&e=qaQmRn