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Multi-disciplinary workshops and owner questionnaire to develop guidelines to aid owner management of equine wounds

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Summary

Significant gaps in horse owners/carers knowledge of equine wounds have been identified in previous studies. The aims of this work were to generate guidelines for horse owners/carers on the management of equine wounds and identify potential barriers to horse owner/carers engaging with such resources.

The first part of the study focused on reviewing and summarising the key current evidence relevant to owners' decision making for equine wounds. A list of the key aspects of the horse owners'/carer's perspectives of decision making was constructed, and a review of the veterinary literature was performed. Where evidence was lacking in veterinary literature, a review was performed of relevant human literature. Key aspects from this were summarised into evidence packs which were used for the second phase of the study.

The second phase of this study involved a series of multi-disciplinary workshops which utilised the experience of horse owner/carers, veterinary professionals, and other stakeholders, along with the latest literature on equine wound management, to generate recommendations for horse owner/carers for equine wound management. The outcome of the workshops was a list of agreed statements on equine wounds, including lameness, depth and location of wounds, bleeding, complications of wound healing, vaccination status, wound cleaning, and topical wound treatments.

The third phase of the study then explored the approaches to equine wounds used by horse owners/carers through an online owner questionnaire and their opinions. Social media was used to both advertise and recruit participants. A total of 600 horse owners/carers completed the online survey. Areas covered in the online survey include excessive granulation tissue (EGT), wounds involving synovial structures, cleaning of wounds and topical wound treatments. Feedback to owners/carers on the survey answers was received well, with a large proportion of horse owners/carers stating they would amend their habits in accordance with their newfound knowledge.

This study used a co-production approach with key stakeholders to develop owner/carer recommendations on equine wound management and identify the key barriers to their implementation. This forms the essential first step in developing a framework for an effective educational campaign.

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CHAPTER 1: Introduction

1.0 Introduction

Wounds are among the most frequently encountered 'out-of-hours' emergencies in equine practice (Bowden et al, 2020). This study analysing data from two UK veterinary practices between 2011-2013 reported that 35% of all 'out-of-hours' visits were due to colic, followed by traumatic wounds (20%), and lameness (11%). These findings are supported by an older study conducted in the USA, which reported a 4.7% prevalence of wounds in horses greater than six months of age, closely followed by lameness (2.8%) and colic (1.9%) (USDA, 2006). Although the figures reported in the later study are much lower, this study is a review of all cases seen by equine practitioners, rather than a focus on out-of-hours cases; the trends seen in both studies are equivalent. Results of an online survey completed by registered veterinarians in New Zealand showed that wounds were the third most common case encountered, behind respiratory disease and lameness (Theoret et al, 2015). Wounds have a significant impact on horse welfare, with the USDA reporting injury/wounds/trauma account for 24% of deaths in younger horses aged between 30-180 days, and 16% of deaths of horses over six months old. The New Zealand study also reported that wounds were the second most common cause of death/euthanasia (Theoret et al, 2015). These studies used different methodological approaches and have different potential biases. The UK study documented actual cases seen by manual searching practice data records, but the time and workload involved in this meant the study was limited in sampling timeframe and data was only from two hospitals. The prevalence of injuries and causes of death in the US study was based on data collected through the USDA's National Animal Health Monitoring System (NAHMS), which relied on surveys completed by veterinarians and horse owners. A strength of this approach was its broad geographic coverage and large sample size, providing a more generalisable estimate of injury prevalence and mortality causes across the U.S. equine population. However, the study was limited by potential reporting biases, as data depended on voluntary responses, which may have led to underreporting or misclassification of cases. Additionally, because the study relied on owner and veterinarian reports rather than direct medical record review, there

may have been inconsistencies in how injuries and causes of death were categorized. The New Zealand study was a survey of veterinarians, which will capture a wider range of vets/hospitals, and reflect the caseload seen by attending vets. A survey format however can introduce selection and recall bias and therefore reflects veterinarians' opinions of most common problems and causes of death rather than the actual case numbers. Despite these differences, all three studies highlighted that wounds are a common and important health and welfare issue in the horse, and a major cause of mortality. In addition to the negative impacts on horse welfare, wounds also have significant financial consequences for horse owners/carers. Wounds involving the skin and underlying structures have been shown to be time-consuming to manage and costly, as well as resulting in decrease athletic performance, early retirement and euthanasia as mentioned previously (Birnie, 2020; Theoret et al, 2015; USDA, 2006).

The complications associated with equine wounds vary significantly depending on their location, with proximal limb and body wounds generally healing more efficiently than distal limb wounds due to key anatomical and physiological differences. Proximal limb and body wounds benefit from a richer blood supply, increased soft tissue coverage, and reduced movement at the wound site, all of which contribute to faster and less complicated healing (Wilmink & van Weeren, 2005). These wounds tend to heal primarily by contraction and epithelialisation, often resulting in minimal long-term functional impairment (Theoret et al., 2016). In contrast, distal limb wounds are more prone to complications such as delayed healing, excessive granulation tissue (commonly referred to as "proud flesh"), and infection due to poor vascularization, continuous movement, and greater exposure to environmental contaminants (Finnie et al., 2020). The lack of soft tissue in the distal limb also means that underlying structures such as tendons, ligaments, and joints are more likely to be involved, increasing the risk of severe complications such as septic arthritis or tendon sheath infections, which can significantly impact the horse's long-term soundness and welfare (Lange et al., 2021). These differences highlight the need for distinct management approaches for wounds in different anatomical locations, with

distal limb wounds often requiring more intensive and prolonged treatment strategies to achieve successful healing.

This considered, it is important to ensure that horse owners/carers have the knowledge to enable them to differentiate wounds that require veterinary attention from those that can be managed appropriately by themselves.

2.0 First aid

2.1 Hand preparation

Hand preparation is key in reducing the transfer of bacteria from hands into the wound bed and is therefore an important component of first aid. Prior to wound treatment, both horse owners/carers and veterinary practitioners should prepare their hands sufficiently before donning gloves. Gloves frequently become perforated, and therefore hands need to be appropriately cleaned in addition to the use of gloves (Jahangiri et al., 2022). There are three solutions which are commonly used for aseptic preparation of hands both in human and veterinary practice: aqueous scrubs, alcohol-based rubs (ABRs) and alcohol-based rubs containing additional active ingredients. The World Health Organisation (WHO) advocate the use of ABRs in human medicine as they have been shown to be equally efficacious for hand antisepsis when compared to aqueous scrubs, as well as decreasing preparation time, cost, and water usage (Kampf and Kramer, 2004; Weber et al., 2009; WHO, 2018). These findings are replicated in prospective studies by da Silveira et al.(2016) and Biermann et al. (2019), which found ABRs to have superior residual efficacy in terms of colony forming units at 3 hrs g. Efficacy for hand antisepsis was assessed in both studies by measuring the number of bacterial colony forming units (CFU) over a period of time rather than the rates of surgical site infections (SSI). In addition, it is important to consider the method of application when using alkaline-based solutions such as chlorhexidine (CHX). Brushes are often employed with these solutions; however, their use can lead to skin excoriation due to the mechanical friction imposed on the skin. Such excoriation may result in micro-abrasions that compromise the stratum corneum, ultimately undermining the skin's

barrier function and increasing susceptibility to irritants and infections (Lin and Chen, 2008; Schauber and Gallo, 2008). Consequently, minimizing mechanical trauma during hand preparation is critical; a notion that is further supported by clinical guidelines recommending reduced mechanical friction to preserve skin integrity (Rutala and Weber, 2004). Sapijaszko, Samadi, and Chow (2024) further highlight the importance of optimising surgical site infection prevention by minimising factors that could damage the skin barrier, including excessive mechanical friction during antiseptic preparation. This reinforces the need for techniques that reduce trauma while maintaining effective microbial reduction. A human healthcare study found no significant difference between the rates of SSI following the use of ABRs and aqueous scrubs containing CH or PI (povidone iodine) (Parienti, 2002). Combining aqueous medical solutions before ABR's does not offer any advantage and actually may increase the incidence of dermatitis and shorten the residual effect of the ABR's. Despite evidence in both human and veterinary practice supporting the use of ABRs, a study conducted by Verwilghen, Grulke and Kampf (2011), found that 84.5% of veterinary surgical specialists said that they use aqueous scrubs containing CH gluconate or PI detergents for hand antisepsis. This result may reflect the lack of equine specific studies on hand antisepsis. However, the study was conducted as an online survey of surgery Diplomates, so is subject to potential biases, including selection and response bias, and the findings may not relate to the wider veterinary population. In a clinical setting, surgeons will wear sterile gloves to prevent the transfer of bacteria between hands and the patient, more specifically the wound bed (Tanner et al., 2016). Due to the risk of perforation of gloves during procedures, it is paramount to ensure that hand antisepsis is performed prior to donning gloves (Hayes et al., 2014; Sapijaszko, Samadi, and Chow., 2024). Sterile gloves are an amenity not readily available to horse owners/carers. To the author's knowledge, there is no data comparing the risk of inoculating the wound bed and/or patient with bacteria following the donning of non-sterile gloves after hand preparation compared with the donning of sterile gloves after hand preparation for equine vets/horse owners. Recommendations from human medicine state hand hygiene before donning gloves is essential, as gloves can develop micro-perforations or become compromised during procedures,

potentially allowing bacterial transmission to the surgical site. The World Health Organization (WHO) emphasizes that surgical hand preparation should be conducted using either antimicrobial soap and water or an alcohol-based hand rub before donning sterile gloves. This practice is crucial in minimising the risk of surgical site infections (SSIs) (WHO, 2016).

Despite the well-established importance of hand antisepsis, there is a lack of studies directly comparing SSI rates with and without hand preparation prior to donning gloves. This gap in research underscores the need for further studies to evaluate the direct impact of hand preparation on SSI rates. In the absence of such studies, current guidelines continue to recommend thorough hand antisepsis before gloving as a standard practice to reduce infection risks (Sapijaszko, Samadi & Chow, 2024). Further research is required to ascertain how both veterinary practitioners and horse owners/carers can best prepare their hands prior to wound treatment in field conditions.

2.2 Wound preparation

Wound preparation consists of hair removal and skin cleaning. Methods of hair removal include chemical depilation, shaving and clipping. Chemical depilation is rarely used in veterinary practice and is contra-indicated in open wounds. Both clipping and shaving can cause microtrauma to the skin (Hague et al., 1997; Adams et al., 2010; Sapijaszko, Samadi and Chow, 2024). While human studies suggest that clipping may reduce the incidence of surgical site infections (SSI), the directly applicability of this finding to equine wound management remains uncertain. Unlike human surgical sites, equine wounds are often exposed to environmental contaminants, which may influence infection rates despite hair removal. Further research is required to determine whether clipping offers a significant benefit in equine practice. In addition to this, clipping is the least traumatic hair removal method and therefore decreases contamination of the skin with opportunistic pathogens (Barwell-Clarke et al., 1979). To prevent contamination of open wounds with hair clippings and dander, a sterile, water-based lubricating gel should be applied to the wound prior to clipping. To avoid cross-contamination, the clipper head should be disinfected between patients (Dart et al, 2017).

The evidence is sparse as it pertains to hair removal and the incidence of infection in equine patients, especially in cases of traumatic wounds. It has however been shown that aseptic preparation for arthrocentesis of the carpal and distal interphalangeal joints can be achieved without hair removal (Hague et al., 1997; Adams et al., 2010). Despite this, a wide margin of hair is most commonly removed from the wound periphery (Dart et al, 2017; Tanner, Norrie and Melen, 2011; Hague et al., 1997). This is important as the wound preparation is only the first step towards the assessment of the wound and clipping is important to make further diagnostic procedures possible, such as ultrasonography.

Following clipping but prior to irrigation or debridement, the skin surrounding the wound is aseptically prepared. The skin at the periphery of the wound is cleaned with an antiseptic solution and rinsed with 70% isopropyl alcohol or isotonic saline (Zubrod, Farnsworth and Oaks, 2004). Commonly used antiseptic solutions include povidone iodine (PI) and chlorhexidine (CH). PI and CH are reported to have a broad spectrum of antimicrobial activity, which includes activity against bacteria, fungi, viruses, yeast, and protozoa. The standard 5-minute mechanical scrubbing preparation of skin prior to aseptic surgery using 4% CH gluconate detergent has been superseded by scrubbing the surgical site using a back-and-forth motion for less than 15 seconds and leaving the CH in contact with the skin for the remaining 225 seconds (Davids et al., 2015). The standard 5-minute mechanical scrubbing preparation of skin prior to aseptic surgery using 4% CH gluconate detergent has been superseded by a technique involving a back-and-forth scrubbing motion for less than 15 seconds, followed by leaving the CH in contact with the skin for the remaining 225 seconds (Davids et al., 2015). Although no study has directly quantified the reduction in mechanical trauma with this 15-second technique, the inference that a shorter, less vigorous scrubbing minimizes trauma is supported by broader literature. Prolonged mechanical friction has been shown to disrupt the stratum corneum and compromise skin barrier integrity, with research indicating that excessive mechanical stress can lead to irritation and micro-abrasions (Lin and Chen, 2008; Schauber and Gallo, 2008). Furthermore, clinical guidelines in surgical site preparation generally recommend minimizing mechanical trauma to preserve skin integrity (Rutala and Weber, 2004; Sapijaszko, Samadi, and Chow, 2024), lending support to the concept that

reducing the duration and intensity of scrubbing may lower the risk of skin damage. Studies have shown PI to be effective in preparing the skin for aseptic surgery following a 10-minute scrub, a 5-minute scrub or three 30-second scrubs (Zubrod, Farnsworth and Oaks, 2004). Following the application of surgical detergents, sterile 0.9% saline or 70% isopropyl alcohol are frequently used to rinse the skin. One study suggests that the residual antimicrobial activity of CH is decreased by 70% isopropyl alcohol rinsing (Zimmerman, 1990). However, increases in SSI rates were not shown using this combined technique. Despite this, Dart et al, 2017 advocates using sterile isotonic saline to rinse the skin after use of 4% CH gluconate detergent. On the contrary, 70% isopropyl alcohol is appropriate when using PI as a surgical detergent, as it potentiates the activity of PI by increasing the release of free iodine (McDonnell and Russell, 1999). In summary, human literature has found PI and CH to both be effective surgical detergents, suggesting the same would be applicable for animals. Some caution should be adopted when deducing best practices for equine patients from human data due to the differences in bacterial skin fauna and cleanliness of the skin prior to preparation.

2.3 Wound lavage/irrigation

Wound lavage/irrigation is a vital element of managing wounds in horses. The aim of lavage is to remove devitalised tissue, bacteria and contaminants which are adherent to the wound bed. Irrigation has shown to be less effective in more chronically contaminated wounds. In these cases, a combination of lavage and debridement is required (Theoret and Schumacher, 2017). A study conducted in America, using a goat musculoskeletal wound model observed a negative correlation between the time since wounding and the time of irrigation on the effectiveness of reducing bacterial CFUs. The wound was inoculated with *Pseudomonas aeruginosa* and irrigated at 3, 6 and 12 hours after wounding, which resulted in 70%, 52% and 37% decrease in bacterial counts respectively (Owens and Wenke, 2007). Unfortunately, in practice it is not uncommon for there to be a significant delay (> 3 hours) between the incident which resulted in a wound and irrigation. Irrespective of timing, volume, solution, and method of delivery are three factors which influence the efficacy of lavage (Theoret and

Schumacher, 2017). Method of delivery and volume will be discussed throughout this section and solution used for irrigation will be included in the following section.

The relationship between volume of fluid used to lavage and the cleanliness of the wound is not exponential, with the optimum volume of solution to lavage being unknown (Anglen, 2001). As a rule, larger and/or more contaminated wounds require a greater volume of fluid than smaller and/or less contaminated wounds. In a randomised controlled trial conducted by Mak et al (2015), which compared swabbing and pressurised irrigation, pressurised irrigation cleansed wounds more effectively, decreased time required for wound healing and consequently decreased the financial implications of the wound (Mak et al., 2015). Dart et al. (2017) suggested that at a minimum, irrigation should remove gross contaminants from the wound and irrigation should be stopped prior to maceration of the tissue.

Optimal irrigation pressures to remove contamination for both humans and equine wounds has yet to be established (Chatterjee, 2005). Dart et al. (2017) reported that pressures of 8-15 psi are sufficient to remove contaminants, without causing damage to the wound bed. Higher irrigation pressures are more effective at removing foreign materials and necrotic tissues, but are not commonly used due to their negative impacts on wound healing. High pressures cause damage to granulation tissue and drive contaminants deeper into the wound bed and surrounding tissues including cancellous bone (Boyd and Wongworawat, 2004; Hassinger, Harding and Wongworawat, 2005; Kalteis et al., 2005). Wounds with severe contamination would benefit from a combination of irrigation and debridement rather than higher pressure irrigation (Chatterjee, 2005). Optimum irrigation pressures can be achieved in practice by using a 30 or 60 ml syringe and a 18 or 19 gauge needle. This method generates pressure of 11-31 psi, however the pressure with which the irrigation solution is delivered to the wound can be as low as 8 psi (Singer et al., 1994). Battery powered irrigation devices are available which can deliver solutions at pressure up to 70 psi (Equine Hydro-T; Stryker Interpulse System). These products also have settings which allow delivery of solutions at more suitable lower pressures.

2.4 Wound cleaning/antiseptics

Ideal properties of an irrigation solution include sterile, normothermic, non-toxic, isotonic, hypoallergenic, and compatible with additives (antiseptics or antibiotics). Antiseptic additives are preferred to antibiotic additives because of the ever-increasing concern regarding antimicrobial resistance and the development of multi-resistant strains of organisms. Commonly used irrigation solutions include sterile isotonic saline, sterile lactated Ringer's solution, potable tap water and solutions containing additives. In cases of wounds which require large volumes of irrigation solution and/or repeated sessions of irrigation, sterile solutions can be very costly (Dart et al, 2017). A systematic review and evidence review conducted in human and equine patients respectively, found potable tap water to be as effective at cleaning both acute and chronic wounds as sterile isotonic solutions, with no increase in healing time or risk of infection being reported following use of potable tap water (Fernandez and Griffiths, 2012; Freeman et al., 2020). In instances where potable tap water is not available, the use of boiled and cooled tap water should be considered. However, while potable tap water has been shown to be effective for wound irrigation and does not appear to increase infection risk compared to sterile isotonic solutions, its hypotonic nature may pose additional considerations. Tap water has a lower osmolality than bodily fluids, making it hypotonic, which can lead to osmotic shifts and potential tissue swelling when used in large volumes or for prolonged irrigation (Dart et al., 2017). This is particularly relevant in delicate tissues or wounds with significant exposed subcutaneous structures, where excessive swelling may contribute to delayed healing or secondary complications (Freeman et al., 2020). While the cost-effectiveness and accessibility of tap water make it a practical choice, clinicians should be aware of its potential effects and consider isotonic solutions, such as sterile saline or lactated Ringer's solution, in cases where tissue oedema could be detrimental to healing. The solutions detailed above are suitable for antisepsis of fresh wounds, unfortunately in equine practice a large proportion of wounds presented to veterinary practitioners are heavily contaminated and not fresh. For such wounds or for those wounds where a biofilm is suspected or signs of infection are present, lavage with an irrigation solution which contains

an additive may be indicated to decrease the bacterial load (Dart et al, 2017). The use of irrigation solutions containing antiseptics is somewhat a controversial topic due to the lack of evidence-based guidelines for their use. Despite the benefit of decreasing the bacterial inoculum concentration within the wound bed, *in vitro* studies have reported antiseptics to have negative effects on wound healing including, fibroblast leucocyte and keratinocyte toxicity, interference with collagen synthesis, inhibited microcirculation and disruption to epithelial cell migration (Brennan and Leaper, 1985; Lineaweaver et al., 1985; Teepe et al., 1993). The most frequently used antiseptics added to irrigation solutions are PI and CH gluconate. Anti-microbial activity is reported for both CH gluconate and PI at low concentrations, with a positive correlation between concentration of antiseptic solution and cellular cytotoxicity existing.

Iodine compounds have antimicrobial activity against Gram-positive and Gram-negative organisms, Protozoa, Fungi and Viruses, there is currently no known resistance to iodine. However, iodine is inactivated by organic matter including serum and blood proteins. Due to issues surrounding tissue toxicity and skin irritation and inflammation, molecular iodine is not used as an antiseptic, instead iodine carriers, known as iodophors are used. Iodophors slowly release free iodine which mitigates the problems regarding inactivity and toxicity. Povidone iodine (PI) and cadexomer (modified starch) iodine (CI) are the two iodophor formulations available. Data on the use of PI in wound management is varied. In vitro studies have shown PI to have the negative effects on wound healing mentioned previously, however there is no data to indicate treatment with PI delays healing of infected wounds *in vivo* (Angel et al, 2008). In addition to decreasing bacterial load within the wound bed, a study found wounds healed faster when treated with a 10% PI ointment compared to wounds treated with silver sulfadiazine cream (Berry II and Sullins, 2003). This finding was not statistically significant and therefore raises the question as to whether wound healing for wounds treated with PI was only quicker in this instance as this study measured the rate of wound healing using two treatments which have known cytotoxic effects. The most frequently used PI product is 10% Betadine solution. Diluting 10-20ml Betadine with 980-990ml of water creates a 0.1-0.2% solution. At this dilution cytotoxicity is

decreased and the availability of free iodine is increased (Dart et al., 2017). Studies surrounding the use of CI products are overwhelmingly positive. Human studies have shown CI to have improved wound healing when compared to other wound treatments including saline dressings, wet-to-dry gauze dressings, hydrocolloid dressings and non-adherent dressings (Miller et al., 2010). *In vivo* and *in vitro* studies have shown faster rates of wound healing with CI treatment as a result of directly stimulating epithelisation and epidermal regeneration and decreasing bacterial load (Lamme, Gustafsson and Middelkoop, 1998; Fitzgerald et al., 2016).

CH is another commonly used antiseptic. CH has activity against Gram-positive and Gram-negative organisms, facultative anaerobes, aerobes, yeasts, fungi, and some viruses. Reported resistance to CH include the genus *Proteus* and *Pseudomonas aeruginosa (*Russell, 1999*).* CH is almost insoluble in water; however, CH salts are soluble in water and therefore able to be used as an antiseptic solution. The most frequently used CH salt is CH gluconate. The most frequently used CH salt is CH gluconate, which is commonly available in concentrations ranging from 0.05% to 4%, with 0.05%–0.2% solutions typically used for wound irrigation and higher concentrations (2%–4%) used for preoperative skin preparation and hand antisepsis (Karpanen et al., 2008). Advantages of CH over PI include its ability to adhere to proteins within the *stratum corneum* which accounts for its prolonged residual effect and activity of CH is not impeded by the presence of organic matter including serum and blood proteins and purulent discharge. The current evidence available on the effects of CH on wound healing is variable. In vitro studies have found CH to have negative effects on cells, which includes toxicity to new keratinocytes and suppression of macrophages (Bonacorsi, Raddi and Carlos, 2004; Fraser et al., 2004). These effects have negative consequences on wound healing. *In vivo* studies conducted in guinea pigs and beagles found CH to have inhibitory and acceleratory effects on wound healing, respectively (Saatman et al., 1986; Sanchez et al., 1988). The enhanced healing observed in the beagle study could be attributed to the use of CH diacetate instead of CH gluconate. CH diacetate has been reported to have better tissue penetration due to its increased lipophilicity, potentially leading to improved antimicrobial efficacy and reduced cytotoxicity compared to CH gluconate (James et al.,

1991). The reduced cytotoxic effects could allow for better preservation of keratinocyte and fibroblast function, thereby promoting wound repair (Sakata et al., 2013). Further comparative studies are required to determine the relative impact of CH salts on wound healing and their potential clinical applications.

The next step in wound preparation is normally debridement. This can be surgical, mechanical (e.g. hydrosurgery or debridement pads), chemical (e.g. Dakins solution), or biological (e.g. sterile maggots) (Freeman et al., 2020). The evidence around this is not reviewed further here, as the focus of this research was developing recommendations for horse owners, and debridement is primarily done by veterinary teams or under veterinary guidance.

2.5 Topical treatments

There are a vast number of topical wound treatments available to both veterinary practitioners and horse carers/owners. The decision of selecting which topical wound treatment to apply to different wounds and at different stages of wound healing can be a treacherous one due to the lack of clear evidence on the efficacy and appropriate use of products available. Below is the current evidence on the most used topical wound treatments.

Silver sulfadiazine

Silver sulfadiazine contains silver and the antibiotic sulfadiazine. Silver has activity against Gram-positive and Gram-negative bacteria, including many antibiotic-resistant bacteria, for example *Staphylococcus aureus*, methicillin-resistant *Staphylococcus aureus* (MRSA), *Enterococcus faecalis*, vancomycin-resistant *enterococci*, *Pseudomonas aeruginosa*, and *Escherichia coli* (Parsons et al. 2005; Ip, 2006). Resistance to silver and products containing silver and an antibiotic, such as silver sulfadiazine is rare. Studies in both human and equine medicine, found low levels of silver resistance genes present in pathogens isolated from wounds and in addition, those pathogens containing the genes were still susceptible to the antimicrobial activity of silver (Loh et al., 2009; Woods et al., 2009).

Studies conducted in horses found that there was no difference in the rate of wound healing when compared to other wound treatments, including PI (Berry II and Sullins, 2003; Harmon et al., 2017; Khafaga et al., 2018). One study in humans found that silver has cytotoxic potential and therefore has negative implications on wound healing (Storm-Versloot et al., 2010). Freeman et al., 2020 suggest that silver sulfadiazine may not be suitable for use in acute wounds and that despite decreasing bacterial load, more research is required to determine the appropriateness of its use in chronic or infected wounds.

Fusidic Acid

Fusidic acid is a narrow spectrum bacteriostatic antibiotic with specific efficacy against *Streptococcus spp.* and *Staphylococcus spp.* Fusidic acid is combined with betamethasone as a cream. The combination of fusidic acid and betamethasone and their resultant anti-inflammatory and antimicrobial actions are more effective at resolving atopic dermatitis than either drug alone (Dart et al., 2017). Despite being advocated for the treatment of wounds and skin of animals infected with *Staphylococcus spp* (Werner and Russell, 1999), a study by Gurel et al. (2014), investigating the rate of healing of full thickness wounds in rats found topical fusidic acid to delay fibroblast proliferation and subsequently prolong wound healing. The evidence regarding fusidic acid is inconsistent, and further research is required to determine of its suitability for use in horses.

Corticosteroids

I*n vivo* and *in vitro* studies on corticosteroids in humans and horses have identified a number of delayed healing effects, such as prolonged neovascularisation and formation of granulation tissue, increased scab formation, immature fibrosis, suppression of angiogenesis, inhibition of epithelialisation, retardation of wound contraction, decreased synthesis of collagen, and decreased wound tensile strength (Blackford, Blackford and Adair, 1991; Miller et al., 2000; Kaufman et al., 2014). These negative effects are likely associated with the immunosuppressive nature of corticosteroids. A

20 horse case series conducted by Bello (2002) reported the use of an antibiotic-steroid cream containing neomycin and triamcinolone to be the most effective wound treatment for the control of excessive granulation tissue, this finding is supported by Barber (1989) and Blackford et al. (1991). In humans, topical application of corticosteroids is recommended for chronic, non-healing wounds which have remained in the inflammatory phase (Bosanquet et al., 2013). Further information on excessive granulation tissue can be found in Section 4. For wounds with excessive granulation tissue present or wounds which require control of excessive inflammation, Dart et al., (2017) recommended the use of topical triamcinolone. This publication stated that treatment with corticosteroids should be alternated between antimicrobial dressings. Neither dressing should be applied for more than four consecutive days (Dart et al., 2017). The current evidence on the use of topical corticosteroid application in equine wounds is for the most part anecdotal.

Honey

Honey's antimicrobial effects are attributed to its low pH and hyperosmolarity, which generates a moist wound bed and aids debridement. In addition, gluconic acid and hydrogen peroxide are mild antimicrobial products, generated by the oxidation of glucose, a reaction catalysed by glucose oxidase which is found in honey (Mueller et al., 2012). Other positive effects of honey include anti-inflammatory effects, source of nutrients for cellular metabolism, promotes fibroplasia and epithelisation, and decreases oedema. There is often discussion over the best 'type' of honey to use. Manuka honey contains methylglyoxal, another antimicrobial factor in addition to those mentioned previously and therefore historically it has been believed that manuka honey is a more effective wound treatment than other 'types' of honey. A study measuring the rate of healing in equine limb wounds, found the rate of healing in those treated with manuka honey to be increased when compared to controls (Bischofberger et al., 2012). However, in a recent study, which measured the growth of bacteria from equine wounds, found other 'types' of honey to be equally effective, if not more effective at decreasing bacterial load than manuka honey (Carnwath et al., 2014). It is important

to note that any type of honey applied to wounds should be sterile, as non-sterile honey can contain *Clostridium botulinum* spores, aerobic bacteria and/or fungi (Dart et al., 2017). Freeman et al., (2020) concluded that manuka honey increases the rate of wound healing up to 21 days after injury.

Gentian violet

Gentian violet, also known as crystal violet, is a triarylmethane dye primarily used as a histologic stain. Gentian violet is reported to have anthelmintic, antibacterial, and antifungal activity, including efficacy against methicillin-resistant *Staphylococcus aureus* (Saji et al., 1995; Okano et al., 2000; Dart et al., 2017). To date, the evidence surrounding the use of gentian violet for the management of wounds in both human and animal medicine is unclear. A retrospective study investigating the use of 1% gentian violet solution for the treatment of wounds in geriatric human patients found 93% of wounds from 70 patients healed, with no adverse reactions reported (Farid, Kelly and Roshin, 2011). Adverse effects of gentian violet include tissue irritation, inhibition of granulation tissue and carcinogenic activity (Mobacken and Zederfeldt, 1973; Ryan, 1990). The formulation of gentian violet typically used by horse owners/carers is a spray, colloquially referred to as 'purple spray'. Unfortunately, numerous products advertised as 'purple spray' do not contain gentian violet, with many just containing a purple dye and alcohol (https://hyperdrug.co.uk/purple-spray-500ml/?gclid=Cj0KCQiAmaibBhCAARIsAKUlaKT6A14Ry5pGUqiPpiHmAIMVU6sY9PcEEiG0S0qbK-0GLlhbR7IHX8waAh3YEALw_wcB). More recently, dressings impregnated with a combination of gentian violet and methylene blue have been investigated. A case series evaluated the response of application of a foam dressing impregnated with gentian violet and methylene blue to chronic lower extremity wounds of 15 human patients. Results showed decreased wound bioburden for all wounds and decreased wound size for 57% of wounds treated. Given the clinically challenging population selected for inclusion, the findings of this study are promising, and support the use of gentian violet and methylene blue dressings in the treatment of chronic wounds in humans (Coutts, Ryan and Sibbald, 2014). Outcome measures for this study included bacterial burden, wound size and pain, but

there was no mention of wound resolution/healing. Further studies comparing these dressings to controls and their effect on the rate of healing are required. These findings have been replicated in a larger case series of 29 human patients conducted by Woo and Heil (2017), with the addition of reporting that the gentian violet and methylene blue dressings were responsible for removal of devitalised tissue. In a randomised experimental study, full thickness wounds were created to the dorsoproximal aspect of both metacarpus of five horses. The results found wounds treated with gentian violet and methylene blue dressings to have significantly decreased wound area and decreased granulation tissue scores when compared to controls, however the complete wound healing times were not significantly different (Kelleher et al., 2014). Further studies are required to determine the cellular effects of this dressing along with its efficacy in a clinical environment.

Wound Powder

Wound powders are commonly used to promote wound healing by absorbing exudate, preventing infection, and providing a protective barrier. Some formulations, such as Wound Powder, contain a hydrophilic polymer and potassium ferrate, which rapidly form a protective scab to stop bleeding (WoundSeal, 2024). While generally considered safe, some studies suggest that ferrate compounds may induce oxidative stress, which could contribute to localised inflammation (Gupta et al., 2019). However, clinical data evaluating the inflammatory response specific to wound powders remain limited. Further research is needed to determine their long-term effects on wound healing, particularly in chronic wounds.

Sudocrem Antiseptic Healing Cream

Sudocrem is a zinc oxide-based antiseptic cream widely used for minor wounds, burns, eczema, and pressure sores. Zinc oxide has well-documented anti-inflammatory and antimicrobial properties (Moore et al., 2006), and its use in wound healing is supported by studies demonstrating its ability to reduce bacterial colonization and modulate inflammation (Lin et al., 2018). However, some evidence

suggests that prolonged application may lead to delayed epithelialization and excessive dryness (Bibi et al., 2017). Other key ingredients in Sudocrem, such as benzyl alcohol and benzyl cinnamate, possess mild anesthetic and antimicrobial properties but may cause hypersensitivity reactions in susceptible individuals (Medicines.org.uk, 2023). Although widely used, further comparative studies are required to assess its effectiveness against other wound care treatments.

Savlon Antiseptic Cream

Savlon is a topical antiseptic cream that contains cetrimide and chlorhexidine, both of which have broad-spectrum antimicrobial activity (Savlon, 2024). Cetrimide is a quaternary ammonium compound that disrupts bacterial cell membranes, while chlorhexidine is known for its persistent antibacterial effects (Russell, 2002). Studies indicate that chlorhexidine can inhibit fibroblast proliferation, which could impair wound healing if used excessively (Denton, 2020). Additionally, some individuals may develop contact dermatitis due to prolonged exposure (Adams et al., 2019). While Savlon is effective in preventing wound infections, careful application is advised to avoid potential cytotoxic effects in healing tissues.

Hydrogels

Hydrogels, when applied directly to wounds in gel or cream form, serve as a hydrating and protective barrier that promotes a moist wound environment essential for cell migration and tissue regeneration (Zhao et al., 2024). This hydration effect is particularly beneficial for dry wounds, burns, and superficial abrasions, where moisture retention accelerates healing and reduces discomfort. Additionally, topical hydrogels have been shown to exhibit anti-inflammatory and antimicrobial properties when infused with bioactive compounds such as silver nanoparticles, growth factors, or herbal extracts (Chen et al., 2023). However, their effectiveness depends on frequent reapplication, as they are more prone to evaporation and contamination compared to structured hydrogel dressings (Zhou et al., 2024). Despite these limitations, topical hydrogels remain a valuable option for managing minor wounds,

burns, and post-surgical incisions, particularly in cases where maintaining a moist environment is crucial for optimal healing.

Hydrogen Peroxide

Hydrogen peroxide has historically been used as an antiseptic in wound care due to its oxidative and effervescent properties, which were believed to aid in debridement and microbial control. However, its use is now discouraged in both human and veterinary medicine owing to its cytotoxic effects on healthy granulation tissue and its potential to delay wound healing (Cooper et al., 2002; Lozano et al., 2018). Studies have shown that hydrogen peroxide can damage fibroblasts and keratinocytes, making it unsuitable for routine use in managing equine wounds. As such, current best practice guidelines recommend against its use in favour of isotonic lavage solutions and evidence-based topical therapies (Swaim and Henderson, 1990; Theoret and Wilmink, 2013).

2.6 Bandaging

Despite both equine vets and nurses applying bandages daily, most of the information in the literature is based on author's clinical experience and that found in textbooks, with very few objective recommendations being made (Rippingale, 2016; Canada et al., 2018).

Eleven factors are reported to inhibit optimal wound healing. These are infection, foreign bodies, movement, necrotic tissue, poor blood supply, poor oxygenation, continued trauma, poor nutrition, poor health status, cell transformation (e.g. sarcoid formation) and genetic factors (Knottenbelt, 2003).

The four main roles of a bandage are to provide support, protection, pressure, and immobilisation. A correctly applied bandage should stop haemorrhage, reduce pain and swelling, prevent infection or contamination, and restrict movement of joints and soft tissues (Aspinall, 2011). Poorly applied bandages can delay wound healing by reducing blood supply and oxygenation if applied too tightly, while too loose an application will fail to provide adequate support, immobilisation, counterpressure

and wound coverage. Both types of incorrect application increase the risk for pressure sores, skin necrosis and infection rates (Rippingale, 2016).

Bandages consist of three layers: a primary layer, a secondary layer, and a tertiary layer. The primary layer comprises of a wound dressing (Rippingale, 2016). The aim of the wound dressing is to create a moist and warm environment to aid wound healing (Packer and Devaney, 2010). The type of wound dressing used will vary depending on specific and individual wound factors. Table 1 outlines common wound dressing, their properties, and typical applications (Packer and Devaney, 2010; Theoret and Schumacher, 2017). The purpose of the secondary layer is to maintain the wound dressing in place, help to prevent movement of the structure being bandaged and to absorb discharge. Materials used within the secondary layer typically consist of soft orthopaedic padding e.g., Soffban$^{(R)}$ (BSN Medical Ltd), followed by cotton wool. A conforming bandage e.g., Knitfirm (Millpledge Ltd) is then applied to hold the padding materials in place. It is important to ensure that the conforming material is not applied directly to the skin (Rippingale, 2016). The tertiary layer is a protective layer. Most used products are self-adhesive conforming bandages e.g., Co-plus (BSN Medical Ltd) and Tenoplast (BSN Medical Ltd). Advantages of Tenoplast (BSN Medical Ltd) when compared to Co-plus (BSN Medical Ltd) include being more difficult to overstretch and subsequently to apply too tightly and the ability to be applied directly to the skin, preventing contaminants entering via the top or bottom of the bandage (Rippingale, 2016).

Complications of incorrect bandaging application include bandage injury or bandage sores. Bandage injuries are classified into two groups: primary ischaemic injuries and secondary ischaemic injuries. Primary injuries occur whilst the bandage is in place. High sub-bandage pressures result in a disruption to or decreased blood flow, which in turn causes pressure necrosis. Secondary injuries occur in the 24–48-hour period after bandage removal due to a reperfusion injury. In these instances, bandage application has interrupted blood flow/caused a period of ischaemia. Following bandage removal, the return of adequate blood flow initiates an inflammatory reaction which consequently damages the

skin (Bennett, 2017). Methods to reduce the incidence of bandage sores includes applying extra materials to the secondary layer, using bandage materials with a width greater than 15cm, ensuring each layer of the bandage overlaps by 50%, and applying 'doughnuts' made from orthopaedic padding (Soffban(R),BSN Medical Ltd) to bony prominences e.g., accessory carpal bone (Rippingale, 2016). It is important to note that inappropriate application is not the only cause of bandage injury, owner compliance with bandage care is paramount, and the horse frequently needs to be on box rest to ensure it moves as little as possible.

Table 1: Common wound dressings (primary bandage layer), their properties, and applications.

Type of Dressing	Properties	Applications
Hydrogel	Donates moisture to the wound bed, maintains a moist wound, and promotes autolytic debridement	Used for clean wounds during the inflammatory phase. Used for necrotic or dry wounds
Foam	Large absorptive capacity which allows removal of excessive exudate. Maintains a moist wound bed whilst preventing maceration	Used for wounds producing large volumes of exudate, typically those wounds in the later proliferation phase which have filled with granulation tissue and require epithelialisation and contraction
Silver	Antimicrobial effects against a wide variety of bacteria	Used for infected wounds
Hydrofibre	Dressing composed of woven Carboxymethylcellulose which turns into a gel substance after absorbing exudate from the wound bed. These dressings provide a moist environment and aid debridement as well as trapping wound fluid including bacteria within the dressing	Used for wounds in the inflammatory phase which require coverage of granulation tissue. Used for necrotic wounds which require debridement and wounds which produce a moderate amount of exudate
Hydrocolloid	Absorption of wound exudate creates a gel substance which maintains a moist wound bed and aids debridement	Used for wounds in the inflammatory and proliferative phase to promote the formation of healthy granulation tissue. Used for wounds that require debridement

Alginates	Dressings with a large absorptive capacity, result in a moist wound bed. Promotes haemostasis, inflammation via activation of mast cells and macrophages, debridement, and formation of granulation tissue via the release of Calcium ions	Used for wounds in the inflammatory and proliferative phases which require coverage of granulation tissue. Used for wounds producing large volumes of exudate. NOTE: Alginates should not be used on wounds with minimal exudate
Gauze/gauze-like	Large absorptive capacity which wicks exudate into the secondary layer of the bandage	Used for necrotic wounds which require debridement (wet-to-dry dressings). Used to cover surgical wounds (dry dressings)
Silicone gel	Prevents/decreases the formation of excessive granulation tissue. Mechanism of action is unknown but suspected to be due to occlusion of micro-vessels and modulation of fibroblast apoptosis	Used for wounds which have excessive granulation tissue or are at risk of developing excessive granulation tissue

3.0 Wound Healing

3.1 Types of wound healing

Wound healing is a dynamic and multifaceted process that varies depending on the type, location, and severity of the wound. In both human and veterinary medicine, wounds heal through one of four primary mechanisms: primary intention healing, delayed primary intention healing, skin grafting, and second intention healing. Understanding these different types of healing is essential for veterinarians and horse owners to implement appropriate wound management strategies and optimize outcomes (Dart et al., 2017).

Primary Intention Healing

Primary intention healing occurs when a wound has minimal tissue loss and its edges can be surgically approximated using sutures, staples, or adhesive strips. This method is commonly used for clean, incised wounds such as surgical incisions or fresh lacerations with little contamination (Steel, 2020). Due to the direct closure of the wound, healing is typically rapid, with minimal scar formation and reduced risk of infection (Wilmink and van Weeren, 2005). However, in horses, particularly for wounds

on the distal limbs, primary closure is often complicated by excessive motion, persistent inflammation, and dehiscence (Theoret and Wilmink, 2013).

Delayed Primary Intention Healing

Delayed primary intention healing, or tertiary healing, is employed when wounds are contaminated or at high risk of infection, necessitating a brief period of open wound management before surgical closure is attempted. This technique is commonly used for traumatic wounds with bacterial contamination, tissue necrosis, or involvement of synovial structures (van den Boom and Wilmink, 2016). By allowing time for initial decontamination and the formation of granulation tissue, delayed closure reduces the likelihood of infection while still benefiting from the advantages of primary intention healing (Leaper and Harding, 2014).

Skin Grafting

Skin grafting is a surgical technique used when extensive tissue loss prevents direct closure or sufficient contraction for secondary healing. In equine medicine, grafting is often indicated for large, full-thickness wounds, particularly on the distal limbs where second intention healing is slow and prone to complications (McCauley et al., 2019). Unlike in human medicine, where skin grafting is well-established for burns and chronic wounds (Orgill and Ogawa, 2014), the success of skin grafts in horses is more variable due to increased movement, infection risk, and difficulties in maintaining a moist wound environment (Wilmink et al., 2005).

Second Intention Healing

Second intention healing occurs when a wound is left to heal without surgical closure, relying on granulation tissue formation, epithelialization, and wound contraction to restore tissue integrity (Finnie, 2006). In horses, this method is the most commonly used for distal limb wounds, as these areas often experience high tension and poor vascularization, making primary closure difficult

(Theoret, 2009). While second intention healing is effective, it is often associated with prolonged inflammation, excessive granulation tissue formation (proud flesh), and delayed epithelial migration, necessitating careful management to optimize healing outcomes (Wilmink and van Weeren, 2005).

By understanding the different types of wound healing, veterinarians and caregivers can make informed decisions regarding wound management, ensuring appropriate intervention strategies are implemented for optimal recovery (Dart et al., 2017).

3.2 Stages of second intention wound healing

Second intention wound healing is divided into four major stages: haemostasis, inflammation, proliferation, and remodelling. Although the assignment of distinct stages suggests simplicity, the process of wound healing is far more complex (Wulff and Wilgus, 2013). For both veterinarians and horse owners/carers to aid wound healing, the mechanisms involved need to be fully understood (Dart et al., 2017). The skin consists of two compartments: the dermis and the epidermis. epidermis consists of five discrete layers of keratinocytes: *stratum corneum, stratum lucidum, stratum granulosum, stratum spinosum and stratum basale.* The dermis is composed of two areas, the reticular dermis, and the papillary dermis. Fibroblasts are the most common cell found in the dermis, with mast cells and macrophages also being present. The dermis occupies most of the skin thickness and consists of dense, fibroelastic connective tissue. The tensile strength of the skin is attributed to the complex network of collagen fibres present within the dermis (McLafferty, Hendry and Farley, 2012). Additional components within the dermis include nerves, epithelial glands, skin appendages and a microvascular and lymphatic system.

3.3 Haemostasis

Only recently has haemostasis been recognised as a phase of wound healing, it was subsequently considered a component of the inflammatory phase. This preliminary phase of wound healing occurs immediately after injury and is completed within a couple of hours. Despite the transient nature of haemostasis, the events which occur are fundamental to the following phases (Dart et al., 2017). Injury

to the skin causes damage to blood vessel linings, resulting in haemorrhage. Disruption of the endothelial cell membrane causes the release of phospholipids which are metabolised. These metabolites initiate peripheral vasoconstriction for approximately 5-10 mins. In addition to decreasing bleeding, vasoconstriction results in hypoxia and increased glycolysis in the surrounding tissues. These local changes initiate the intrinsic pathway of coagulation by heightening the activation, adhesion, and aggregation of platelets. The outcome of this cascade of events is the formation of a clot (de Groot and Sixma, 1993). Along with the cessation of haemorrhage, the clot not only occupies the space formed by the wound, but it also provides a matrix packed full of fibrin, fibronectin, vitronectin and thrombospondin which forms a scaffold helping the migration of cells into the wound. The migration of cells is mediated by the release of chemoattractants by platelets (Herter, Rossaint and Zarbock, 2014). Following a period of vasoconstriction, mediators released from both mast cells and platelets results in decreased vascular tone and increased vascular permeability, enabling cellular migration and the delivery of oxygen and nutrients required following cellular influx. Desiccation of the clot results in the formation of a scab which is slowly lysed and sloughs as the wound healing progresses underneath.

3.4 Inflammatory phase

The inflammatory phase of wound healing is broadly separated into two sections: the early phase, which is defined by the recruitment of neutrophils and the late phase, which is defined by the infiltration and transformation of monocytes. The magnitude of the inflammatory response correlates to the extent of the injury. The process of inflammation is regulated by the release of various mediators and chemo-attractants. The inflammatory phase is first stimulated during haemostasis by the aforementioned chemicals released by platelets, mast cells, injured or activated stromal cells and the coagulation pathway (Singer and Clark, 1999; Wulff and Wilgus, 2013). This first stage of inflammation results in diapedesis of neutrophils from the circulating blood to the site of injury. The migration of inflammatory cells through the endothelium is assisted by an increase in vascular

permeability which occurs in response to the release of vasoactive mediators from mast cells and platelets. Infiltration of inflammatory cells into the wound is rapid, with peak concentration occurring at 1-2 days post injury. Bacteria and debris present in the wound is phagocytosed by neutrophils and disposed of via enzymatic reactions or oxygen-radical mechanisms. The migration of neutrophils into the wound halts when contaminants have successfully been removed from the wound. Those cells which are not trapped within the clot and subsequently sloughed, are phagocytosed by modified wound fibroblasts or macrophages. The removal of neutrophils from the wound draws the early inflammatory phase to a close and marks the start of the late inflammatory phase (Singer and Clark, 1999). The late inflammatory phase is characterized by the infiltration of monocytes, which differentiate into macrophages upon entering the wound environment. These macrophages play a crucial role in orchestrating the transition from inflammation to tissue repair. They contribute to wound healing by phagocytosing apoptotic neutrophils, cellular debris, and pathogens, thereby ensuring a clean wound bed conducive to tissue regeneration (Wulff and Wilgus, 2013). In addition to their phagocytic function, macrophages release cytokines and growth factors such as transforming growth factor-beta (TGF-β) and vascular endothelial growth factor (VEGF), which stimulate angiogenesis and fibroblast proliferation. This shift in the wound microenvironment promotes the transition to the proliferative phase of healing, where new tissue formation begins (Singer and Clark, 1999). The polarization of macrophages into pro-inflammatory (M1) and pro-healing (M2) phenotypes is also a key feature of this phase, as excessive or prolonged inflammation can impair healing, while a timely shift to an anti-inflammatory state supports tissue repair (Dovi, He and DiPietro, 2003).

The action of neutrophils in infected wounds is imperative, without, healing would not progress into the proliferative phase. On the contrary, non-infected wounds have been shown to heal without the presence of neutrophils. Studies conducted on 197 guinea pigs and more recently on mice found that the absence of neutrophils within sterile wounds had no effect on tissue repair and increased the rate of healing, respectively (Simpson and Ross, 1972; Dovi, He and DiPietro, 2003).

Neutrophils are not the only cell to play a fundamental role in coordinating the events of wound healing, with macrophages influencing all stages of wound healing. The swift increase in concentration of macrophages present during the inflammatory phase is a result of the movement and differentiation of monocytes from the vasculature. Interestingly, the functional properties of macrophages are determined by the conditions of the environment. Roles of macrophages during the early inflammatory phase include antigen presentation, phagocytosis and production of growth factors and inflammatory cytokines. Like depletion studies conducted using neutrophils, it has been suggested that the absence of macrophages does not affect wound healing. Injured genetically modified mice, incapable of generating a normal inflammatory response because of the absence of macrophages, have been shown to heal adequately when compared to wild-type mice (D'Souza, Martin and Martin, 2003). However, the depletion of macrophages at different stages of wound healing have been shown to negatively influence repair. Changes seen due to macrophage depletion include failure of ECM degradation and reduced scarring (Duffield et al., 2005). Although this study investigated the effects of macrophages on liver injury, it is not unreasonable to assume that macrophages have similar effects on skin injury. Reduced scarring, while often viewed as a beneficial outcome in wound healing, can paradoxically impair the repair process by compromising the integrity and function of the newly formed tissue. Scar formation is a critical aspect of wound repair as it provides mechanical stability and tensile strength, particularly in larger or deeper wounds (Eming, Krieg and Davidson, 2007). Acute inflammation remains a vital component in the healing of non-sterile wounds. Problems arise when inflammation fails to subside, and a chronic inflammatory state occurs. The resultant pathologic wound repair is characterised by excessive fibrosis leading to the formation of a permanent fibrotic scar. The presence of such fibrosis decreases organ function and in the most extreme cases causes organ failure and death (Dart et al., 2017). Excessive granulation tissue is the most commonly encountered fibroproliferative disorder following full-thickness cutaneous injuries in the horse. For inflammation to subside, inflammatory cells are removed from the wound via programmed cellular death or apoptosis. This method of removal does not cause additional

inflammation (Greenhalgh, 1998). Incoordination at any given stage of this multi-step process can result in suppuration, chronic inflammation and/or excessive fibrosis.

3.5 Proliferative phase

The proliferation phase consists of three major components: fibroplasia, angiogenesis, and epithelisation, which correlate to the objectives of the proliferative phase- protection of the wound through the formation of granulation tissue, restoration of vascular channels, and establishment of an epithelial cover.

Fibroplasia

With the cessation of inflammation comes the initiation of proliferation. In the first 3-5 days after injury, fibroblasts, endothelial and epithelial cells are recruited into the deficit created by the injury, forming a matrix which then matures to form granulation tissue. Formation of the granulation tissue relies upon macrophages, fibroblasts, and the formation of new blood vessels to allow the delivery of oxygen and nutrients required for metabolism and growth of the granulation tissue.

Roles of macrophages during the proliferative phase of wound healing include debridement, stimulation of dermal, endothelial, and epithelial tissue to aid angiogenesis, epithelialisation and to finalise formation of the extracellular matrix (ECM) (Delavary et al., 2011; Novak and Koh, 2013). Fibroblasts are responsible for the synthesis of ECM components. Following a period of proliferation, fibroblasts alter their function to protein synthesis to create a protein-rich matrix, replacing the provisional one generated during the inflammatory phase. This advancement of the matrix is mirrored by the increase in type I (mature) collagen fibres and the decrease in type III (immature) collagen fibres. As expected during the early stages of wound healing, when cellular activity is high, wound strength is minimal. Wound tensile strength increases from day 7- 14 after injury. This increase in strength correlates to the accumulation of connective tissue. At this stage granulation tissue is vascular and contains numerous fibroblasts. Regression of wound capillaries, down-regulation of

fibroblast activity, apoptosis of fibroblasts or transformation of fibroblasts into myofibroblasts results in the construction of a cellular and avascular granulation tissue (Desmoulière et al., 1995). The events described above are controlled by stimuli which originated within the wound environment. If the conditions within the wound are not optimal, down-regulation of fibroblast activity is delayed, and the development of excessive granulation tissue (EGT) follows.

Angiogenesis

In addition to the roles played during the inflammatory phase, endothelial cells are heavily involved during the proliferative phase of wound healing. The creation of new blood vessels is necessary to deliver oxygen and nutrients to granulation tissue. Angiogenesis occurs in response to tissue hypoxia and is facilitated by growth factors (vascular endothelial growth factor (VEGF), platelet-derived growth factor (PDGF), fibroblast growth factor (FGF)- 2, and transforming growth factor (TGF) angiogenic enzymes (serine proteinase thrombine), chemokines, endothelial-specific receptors and adhesion molecules (integrins) (Liekens, De Clercq and Neyts, 2001; Pardali, Goumans and ten Dijke, 2010). Notably, these mediators are found in serum and the ECM and are released primarily during the inflammatory phase of wound healing. In addition to the correct cells and cytokines being required for angiogenesis, the production and the organisation of the ECM is also vital to allow the migration of endothelial cells. The production and organisation of the extracellular matrix (ECM) play a fundamental role in facilitating angiogenesis by providing both structural support and biochemical signals necessary for endothelial cell migration, proliferation, and capillary formation. During the early stages of angiogenesis, the ECM undergoes controlled degradation through the action of matrix metalloproteinases (MMPs), which cleave structural components such as collagen and fibronectin. This degradation not only creates physical space for endothelial cell sprouting but also releases ECM-bound growth factors, including vascular endothelial growth factor (VEGF) and basic fibroblast growth factor (bFGF), which further promote angiogenic signalling (Chung et al., 2011). Interestingly, the density of vessels produced within the granulation tissue in response to injury is far greater than that

of uninjured tissue (DiPietro, 2013). Once the matrix has been finalised, the extensive vascular tissue which exists within the granulation tissue is no longer required. The release of anti-angiogenic factors (interferon gamma-induced protein 10/CXC motif chemokine 10, Sprouty 2 and thrombospondin) increases and pro-angiogenic factors are down-regulated (Bodnar et al., 2009; Wietecha et al., 2011). Matrix metalloproteinases are responsible for the rapid involution of the capillary network (Zhu et al., 2000). The previously red colour of the granulation tissue is replaced by a paler shade.

Epithelialisation

Epithelium replaces the temporary wound barrier that is established during haemostasis. Wound closure is established via centripetal growth of new epithelium. The process of epithelialisation begins within the first 24-48 hours after injury, however macroscopic visibility of the pink 'rim' of new epithelium at the wound periphery is not seen until sometime later. This period is dependent on the size, location, and cause of the wound as well as the species of animal. For full-thickness wounds healing by second intention, the process of epithelialisation cannot begin until a sufficient bed of granulation tissue has developed (Dart et al., 2017). Like other processes involved in wound healing, epithelialisation requires careful regulation by various mediators which include integrins, cytokines, chemokines, keratins, MMPs and ECM molecules. These mediators are responsible for stimulating keratinocytes at the wound periphery to loosen their adhesions between adjacent keratinocytes (desmosomes) and the basal lamina (hemidesmosomes). This laxity allows the keratinocytes to migrate across the matrix scaffolding created during the inflammatory phase (Pastar et al., 2014). Those keratinocytes at the wound margin upregulate the activity of proteolytic enzymes to degrade components of the ECM, the clot, and debris, this aids migration. Once the entirety of the wound is covered with epithelium, the upregulation of laminin inhibits further migration of epithelial cells (Pastar et al., 2014). The regenerative ability of the epidermis is dependent on epithelial stem cells (ESC)/keratinocyte stem cells (KSC) which reside in three locations: the base of the sebaceous gland, the bulge of the hair follicle (HF) and the basal layer of the interfollicular epidermis (IFE) (Boehnke et

al., 2012). Although initially not required, 1-2 days after injury KSC begin to proliferate to replace those migrating epithelial cells. New cells pass over those at the wound edge to form the new wound margin. As epithelialisation progresses, the monolayer of keratinocytes restratifies to form the original five-layered epidermis. The process of epithelialisation is long and even after coverage of the wound, the neo-epidermis is fragile and easily traumatised.

3.6 Remodelling phase

The process whereby the epidermis and dermis at the periphery of full-thickness wounds are drawn in from all sides centripetally over the wound is referred to as contraction (Desmoulière, 1995). Wound contraction plays a major role in the successful closure of full-thickness wounds. Contraction results in a smaller wound area which correlates to faster rates of wound healing, superior scar strength and improved cosmetic appearance. It is hypothesised that the tractional forces required for wound contraction are generated by migration of fibroblasts and the action of myofibroblasts, a specialised fibroblast phenotype. The differentiation of fibroblasts into myofibroblasts is stimulated by a combination of the migration of fibroblasts through the wound matrix which increases wound tension over a given threshold and the action of TGF-β1 and the ED-A splice variant of fibronectin (Serini et al., 1998; Hinz, 2006). Myofibroblasts are the most plentiful cell type present within granulation tissue. Contraction consists of three phases, the first being a lag phase in which the wound area increases for approximately 1-2 weeks following retraction of the skin edges. Secondly, a period of rapid contraction which is followed by a period of slower contraction, as complete wound closure approaches. The concentration of myofibroblasts correlates to the requirement for contraction. A decrease in the rate of concentration is mirrored by a decrease in the concentration of myofibroblasts. There are three triggers to the cessation of wound contraction; the contractile force produced by the myofibroblasts is equal to or less than the tension within the surrounding skin or wound closure, which results in the inhibition of contraction along with epithelialisation or low numbers of myofibroblasts within granulation tissue as seen in chronic wounds may result in failure of wound contraction. The

location of the wound and the correlating tension of the skin is a factor which affects the degree of wound contraction, typically wounds of the distal limb will contract the least. It has also been suggested that the shape of the wound may affect contraction, however the shape of a wound does not appear to influence the degree of contraction of distal limb wounds (area of the skin under the most tension) (Madison, 1992). Unpublished data from Wilmink showed a substantial difference in the rate of wound contraction of body wounds and distal limb wounds. There are questions over why this data was not published and therefore the significance of the findings. Myofibroblasts present following the cessation of contraction undergo apoptosis or revert to the fibroblastic phenotype. The ECM is an acellular structure composed of proteins, water, polysaccharides and glycosaminoglycans. The role of the ECM is to allow open communication between cells and their biophysical/biochemical environment (Wong, Gurtner and Longaker, 2013). Changes to the ECM occur throughout the remodelling phase to ensure the highest strength and functionality of the tissue. The final phase of wound healing is the transformation of the ECM granulation tissue to scar tissue. The role of macrophages during the remodelling phase includes altering the composition of the ECM through the release of degradation enzymes (Delavary et al., 2011; Novak and Koh, 2013).

Following the replacement of hyaluronan with proteoglycans, collagen fibres are deposited and the results in a dramatic increase in tensile strength. During the earlier stages of wound healing, deposition of collagen fibres tends to be disorganised which correlates to a low tensile strength. Throughout the remodelling phase deposition is more controlled, with collagen fibres reforming along lines of stress, this in combination with more effective cross-linking of later formed collagen explains the increased tensile strength. The process of ECM remodelling is dependent on numerous proteolytic enzymes including MMPs, serine proteinases and cysteine proteinases. To prevent the accumulation of collagen fibres and the formation of a pathologic scar, collagen synthesis and collagen lysis exists in a state of equilibrium during remodelling, this balance is reliant upon the presence of both MMPs and inhibitors of proteinase enzymes (α2-macroglobulin, α1-antiproteinase and tissue inhibitors of metalloproteinases (TIMPs)) (Martins, Caley and O'Toole, 2012). Abnormal or delayed wound healing

has been attributed to an imbalance between MMPs and TIMPs. A study which evaluated the fluid of chronic wounds revealed increased concentrations of proteinases including MMPs and decreased concentrations of inhibitors of proteinase enzymes including TIMPs, resulting in excessive degradation of proteins (Yager et al., 1997). In addition to collagen fibres being re-organised during the remodelling phase, type III collagen fibres which are deposited initially are replaced by type I collagen fibres and the normal ratio of 4:1 type I to type III collagen is re-established. Changes associated with the remodelling phase can be seen for up to two years following injury. Despite the length of the remodelling phase, the skin never reaches its original strength. When compared to normal/uninjured skin, the maximum breaking load was decreased by 40% for areas of skin healed by second intention following cutaneous wounds (Monteiro, Lepage and Theoret, 2009). A similar study in mice found a 15-20% reduction in maximum breaking load after injury to the skin (Levenson et al., 1965).

4.0 Complications of wound healing

4.1 Tetanus

Tetanus is a neurological disease caused by the neurotoxin, tetanus toxin (TeNT) which is produced by the gram-positive anaerobic bacterium, *Clostridium tetani. C. tetani* is a widespread organism most commonly found in soil, more specifically soil contaminated with faecal matter. Tetanus is a disease characterised by spastic paralysis of multiple muscles, with a poor response to treatment and high mortality rates. Environmental factors including temperature, pH, presence and quantity of organic matter and moisture have been shown to influence the distribution of *C. tetani,* with the incidence of *C. tetani* having been shown to be decreased in regions of the world with cooler climates including England (Smith, 1975). Immunisation remains the mainstay of prevention of tetanus, with it being recommended that all horses receive a primary vaccination course which consists of two injections 3-4 weeks apart, followed by a 12-month booster, with subsequent boosters administered bi-annually. For wounded non-vaccinated horses, both tetanus antitoxin and tetanus vaccination should be administered in different injection sites. For wounded horses who haven't received a tetanus vaccine

booster in the previous 12 months, tetanus vaccination should be administered. A standard vaccination protocol and/or immediate anti-toxin cover offer a high level of protection from clinical disease when a horse is wounded.

4.2 Synovial sepsis

The distal limb (below the carpus and tarsus) is the most common location of wounds in all limbs. A survey conducted in the UK found 46% (n=170/370) of wounds to affect the distal limb (Owen et al., 2011). Wounds of the distal limb are most at risk of involving synovial structures (joints, tendon sheaths and bursae) (Schneider et al., 1992; Baxter, 1999; Baxter, 2004). Tarsal joints, metacarpo/metatarsophalangeal joint and digital flexor tendon sheath (DFTS) are the synovial structures most frequently penetrated (Schneider et al., 1992; Taylor et al., 2010; Rubio-Martínez et al., 2012). Although uncommon, involvement of multiple synovial cavities is possible, especially with solar penetrations of the foot (e.g. contamination of the distal interphalangeal joint and navicular bursa), and larger wounds of the carpus and tarsus (Seabaugh and Baxter, 2017). Joints are located at the interface of two bony surfaces which allow flexion and extension of limbs. Synovial fluid contained within the joint capsule is composed of hyaluronan and lubricin which negates friction between the opposing bones (Todhunter, 1996; Frisbie, 2012). Tendon sheaths are located in areas of high motion for example palmar/plantar surface of the metacarpo/metatarsophalangeal joint. Bursae are located between a tendon and the adjacent bone for example the navicular bursa is situated between the navicular bone and surrounds the deep digital flexor tendon at this level. Tendon sheaths and bursae act to protect tendons by enabling their smooth passage over bony prominences. It is important to note that synovial fluid within tendon sheaths and bursae is very similar to that within joint capsules (Seabaugh and Baxter, 2017). A recent owner questionnaire found that 78% (n=809/1037) of horse owners/carers were unable to identify a puncture wound over the DFTS as an injury which requires high priority veterinary attention (Birnie 2020). Early recognition and appropriate treatment of synovial infections is vital to minimise the risk for developing arthritis/restricted movement/chronic

lameness, and provide the optimal conditions for a return to pre-injury-levels of athletic performance (Seabaugh and Baxter, 2017). It is therefore hugely important that horse owners/carers can identify wounds which may involve synovial structures. Often small and inconspicuous wounds to the untrained eye, for example puncture wounds, can communicate with synovial structures. The external size of a wound often does not correlate with the severity of the injury. Initial incorrect management of a small puncture wound into a synovial structure can allow infection to become established making subsequent correct treatment more challenging.

Following inoculation, factors which affect the development of synovial infection include virulence of the bacteria, severity of the concurrent soft tissue trauma, the size of the synovial structure involved, the individual horse's immune response and the presence of a foreign body (Goodrich, 2006; Goodrich and Nixon, 2010). Introduction of a very small number of bacteria can result in synovial infection. Experimental studies have shown that introduction of 1.6×10^6 colony-forming units (CFU) of *Staphylococcus aureus* into the tarsocrural joint and the introduction of 33 CFU of *Staphylococcus aureus* combined with polysulfated glycosaminoglycans (PSGAGs) into the middle carpal joint of normal horses resulted in synovial sepsis (Bertone et al., 1987; Gustafson, McIlwraith, and Jones, 2014). Once a synovial infection becomes established, a fibrinocellular clot called a pannus forms within 24 hours of initial synovial contamination. Pannus is similar to the biofilm found on the surface of infected bone (Goodrich and Nixon, 2010). Pannus serves as a growth medium for bacteria, protects foreign contaminants and devitalised tissue, and inhibits the transport of drugs to the site of infection which obstructs successful treatment of synovial sepsis (Goodrich and Nixon, 2010 and Souza et al., 2021). Positive correlation exists between the duration of synovial infection and the likelihood of permanent damage (Seabaugh and Baxter, 2017). The consequences of prolonged septic arthritis include damaged articular cartilage, fibrosis of the joint capsule and chronic osteomyelitis which result in pain, a decreased range of motion and osteoarthritis, and ultimately lameness (Baxter, 2004). The consequences of chronic septic tenosynovitis or bursitis are the formation of adhesions, septic or non-septic tendonitis and osteomyelitis of adjacent bone which also will result in chronic lameness

(Seabaugh and Baxter, 2017). A number of studies have reported conflicting evidence on the effect of time delay between the onset of synovial infection and initiation of treatment in relation to survival rates and returning to prior performance levels (de Souza et al., 2021). A retrospective case study in Australia examined 75 cases which underwent treatment for synovial sepsis. The results of this study found duration from contamination to the initiation of treatment had an effect on survival rate (Walmsley et al., 2011). Interestingly there is no reference to the time which elapsed between contamination of the synovial structure and the onset of treatment, which begs the question as to whether median time lapsed in the cases reviewed was hours, days or weeks. The findings of Walmsley et al. (2011) are replicated in another retrospective case study which examined 214 cases which underwent endoscopic lavage for the treatment of synovial sepsis found time elapsed between onset of clinical signs of synovial sepsis and treatment was not significant (Milner et al., 2014). An older study by Fraser and Bladon (2004) found that horses with wounds communicating with the DFTS were more likely to return to pre-injury-level athletic performance if the DFTS sheath was endoscopically lavaged and debrided within 36 hours of injury (Fraser and Bladon, 2010). These findings were supported by a study which reported a 65% survival rate for horses which underwent treatment for septic arthritis within 24 hours of injury and 38.5% survival rate for horses which underwent treatment within 36 hours (Gibson et al. 1989). A more recent study reported that survival rate was significantly increased when treatment of septic tenosynovitis occurred within 24 hours of the onset of clinical signs of synovial infection when compared to treatment of septic tenosynovitis after 10 days after the onset of clinical signs of synovial infection. Despite these results, for horses treated between days 1 and 10 after the onset of clinical signs of synovial infection, there was very little difference in the survival rate or the likelihood of return to athletic function of horses (Wereszka, White and Furr, 2007). The contradictory findings on successful treatment of synovial treated wounds and time delay to treatment is confounded by multiple factors including the pathogenesis of the bacteria, the concentration of the bacteria, ongoing contamination, antimicrobial usage and surgical treatment method. However, Post et al., 2003; Duggan et al., 2019; Isgren et al., 2019 and de Souza et al., 2021

report that sooner treatment results in more favourable outcomes. Further studies investigating the survival rate of synovial infection (septic arthritis, septic bursitis, and septic tenosynovitis) associated with a wound, following treatment at a range of different time intervals is required. Uniformity with regard to the definition of 'survival' would provide further clarity.

Synovial sepsis will typically present to veterinarians as a wound. Puncture wounds, though often clinically inconspicuous, pose a significant risk for synovial sepsis. Research has demonstrated that even minimal bacterial inoculation (as low as 33 CFU of Staphylococcus aureus) can precipitate synovial infection (Bertone et al. 1987). Delayed recognition significantly increases the likelihood of permanent joint damage, with chronic synovial infections often resulting in osteomyelitis, fibrosis, and reduced range of motion (Goodrich & Nixon, 2010). Whilst synovial structures are open and draining, lameness may only be slight. However, following natural sealing of a contaminated synovial membrane with fibrin, infection establishes causing synovial membrane distension resulting in severe lameness (Kraus, 2006). If a wound is located close to a synovial cavity, it should be considered to communicate until proven otherwise. Following appropriate preparation of the skin, assessment of the wound starting with sterile digital exploration and/or probing can begin (Kraus, 2006). Often further diagnostic tests including ultrasonography and cytologic evaluation of synovial fluid aspirated from a distant location to the wound in a hospital setting, or pressure testing of an acutely contaminated synovial structure in the field to determine if the capsule is intact can be extremely useful to determine if synovial contamination has occurred (Seabaugh and Baxter, 2017).

Synovial fluid should be collected into an ethylenediaminetetraacetic acid (EDTA) tube, in order to prevent clotting of the sample (Steel, 2008). Characteristics of normal synovial fluid include < 1000 nucleated cells/µL, total protein concentration which is 20-25% of the horse's plasma protein concentration (Trotter and McIlwraith, 1996), which generally correlates to < 2.0g/dL. Characteristics of synovial fluids obtained from a septic synovial structure include > 30,000 nucleated cells/µL, of which > 90% are neutrophils and total protein concentration >4.0g/dL (Trotter and McIlwraith, 1996).

Total protein concentration can be used as a prognostic indicator. A retrospective study found that horses with synovial fluid total protein concentration <6.0g/dL were likely to survive following endoscopic treatment of synovial sepsis (Milner et al., 2014). However, nucleated cell counts and the % of neutrophils in synovial samples in addition to clinical comfort are routinely used as a guidance to determine successful response to treatment.

With the goal of re-establishing a normal synovial environment as quickly as possible to prevent the development of irreversible damage, the mainstay of treatment for synovial infection is high volume synovial lavage with sterile isotonic fluid, arthroscopic inspection with removal of pannus and foreign bodies, and antimicrobial therapy (Seabaugh and Baxter, 2017; Joyce, 2007; Schneider et al., 1992a). There are a variety of methods for both components of this treatment regime.

Endoscopic lavage allows visual inspection of the synovial cavity, permits a greater volume of lavage solution and removal of pannus, necrotic tissue, foreign bodies and debridement of torn fibres more readily than through-and-through needle lavage. Needle is dependent on the inner diameter of the needle gauge to allow evacuation of pannus, foreign material, and devitalised tissue in a blind manner (Milner et al., 2014; Wright et al., 2010). However, a recent case series reported no difference in clinical outcome in septic calcaneal bursae managed by bursoscopic lavage and needle lavage, but case selection may have biased these results (Duggan & Mair 2019).

4.3 Excessive granulation tissue

Excessive granulation tissue (EGT) is a common complication of wound healing, most frequently observed in distal limb wounds healing by second intention. The formation of normal granulation tissue, fibroplasia, is an imperative component of wound healing. Functions of granulation tissues include the filling of the deficit created by the wound, protection from external contaminants and provision of a surface which allows the migration of epithelial cells. Problems arise when fibroblast proliferation continues and the resultant granulation tissue grows beyond the wound margins, at this point the granulation tissue is exuberant or colloquially referred to as ‘proud flesh’ limiting the

migration of the epithelial cells (Theoret and Wilmink, 2017). The development of EGT is a process influenced by numerous factors including a prolonged inflammatory response, angiogenesis and oxygenation, location and the use of bandages and casts.

CAUSES OF EXCESSIVE GRANULATION TISSUE

Inflammatory response

Several studies have shown that the inflammatory response is weaker and more specifically the concentration of TGF-β1 is lower for horse lower limb wounds compared to pony lower limb wounds. TGF-β1 is responsible for the differentiation of fibroblasts into myofibroblasts. As a consequence of decreased numbers of myofibroblasts, wound contraction is decreased, fibroblast proliferation continues and the formation of EGT ensues (Van Den Boom et al., 2002; Wilmink et al., 1999; (Wilmink et al., 2010). A weak acute inflammatory response is seen in equine wounds generally, with the weakest response seen in lower limb horse wounds. The acute inflammatory response is then followed by a prolonged/chronic inflammation (Wilmink et al., 1999).

A chronic inflammatory state is perhaps the most common cause of EGT; however, it often goes unnoticed due to the subtlety of associated signs. The removal of purulent exudate and topical application of corticosteroids can result in significant progression of second intention healing, thus supporting the evidence that chronic inflammation causes excessive fibroblast proliferation (Theoret and Wilmink, 2017).

Angiogenesis and oxygenation

Fibroblast proliferation and synthesis of ECM components is increased in response to hypoxia; therefore, it can be assumed that low oxygen concentrations contribute to the development of EGT (Theoret and Wilmink, 2017). Angiogenesis is the physiological process by which new blood vessels form from pre-existing vasculature. It is a critical component of wound healing, tissue repair, and

embryonic development. The process involves several key steps, including endothelial cell activation, proliferation, migration, and tube formation. Angiogenesis is tightly regulated by a balance of pro-angiogenic factors, such as vascular endothelial growth factor (VEGF) and fibroblast growth factor (FGF), and anti-angiogenic factors, including thrombospondin-1 and angiostatin (Carmeliet, 2003). During wound healing, angiogenesis restores blood flow to the injured tissue, ensuring the delivery of oxygen and nutrients necessary for cellular functions and tissue regeneration. Dysregulation of angiogenesis is implicated in various pathological conditions, including chronic wounds, ischemic diseases, and cancer (Folkman, 2007). Angiogenesis is more profound in granulation tissue of limb wounds compared to body wounds. Due to the extensive angiogenesis of limb wound granulation tissue, it would be expected that the oxygen concentration would be increased, however the lumen of these new vessels is significantly occluded compared to the lumen of the new vessels present in granulation tissue of body wounds. Temperature plays a key role in regulating blood flow and oxygen saturation, as cutaneous vasodilation occurs in response to increased temperatures, enhancing blood flow and oxygen delivery, while vasoconstriction at lower temperatures reduces perfusion and oxygen availability (Charkoudian, 2003). In studies reviewing cutaneous blood flow of wounds, conducted by Sørensen et al. (2014) Celeste et al. (2012) and Celeste et al. (2010), temperature of the skin and wound, transcutaneous oxygen saturation and laser Doppler flowmetry were measured, respectively. The findings of all three studies support the hypothesis that blood flow and subsequently oxygen saturation of lower limb wounds is significantly decreased compared to body wounds, and concomitantly that local hypoxia contributes to the formation of EGT. Results of preliminary investigations using hyperbaric oxygen therapy (HBOT) and topical oxygen therapy (TOT) were not as expected with HBOT decreasing the viability of full-thickness skin graft and TOT having no effect on healing of full thickness wounds. Despite these results, further studies using HBOT and TOT on different types of wounds would be required before discarding their use on equine wounds.

Location

Wounds on the body heal quicker than wounds on the distal limb and are less likely to develop EGT.

The rate of healing is also affected by the location on the distal limb- with wounds over the dorsal aspect of the carpus/tarsus having been shown to heal faster when compared to wounds over the metacarpus/metatarsus (Bertone, 1989; Woollen et al., 1987). This disparity in healing rates is likely due to the differences in vascularity and tissue composition between these regions. The dorsal aspect of the carpus and tarsus is characterized by a richer vascular supply and looser, more pliable skin, which facilitates faster tissue perfusion and wound contraction. In contrast, the metacarpus and metatarsus have denser connective tissue and relatively poorer vascularization, which can hinder perfusion and delay the healing process (Theoret, 2017). Movement and the resultant damage to granulation tissue increases the risk of EGT formation, this is commonly seen with wounds located over the extensor and flexor surfaces of joints (Fretz et al., 1983).

Bandages and casts

Numerous studies have shown that the application of a bandage or cast to a full thickness wound of the distal limb increases the likelihood of EGT formation (Dart et al., 2009; Berry II and Sullins, 2003; Theoret et al., 2002; Barber, 1989; Woollen et al., 1987; Fretz et al., 1983). The application of a bandage or cast creates a moist, warm, and acidic environment, decreases oxygen saturation in wound tissues, and exacerbates the gradient between the wound surface and the deeper tissues which enhances angiogenesis, cellular migration, and proliferation of fibroblasts (Kirsner and Eaglstein, 1993; Bertone, 1989; Knighton, Silver and Hunt, 1981). Despite creating an environment which promotes the formation of EGT, bandages and casts remain a fundamental component of wound healing, with the positive effects superseding the negative implications. The primary benefit of bandaging is limb immobilisation, which reduces movement at the wound site, thereby minimising disruption to fragile granulation tissue and newly formed epithelium. This stabilisation is particularly important for wounds over mobile structures, such as joints, where constant motion can delay healing and promote EGT formation (Caron and Fretz, 1986). Additionally, bandages provide mechanical protection against external contaminants, reducing the risk of secondary infection, which is a common complication in

equine wounds (Lavoie-Lamoureux et al., 2010). The maintenance of a moist wound environment under bandages has also been shown to promote faster re-epithelialisation and enhance tissue repair by preventing desiccation and maintaining cellular viability (Winter, 1962).

TREATMENT OF EGT

Before initiating treatment of EGT it is important to determine if an underlying cause of chronic inflammation is present- bone sequestra, necrotic tendon or ligament, foreign bodies, or contaminants. If such conditions are present, they should be removed in order to dampen the chronic inflammatory drive towards the production of EGT. If an underlying cause cannot be determined, then it is likely that inherent chronic inflammation of equine limb wounds is the cause of EGT formation (Theoret and Wilmink, 2017). A study investigating methods of treating EGT found that excision of granulation tissue only was superior to cryosurgery, excision of granulation tissue and pressure bandaging, and excision of granulation tissue and immobilisation of the limb with a plaster cast. Interestingly, no further development of EGT was seen for both cryosurgery and excision only treatments, however wounds treated with cryosurgery healed with marked fibrosis (Fretz et al., 1983). Limitations of this study include the small sample size (ten equids), the use of ponies rather than horses and the treatment of EGT from artificially inflicted wounds. Excision is a simple procedure which can be performed in the standing horse. Due to the lack of innervation within granulation tissue, desensitisation of the area is not required. It is important that excision commences at the distal border to prevent haemorrhage obscuring the surgical field. Excision not only removes non-viable tissue but significantly decreases the stimulus for chronic inflammation by removing gross contaminants and many leucocytes (Theoret and Wilmink, 2017). An experimental study conducted by Ducharme-Desjarlais et al. (2005) investigated the effects of silicone-containing dressing on the formation of excessive granulation tissue. Two full-thickness artificial wounds were inflicted to both metacarpii of five horses- the rate of healing and the frequency of excisions of EGT were compared for ten wounds treated with a silicone-containing dressing compared to ten wounds treated with a control dressing.

Silicone-containing dressings prevented the development of EGT (Ducharme-Desjarlais et al., 2005). Studies further investigating the use of silicone-containing dressings on naturally occurring wounds would be required to validate the use of such dressings in preventing or even reducing EGT formation.

The evidence surrounding the topical application of corticosteroids for the treatment of EGT is inconclusive. A study using a wound healing model found corticosteroids to decrease the expression of molecules which are key in regulating the wound healing process. One of those regulatory molecules include TGF-β1. Inhibition of TGF-β1 will result in decreased fibroblast proliferation and ECM synthesis, however, selective targeting of just those regulatory molecules associated with the formation of EGT is somewhat of an enigma (Beer, Fässler and Werner, 2000). The negative effects of corticosteroids include a reduction in angiogenesis, wound contraction, and epithelialisation resulting in delayed wound healing (Hashimoto, 2002; Kaufman et al., 2014). Theoret and Wilmink (2017) recommend that the topical application of corticosteroids should be limited to when EGT is first noticed and only used repeatedly in cases where the continued presence of EGT is compromising wound healing. No recommendation as to the duration of use and the frequency of application was made.

Although Fretz et al. (1983) reported no re-occurrence of EGT following treatment with cryosurgery, Theoret and Wilmink (2017) reject the use of cryogenic surgery as it causes necrosis and induces a state of chronic inflammation.

EGT is a complication of wound healing that is frequently seen in equine practice, hopefully continued research will allow for the development of protocols which prevent or better manage EGT. A recent scoping review by Anantama et al. (2022) on equine distal limb exuberant wound healing disorder concluded there was a necessity for the development of evidence-based recommendations for the treatment of EGT.

4.4 Cellulitis/lymphangitis

Although used interchangeably in clinical practice, the definitions of cellulitis and lymphangitis differ. Cellulitis is defined as a diffuse bacterial infection of the dermis and subcutaneous tissues (Baxter, 1999; Evans and White, 2002; Swartz, 2004; Adam and Southwood, 2006; Braid and Ireland, 2020). Lymphangitis is defined as inflammation of lymphatic vessels (Thomson et al., 2001). Cellulitis will be the focus of this section; however, it is worth noting that complications of cellulitis can include lymphangitis. Clinical signs of cellulitis include a painful swelling of a portion or entirety of the limb, pyrexia, mild tachycardia, leucocytosis, and increased concentrations of acute phase proteins (APP's). The mainstay of treatment includes NSAIDs, antimicrobials, light walking exercise and hydrotherapy. Cellulitis is a common complication of traumatic injury due to the bacterial contamination of the dermis and subcutaneous tissues which occurs during wounding. In a retrospective study conducted in the United States of America, 25% (n= 16/64) of cellulitis cases presented to the hospital were secondary to a traumatic injury (Fjordbakk, Arroyo and Hewson, 2008). There is a risk of synoviocentesis introducing bacteria into deeper/synovial structures if performed when cellulitis is present and therefore the collection of synovial fluid in these circumstances may be contraindicated. In order to minimise the risk of iatrogenic septic synovitis, it is recommended to conduct localised hydrotherapy and subsequently place a compressive bandage, and administer antimicrobials and anti-inflammatories for 24 hours before completing synoviocentesis (Fjordbakk, Arroyo and Hewson, 2008).

4.5 Wound dehiscence

Wound dehiscence refers to the premature separation or breakdown of a wound along surgical or traumatic wound margins and is a relatively common complication following equine wound closure (Theoret and Wilmink, 2017). Dehiscence most commonly occurs in wounds subjected to high motion, tension, infection, or compromised perfusion (Fretz et al., 1983). Particularly in equine distal limb wounds, the inherent characteristics of these wounds — including minimal soft tissue coverage,

decreased vascular supply, and significant motion — predispose them to delayed healing and subsequent dehiscence (Wilmink and van den Boom, 2003). Wound dehiscence can range from minor suture line gaping to complete failure of closure and exposure of underlying structures, such as tendons or bone. This breakdown not only complicates the healing process but significantly increases the risk of secondary complications, such as infection, excessive granulation tissue (EGT), and fibrosis (Theoret and Wilmink, 2017).

Factors contributing to dehiscence include surgical or traumatic wound contamination, tension at the wound site, infection, motion, and systemic factors such as malnutrition, endocrinopathies, and immune compromise (Barber, 1989; Dart et al., 2009). A retrospective study by Wilmink et al. (2005) noted that distal limb wounds, particularly those overlying joints or tendons, had significantly higher rates of dehiscence, with a correlation between motion-induced shear forces and wound breakdown. Wound closure techniques and selection of suture material also influence dehiscence rates. Interrupted or tension-relieving suture patterns, the use of monofilament synthetic sutures, and immobilisation techniques such as bandaging or casting are recommended to mitigate the risk of dehiscence (Theoret and Wilmink, 2017; Bertone, 1989). However, immobilisation must be judiciously applied, as excessive bandaging or prolonged immobilisation can exacerbate wound complications such as EGT or pressure sores (Woollen et al., 1987).

Once dehiscence occurs, the wound must be carefully re-evaluated for signs of infection, necrotic tissue, or foreign material. Wound culture, debridement, and conversion to second-intention healing are often necessary. The use of non-adherent dressings and moisture-retentive bandaging can promote granulation tissue formation and epithelialisation (Theoret and Wilmink, 2017). Where significant dehiscence results in exposure of deeper structures such as tendons or bone, prognosis is guarded, and referral for surgical intervention may be warranted.

4.6 Lameness/gait dysfunction

Lameness and gait dysfunction frequently accompany wounds of the distal limb and can be the result of pain, infection, soft tissue disruption, or mechanical compromise due to fibrosis or scar contracture (Kraft and Gavin, 2001). Importantly, the presence of lameness must prompt consideration of underlying synovial involvement, especially in the context of small or puncture wounds (Seabaugh and Baxter, 2017). However, even in the absence of synovial sepsis, significant lameness may develop secondary to involvement of key locomotor structures such as tendons, ligaments, or periarticular tissues.

Persistent lameness following wound healing can be a consequence of fibrosis and adhesion formation, particularly when wounds affect regions of high motion such as the extensor surfaces of joints or digital flexor tendon sheaths (Schneider et al., 1992). Adhesions can tether tendons or joint capsules to surrounding tissues, impairing gliding function and joint mobility. This results in a mechanically restrictive gait pattern, often characterised by reduced range of motion and compensatory locomotor changes (Goodrich and Nixon, 2010).

Additionally, chronic pain due to neuroma formation, scar hypersensitivity, or subclinical infection can perpetuate lameness. In some cases, lameness persists despite resolution of the primary wound due to learned disuse or altered proprioception (Kraft and Gavin, 2001). A detailed lameness evaluation including flexion tests, nerve blocks, and diagnostic imaging may be warranted to localise the source of dysfunction. Ultrasonography is particularly useful in identifying soft tissue disruption, tendon adhesions, or fibrosis (Wright et al., 2010).

Management of gait dysfunction following wound healing often includes physiotherapy, controlled exercise, and in some cases, surgical debridement of adhesions or fibrotic bands. Adjunct therapies such as extracorporeal shockwave therapy (ESWT) and therapeutic ultrasound have also been used to reduce fibrosis and improve mobility (Frisbie, 2012). Ultimately, the prevention of gait dysfunction

hinges on minimising wound-associated complications through early intervention, appropriate wound management, and rehabilitation protocols tailored to the anatomical location and structures involved.

5.0 Aim of the project

The literature reviewed highlights the complexity of equine wound management and the multifactorial nature of wound healing complications. Despite the volume of research available, the breadth and variability of the evidence can be overwhelming and, at times, contradictory—particularly for non-clinical audiences such as horse owners and carers. Many studies focus on isolated elements of wound care, yet few provide a cohesive, evidence-based guide that can be readily applied outside of veterinary practice. The abundance of products and protocols, combined with a general lack of clarity in the evidence, poses a significant challenge for those tasked with managing equine wounds in the field (Freeman et al., 2020; Dart et al., 2017).

Some wound-related complications are not only more prevalent but also carry more serious consequences. Synovial sepsis and excessive granulation tissue (EGT), for example, are among the most problematic. Early recognition and intervention are essential for improving prognosis, particularly in cases of synovial involvement where delayed treatment can result in irreversible damage and reduced survival outcomes (Goodrich and Nixon, 2010). Similarly, the development of EGT is often linked to a combination of chronic inflammation, local hypoxia, and inappropriate bandaging, yet may go unrecognised or be mismanaged by horse owners due to its subtle progression (Theoret and Wilmink, 2017; Ducharme-Desjarlais et al., 2005).

One of the most significant gaps in the current body of literature is the limited focus on educational resources directed at horse owners and carers. The majority of available evidence is written for, and intended to be interpreted by, veterinary professionals (Anantama et al., 2022). However, given the vital role that owners play in the initial management of wounds and the potential consequences of

delayed recognition of complications, it is crucial that guidance is accessible, comprehensible, and practically applicable to those outside the veterinary profession.

Therefore, the rationale for the present study lies in addressing this disconnect. By combining qualitative and quantitative methods, the study aims to explore the knowledge and perceptions of horse owners regarding wound complications and management strategies. In doing so, it seeks to support the development of clearer, evidence-informed resources tailored to the needs of non-professional equine caregivers, with the ultimate goal of improving equine welfare and clinical outcomes.

Aim: The overall aim of the study is to use a co-production and behaviour change methodology (working with horse owners and other stakeholders) to develop evidence-based guidance for horse owners on managing wounds.

This was achieved through three phases. The first phase (Chapter 2) conducted online workshops with stakeholders to develop recommendations on first aid and decision-making for wounds in the horse. The second phase (Chapter 3) used an online survey to evaluate horse owners' current attitudes to wound treatment and decision-making, their opinions on the proposed recommendations, and identified factors that may affect adoption of recommendations. The final phase of the study combined the findings of the workshops and survey to develop final recommendations for a wound educational campaign. Specific aims and objectives for both the first (Chapter 2) and second (Chapter 3) phase of the study can be found in in sections 7.0 and 12.0 respectively.

CHAPTER 2: Multi-disciplinary workshops on wounds which require veterinary attention and first aid treatment

6.0 Introduction

The literature review highlighted a number of areas around equine wound management where there is currently insufficient evidence within the veterinary literature. Current information or approaches are instead often extrapolated from studies and recommendations in the human literature. A key approach to developing recommendations in the absence of supportive scientific evidence, is through co-production methodology working with the key stakeholders involved in the diagnosis, care and management of equine wounds. The key stakeholders in equine health and welfare including the veterinary profession, equine welfare and charity staff, other equine professionals, and horse owners/carers. The involvement of a range of stakeholders is important in the development of recommendations to ensure that views and perspectives from all who may be involved in implementing recommendations are listened to and considered. This ensures that any recommendations are relevant and practical for use. The use of workshops or focus groups enables groups of people with different backgrounds and experiences to come together, discuss their perspectives and hopefully reach agreement.

7.0 Aims and objectives

Aim: The aim of this phase of the study was to develop recommendations on first aid and decision-making for wounds in horses through a co-production approach with key stakeholders.

Objectives:

- To generate statements on determining wound severity and need for veterinary intervention through online workshops with horse owners, veterinary professionals, and other stakeholders
- To generate statements on first aid treatment of wounds through online workshops with horse owners, veterinary professionals, and other stakeholders

8.0 Materials and methods

8.1 Ethical review

This collaborative study 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).

8.2 Study overview

The study used a co-production methodology with key stakeholders to generate recommendations on equine wounds. Using both personal knowledge and experience and research evidence provided, small groups of horse owners/carers, veterinary professionals and other stakeholders took part in a series of facilitated multi-disciplinary workshops. Participants were invited to contribute to two workshops. Workshop One focused on the recognition of wounds which require veterinary intervention. Workshop Two focused on first aid treatment of equine wounds. Following the workshops, all the recommendations were reviewed, combined, or condensed if similar/duplicated, edited into similar formats, and then collated into areas/themes. The collated recommendations were then distributed to all participants through an online Delphi process to determine participant agreement or disagreement with each statement and generate a final list of consensus statements (Appendix 3).

8.3 Participant recruitment

A database of veterinary practitioners who had previously contributed to the collaborative University of Nottingham and British Horse Society Colic Champions scheme was used to recruit participants for the multi-disciplinary workshops. Equine veterinary specialists, practitioners, UK equine charities and professional organisations (including British Horse Society (BHS), CVS Equine) were also recruited by selective sampling to provide broad representation. These participants were recruited via personal

communication. Those who had not previously contributed to work conducted by The University of Nottingham and the BHS were required to complete a short online survey which captured information such as practice type and clinician experience. Experience covered mixed practice, equine first opinion practice and equine referral practice. A copy of the online questionnaire which veterinary practitioners were asked to complete prior to participation in the equine wound workshops can be found in Appendix 1.

Horse owners with a range of different experiences were recruited through social media (Nottingham Colic and Wound Project and British Horse Society (BHS) Facebook page). An online questionnaire, which included a consent form, was linked to all social media posts, a copy of which can be found in Appendix 2. The online questionnaire gathered demographic data including age, geographical location and number of equine wounds experienced. To ensure a range of 'types' of owners were included, the method used by Scantlebury et al (2014) was adapted to categorise horse owners depending on their views on the human-horse relationship.

Five owner typographic categories based on Scantlebury et al (2014) were used in the present study. The five typographies were competing professional, all-round amateur, non-competing professional, friend/companion and competing amateur. Owners were assigned to a category using a rudimentary visual examination of responses and fitting respondents with the closest fitting typography.

Results from respondents were inputted into a separate file and grouped depending on their availability for each of the workshops, typography, number of equine wounds experienced and finally their age. Each group was purposively selected to include a variety of 'types' of horse owner, ages, and experience. Individual email invitations to attend the workshops were sent out.

8.4 Multi-disciplinary workshops

An 'evidence pack' was produced and distributed via email to all participants, including both horse owners and veterinary professionals, of the multi-disciplinary workshops. The evidence pack consisted

of general information on the workshop formats, and evidence to support the topics being discussed in Workshop one and two. For each source of evidence, a simple summary, abstract and full text publication was included. The contents of the evidence pack included:

- Overview of the workshop/Delphi process
- What to expect on the day?
- How to prepare for the workshop
- Critical reading- a guide on how to interpret the evidence
- A question and answer guide for participants
- Contact information- what to do if you need help
- Essential reading- summaries of presentations

The evidence packs also contained a consent form and a guide to using Microsoft Teams. Due to the circumstances surrounding COVID-19, all workshops took place online via Microsoft Teams, meaning that all participants required internet access. A copy of the evidence pack can be found in Appendix 3.

Along with the 'evidence pack' a link to three short presentations were emailed to all participants prior to the workshops. The presentations were created around key areas identified from the literature review and from the researcher's clinical experience on the challenges of wound management. The presentations on: explaining the normal phases and processes of wound healing, the different treatments used, and the evidence for the advantages and disadvantages of each, the location and significance of synovial structures. The presentations were designed to be understandable and accessible to any stakeholders without any prior knowledge and present the key principles for each topic.

The format for the online workshops were as follows: each workshop consisted of approximately six participants, a note-taker, and a trained facilitator. Following a welcome from the group facilitator,

each member of the group introduced themselves. Evidence provided in the evidence pack was then summarised by the facilitator.

A facilitator guide defining how the workshops would be run was written by the primary researcher and distributed, along with a copy of the evidence packs for those who were helping with facilitation. A copy of the facilitator guide can be found in Appendix 4. The overall role of the facilitator was to ensure the smooth running of each workshop, more specifically to advise the group on how to work together, on the aims and objectives of the session, what constitutes different levels of evidence, and how to construct appropriate recommendations.

Facilitators were only allowed to influence discussion to ensure conversation remained within the constraints of the aims and objectives, and to encourage all members of the group to be involved and listened to. The role of the note-taker was to record general comments made during discussions and the recommendations from each group.

Each group talked through the objective for each session, with the outcome of discussions being a series of recommendations. Workshop one focused on determining which wounds require veterinary attention. The following areas were discussed: degree of lameness, depth and location of wound, haemorrhage, and complications of wound healing. Workshop two focused on first aid management of wounds. The following areas were discussed: wound lavage, topical treatments, and bandaging. Statements generated from each group were collated, generating two separate tables, one containing unedited recommendations from workshop one and the other containing unedited recommendations from workshop two.

A feedback form was circulated to all participants of the multi-disciplinary workshops after completion of the second workshop. Thirty percent (n= 21/70) participants returned feedback forms. The results of feedback form responses were collated to gather information whether participants felt prepared for the workshops and to determine participants opinions on the general execution of the workshops,

along with areas which could be improved for future events and whether online participation affected the quality of discussions.

8.5 Delphi Process

The next phase of the study was a Delphi process to collate, distribute and generate consensus around the recommendations developed by each group in the workshops. The first stage involved sorting and collating recommendations. Statements with common themes were combined (all combined statements were labelled to ensure each statement could be traced back to the original workshop, evidence statement and group). Statements were re-worded where necessary to ensure clarity and no ambiguity and to provide consistency and ease of use of participants in the voting round.

Following editing of all statements generated during the workshops, the statements were circulated to all members of the research team for review before commencement of the Delphi process.

An online survey was generated using Online Surveys (www.onlinesurveys.ac.uk) and distributed to participants of the aforementioned workshops via email. Those completing the survey were asked to rank their agreement with the 29 statements generated during both workshops using a 6-point Likert Scale. A free-text box below the statements from each workshop was included to allow for comments and feedback. The survey was live for two weeks and participants were asked to complete the survey within this time frame. Following closure of the survey, results were analysed.

Statements from workshop one covered the following areas: lameness, depth and location of wound, bleeding, wound complications, and vaccination status. Statements from workshop two covered the following areas: wound lavage and topical wound treatments.

Statements were accepted if more than 75% of participants selected ‘Slightly Agree’, ‘Agree’ or ‘Strongly Agree’. Statements with less than 25% ‘Slightly Agree’, ‘Agree’ or ‘Strongly Agree’ were rejected. Statements which had 25-75% of participants ‘Slightly Agree’, ‘Agree’ or ‘Strongly Agree’

were considered to be without consensus. These statements would be modified based on feedback prior to re-distribution.

Data analysis was performed using descriptive statistics, including the number of responses, and the frequency percentage of responses for each statement and level of agreement. Results are presented as % (x/y) to represent the number of responses / number of participants.

9.0 Results

9.1 Participants

A total of 11 groups took part in Workshop one across the week commencing 11/01/2021 and Workshop two across the week commencing 18/01/2021 (total of 22 workshops). The number of participants in each workshop ranged from 5 to 10, with a median of 6. Where possible, each group within Workshop one and two included a veterinary practitioner involved in first opinion practice work, a veterinary practitioner involved in specialist/referral work, a stakeholder from an equine organisation, an experienced (had seen more than 11 equine wounds) and a less experienced (had seen less than 11 equine wounds) horse owner of differing typographies. The length of time for each workshop varied from 45 minutes to 1 hour 45 minutes.

9.2 Multi-disciplinary workshops

There was a total of 32 accepted statements generated. Of the sixteen accepted statements generated from the first workshop; four statements related to lameness, four statements related to the depth and location of wounds, two statements related to bleeding from wounds, four statements related to complications of wound healing and two statements related to 'other' factors surrounding wounds. Of the sixteen accepted statements generated from the second workshop; three statements related to cleaning of wounds and thirteen related to topical wound treatments.

9.3 Delphi process

Thirty four percent (n=24/70) of the 70 workshop participants completed the first and only round of the consensus survey, summarised in Table 2. No statements were rejected, and one survey round was required for the development of consensus.

Table 2: The accepted statements generated by veterinary professionals, horse owners/carers and other industry stakeholders from mutli-disciplinary workshop one, with the corresponding percentage of participants that slightly agreed, agreed or strongly agreed with each statement.

	ACCEPTED STATEMENTS	***Percentage of participants that slightly agreed, agreed, or strongly agreed***
Statements on lameness associated with wounds	Degree of lameness is not a reliable indicator of wound severity	75% (18/24)
	A wound requires urgent veterinary attention if: ▪ The horse is non-weight bearing lame ▪ The horse is lame at walk ▪ The horse is becoming progressively more lame following injury	 100% (24/24) 79% (19/24) 100% (24/24)
Statements on depth and location of wounds	Any penetrating foreign bodies require urgent veterinary attention	100% (24/240)
	Wounds which have broken the skin/full skin thickness require veterinary attention/veterinary advice	96% (23/24)
	Wounds which are in/over the following locations require urgent veterinary attention: ▪ Synovial structures: joints, tendon sheaths and bursae ▪ Coronary band ▪ Eye ▪ Mouth ▪ Genitalia ▪ Nostrils ▪ Ears	100% (24/24)
	Wounds involving the following structures require urgent veterinary attention: ▪ Bone ▪ Tendon ▪ Ligament	100% (24/24)

Statements on bleeding from wounds	Urgent veterinary attention is required if: ▪ Blood is pumping/pulsing from the wound ▪ Bleeding continues, despite the application of a pressure bandage	96% (23/24) 100% (24/24)
Statements on wound complications	Complications of wound healing are common. The horse will require veterinary attention/veterinary advice in the following circumstances: ▪ Inflammation of the affected area: heat, pain OR swelling ▪ Purulent discharge and/or foul smell from the wound ▪ Presence of excessive granulation tissue/proud flesh ▪ High rectal temperature	92% (22/24) 100% (24/24) 96% (23/24) 100% (24/24)
Other statements	Veterinary attention/veterinary advice is required if the horse shows signs of pain or distress irrespective of the size or location of the wound	96% (23/24)
	Horses are routinely vaccinated against tetanus. Wounds sustained by horses that are unvaccinated or not up-to-date with vaccinations, require urgent veterinary attention	96% (23/24)

Table 3: The accepted statements generated by veterinary professionals, horse owners/carers and other industry stakeholders from multi-disciplinary workshop two, with the corresponding percentage of participants that slightly agreed, agreed or strongly agreed with each statement.

	ACCEPTED STATEMENTS	***Percentage of participants that slightly agreed, agreed, or strongly agreed***
Statements on cleaning wounds	Drinking quality running water (i.e. mains water hosepipe) is the preferred method of cleaning/decontaminating wounds	100% (24/24)
	Before touching a wound, make sure you have washed your hands and are wearing clean latex/disposable gloves	100% (24/24)
	When using dilute antiseptic solutions e.g. chlorhexidine (Hibiscrub) or iodine to clean wounds, gauze swabs/cotton wool should be safely disposed of after use, and should not be re-immersed in the clean solution after being in contact with the skin or wound	100% (24/24)
Statements on topical wound treatments	Wound powder causes a foreign body reaction within the wound	92% (22/24)
	Wound powder would not be recommended for use in open wounds	100% (24/24)
	The contents/ingredients of any sprays, including 'purple' or 'blue' sprays should be checked before their use	100% (24/24)

Statements on topical wound treatments Continued...	Sprays that contain alcohol or high concentrations of antiseptics/antimicrobial products are cytotoxic (kills cells) substances	100% (24/24)
	Sprays that contain alcohol or high concentrations of antiseptics/antimicrobial products are not recommended for open wounds	96% (23/24)
	Honey (medical grade) decreases wound infection/contamination	96% (23/24)
	Honey may be useful as a topical treatment in the early stages of wound healing for infected wounds	88% (21/24)
	The contents of Silver spray/creams should be checked before use	100% (24/24)
	Silver spray/creams which contain Silver have antibacterial properties but may also be cytotoxic (kills cells)	96% (23/24)
	Silver spray/creams would not be recommended for routine use in wounds due to its negative effects on wound healing	96% (23/24)
	Hydrogels provide ideal conditions for wound healing	96% (23/24)
	Hydrogels are useful as a topical treatment in uncontaminated/clean wounds (including later stages of wound healing). Examples: Intrasite, Vetalintex, Derma Gel	100% (24/24)
	Barrier creams/oil-based creams will restrict oxygen to the repairing cells and should be used around the wound, or under veterinary advice. Examples: Sudocream, Vaseline	92% (22/24)

10.0 Discussion

10.1 Summary of main results

The workshops included in this section of the study generated a concise list of statements surrounding the topics of wound severity and the requirement for veterinary attention and first aid treatment of wounds. The accepted statements generated from workshop one provides the basis of an extensive framework which horse owners/carers can use to determine whether a wound requires veterinary attention. The accepted statements from workshop two provide guidelines for first aid treatment of equine wounds and the beginnings of establishing what should be present in a horse owner's/carer's first aid kit. The study was conducted with a small number of participants, and these findings should be investigated in a larger scale study to determine if they are representative of the wider study population.

10.2 Study methodology and limitations

Although a small number of participants, the use of stakeholder workshops and Delphi consensus survey allowed for the consideration of all opinions. The use of stakeholder workshops lent itself to generating contextualised responses, and discussions between participants, and explanations of reasoning. These which would have perhaps been missed if online surveys had been adopted, and therefore is a preferred method for generating recommendations (Leong et al., 2024). The use of an online survey to evaluate consensus maintains the anonymity of the participants and removes the risk of dominance and group conformity bias (Nasa, Jain and Juneja, 2021).

There are a number of potential biases and limitations that should be considered. Recruitment of participants for the wound workshop occurred predominantly via social media, it is possible that those that completed the online recruitment survey and subsequently took part in the equine wound workshops were those horse owners/carers who had a pre-existing interest in equine wounds. With this there is the possibility that the findings from this study may not be generalisable to the horse owner/carer population. All participants of the wound workshops were residing and where applicable practising in the United Kingdom (UK), therefore statements generated may only be applicable to the management of equine wounds in the UK. Differences in horse owner/carer knowledge of equine wounds and the availability of first aid treatments is likely to vary across the world.

Delphi methodology

The literature review highlighted the lack of evidence within the veterinary literature to support the management of equine wounds. The guidelines developed in this study were based largely on the opinions of the members of the multi-disciplinary workshops. The workshops were structured to aid the development of guidelines. Each workshop group included veterinary practitioners with expertise in managing wounds to help moderate any discussions. All participants were also provided with 'Evidence Packs' (Figure 1) prior to the workshops. This was to provide them with a succinct summary of the current information, and to attempt to decrease the collective error where supporting evidence

was insufficient. Similar approaches have been used in both human and veterinary medicine. Wilne et al. (2010) recruited 20 healthcare professionals and parents to participate in a multi-disciplinary workshop which generated 77 statements on the identification, assessment and investigation of children exhibiting clinical signs which could be a result of a brain tumour. The workshops were used due to a lack of evidence, and the workshop participants included both medical clinicians and parents of children who had had brain tumours. This mix of participants was also used in the current study, and is important. The parents will see and recognise different things to the clinicians, and have a different perspective. Similarly, horse owners' experiences and opinions are essential in planning equine wound care. They are the primary carers and are responsible for requesting health care interventions for their animals – they act as gatekeepers for veterinary treatment. In the study by Wilne et al. (2010), the workshop statements were then reviewed by healthcare professionals in a Delphi process. The brain tumour workshop generated 77 statements, these were then reviewed by 112 health professionals in the first round of the Delphi process, with 88 participants completing all three rounds (completion rate 79%). The study by Wilne et al. (2010) had 64 statements that reached consensus. The Delphi process using a range of different stake-holders is time consuming, but is important to capture a range of perspectives and also generate evidence based solutions which are practical to implement. For the brain tumour study, it was recommended that implementation of the statements which reached consensus into clinical practice would decrease the morbidity of children associated with brain tumours (Wilne et al., 2010). It led to the development of the 'HeadSmart – Be Brain Tumour Aware' campaign (2011) which reduced the time taken to diagnose childhood brain tumours from 9.1 to 6.7 weeks within two years (https://www.thebraintumourcharity.org/brain-tumour-diagnosis-treatment/child-brain-tumour-research/impact-of-the-headsmart-early-diagnosis-campaign/).

The Delphi process has been used for a small number of veterinary diseases / problems. Belshaw et al. (2019) generated a list of 18 recommendations for preventative healthcare consultations involving dogs and cats, following careful examination of the available literature. These recommendations were

subsequently reviewed by veterinary surgeons and pet owners as part of a Delphi process. This Delphi process involves a wider group of stakeholders, and allows anonymised opinions and feedback to be given (Nasa, Jain and Juneja, 2021). The study by Belshaw et al. 2019 aimed for 75% veterinary surgeon and 25% owner distribution for the participants. The final participants were 22 veterinary surgeons and seven owners, and the completion rate for all three rounds was 69%. This was reported to be the first evidence-based recommendations relating to small animal general practice consultations, and the outcome was 13 recommendations with consensus and five which did not reach consensus. The methodology in this current study on wounds included a higher proportion of horse owners throughout the Delphi process. Horse owners have a significant role in managing equine wounds, and deciding when to call a vet, so their involvement and influence on this process was critical. The current study had the same participants invited to contribute to the survey, which may have contributed to the high levels of agreement and the need for only one round to reach consensus. Further studies using a different and larger pool of participants would be helpful to confirm and validate the findings. There was however clear agreement between the participants in the current study on a number of aspects, as outlined below.

10.3 Main findings

Lameness following wounding was identified by participants of the workshops as an indicator to seek veterinary attention but was not a reliable indicator of wound severity in the acute phase. The discrepancy here may relate to the complications of wounds, including fracture, tendon damage and synovial sepsis. Whilst acute onset and severe lameness would be expected with wounds involving fractures and tendon damage, synovial involvement may result in a slower onset of lameness. This distinction between lameness severity and time since wound occurred was not explored in the Delphi process, but may be significant. A retrospective case series by Milner et al. (2014) found an association between severity of lameness on admission with survival of synovial sepsis, highlighting that those horses with a more severe lameness are presented for veterinary attention in a timelier manner than

those with a mild degree of lameness. Another retrospective study which investigated the role of kick injuries in equine fractures, found that 43.6% of fractures were caused by a kick from another horse. Of those fractures associated with a kick, 44.7% produced open wounds (Donati et al., 2018). In these instances, the wound and the complicating fracture would have resulted in a severe degree of lameness which would have prompted the need for veterinary attention. Whilst degree of lameness may be an indicator of pathology/complication associated with wounds, lameness severity and timing will vary depending on the specific structure affected. Severe lameness is a reliable indicator to seek veterinary attention, but the presence of a lower grade lameness does not rule out the potential for a significant complication and therefore the need for prompt veterinary attention to optimise full athletic recovery.

There was clear agreement amongst participants of the workshops which is supported by the available evidence from human and veterinary literature on the use of tap water to lavage wounds following injury (Fernandez and Griffiths, 2012; Freeman et al., 2020) as a first aid treatment to reduce degree of contamination. Tap water is hypotonic which may result in tissue oedema, however whether this impacts overall wound healing in horses is not determined. In human medicine, there are only a small number of studies which directly compared the two approaches. A Cochrane review in 2022 concluded that there was insufficient evidence to make recommendations of one method over the other (Fernandez, Griffiths and Ussia, 2004). In human medicine, the cost and availability issues are important considerations, and with a lack of evidence against tap water, it then becomes the preferred option (Holman, 2023). Many horse owners will not have sterile saline available for lavage, and therefore extrapolating this recommendation to horses provides a first aid lavage option which is more accessible and cost effective for horse owners.

10.4 Conclusion

Results from this research can be utilised to produce evidence-based guidelines and resources to aid the recognition of wounds which require veterinary attention and improve/assist horse owner first

aid treatment of wounds. All accepted statements are supported by literature which makes them applicable to be used in this manner. As wounds are the second most common 'out-of-hours' condition seen by first opinion equine practitioners in the UK (Bowden et al, 2020), these guidelines and resources will be sure to improve equine health and welfare by ensuring wounds that require veterinary attention are seen in a timely manner and wounds that do not require veterinary attention are managed appropriately by horse owners/carers.

The statements produced during the second chapter of this study are the first evidence-based recommendations developed specifically for the management of equine wounds, generated via multi-disciplinary workshops and a Delphi process.

CHAPTER 3: Survey on the current behaviours and knowledge of horse owners when managing equine wounds and their willingness to change their behaviours based on evidence provided

11.0 Introduction

Previous work has identified areas where there are significant gaps in horse owner/carer knowledge (Birnie, 2020). Prior to the development of a campaign to improve horse owner/carer management of wounds, similar to the 'REACT Now to Beat Colic' campaign, it is important to determine potential barriers to behaviour change (Hannelly, 2016). Behaviour change studies have been shown to identify barriers and facilitators to behaviour change in horse owners (Lightfoot et al., 2023; Grimshaw et al., 2002). The study by Lightfoot et al. (2024) investigated horse owners intention to adopt emergency colic recommendations in a survey using the trans-theoretical model of behaviour change and the theory of planned behaviour. It identified a number of factors influencing intentions, including awareness of an educational campaign, and beliefs in the value of emergency plans (Lightfoot et al., 2023). The study by Furtado et al. (2022) used the COM-B model to investigate horse owners and professionals' attitudes to equine obesity. This study showed that multiple environment and social norms influenced approach, with owners finding it difficult to identify overweight horses, the social norms around overweight horses, and the difficulties of implementing strategies to manage weight (Furtado et al., 2022). By establishing impediments to behaviour change at this stage, allows further development of campaign content, with the hope of generating a more impactful campaign. Such a campaign has the potential to have a hugely positive effect on horse health and welfare. The use of an online survey to establish horse owners/carers willingness to change their current behaviours gives an indication of the response from horse owners/carers to an educational campaign on the management of wounds.

12.0 Aims and objectives

Aim: The aim of this study was to establish current horse owner/carer knowledge on wounds and whether the dissemination of equine wound resources has the potential to change their approach to the management of wounds.

Objectives:

- To identify gaps in horse owner/carer knowledge and first aid treatment of equine wounds through and online survey
- To establish a baseline for owner's/carer's willingness to change their current behaviours and management of equine wounds

13.0 Material and methods

13.1 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).

13.2 Study design

The second component of this project was the development and dissemination of a survey to ascertain the current habits and knowledge of horse owners/carers when approaching and managing equine wounds and to gauge willingness to change/modify those behaviours based on most recent evidence. The topics covered included participants' demographic, duration of equine experience, relevant qualifications, sources of information/advice considered to be trustworthy, and owner wound first aid practices, including wound cleaning and topical wound treatments. The latest evidence on wound cleaning, topical wound treatments, excessive granulation tissue and wounds involving synovial

structures was presented to all participants. Similar to the previous body of work, horse owners with a range of different experiences were recruited through social media (Nottingham Colic and Wound Project and British Horse Society (BHS) Facebook page) posts which contained a link to the online survey.

13.3 Sample population

A convenience sample method utilising social media was adopted to recruit participants. The survey was available to be completed between 29/06/2021 and 27/07/2021. The survey target population was both horse owners and carers, not limited to those who own horses, but also including those who are heavily involved in the care of horses.

13.4 Survey development

As a continuation of the work on the Equine Wound Project (EWP) started by Birnie (2020), Jisc Online Surveys (www.onlinesurveys.ac.uk) was used to develop an online survey titled 'Equine wounds- what do you do?'. A copy of the survey can be found in Appendix 5. This survey was advertised as taking approximately ten minutes to complete. Compulsory questions were limited to the page titled 'Consent Form' to ensure informed consent was obtained from all participants and that participants were able to bypass questions they preferred not to answer instead of ceasing to complete the survey. The first section of the survey captured data on participant demographics and their previous equine experience, including related qualifications. The second section aimed at establishing what horse owners/carers know about wounds and what they would do if their horse sustained a wound. A variety of open and closed questions were asked covering sources that horse owners/carers use to obtain advice, and their opinions on the reliability of these sources, wound cleaning, topical wound treatments, stages of wound healing and management of wound healing. The third part of the study provided participants with current evidence and recommendations generated during the previous part of the study. Participants were then asked if they knew this information previously, and whether having read the information, their approach to wound management would change. The survey closed

with a section providing website links to publications which support the facts presented in the preceding section. The number of respondents for non-compulsory sections varied, and there all data is presented as x/y (number of responses / number of respondents to this question).

13.5 Survey dissemination

Information regarding the online survey and links to the online survey were distributed using social media, predominantly Facebook. Posts were generated and shared by both the BHS and the University of Nottingham (UoN)'s Nottingham Equine Research Facebook group. These posts were then shared within further equine focused Facebook groups which were identified by both searching the following terms 'horse', 'horsey', 'equine' and 'equestrian'. In addition to the above details of the survey and a link to the survey was emailed to all participants of the equine wound workshops detailed in Chapter 2.

13.6 Data analysis

Jisc online surveys automatically collated responses into a spreadsheet. The online data spreadsheet was transferred into an Excel spreadsheet (2016, Microsoft Corporation, WA, USA). The data was manually checked, ensuring inaccurate and/or incomplete records were corrected or deleted.

14.0 Results

14.1 Survey Engagement

A total of 600 horse owners consented to participate in the online survey. Only questions regarding consent were deemed mandatory to complete. Participants were able to select multiple options per questions resulting in response rates greater than the total number of participants. The total number of responses for each question is reported below as (x/y). The survey was disseminated via horse-specific Facebook groups across the UK. Although it is not possible to determine the exact number of individuals who viewed the survey, it is estimated to have reached approximately 5,000 potential participants based off social media analytics. This results in an approximate response rate of 12%,

which is consistent with expected rates for voluntary online surveys distributed through social media platforms (Nulty, 2008). Despite limitations in reach measurement, the sample size and diversity in qualification levels and experience provide confidence in the generalisability of the findings to the wider horse owner and carer population.

14.2 Demographics

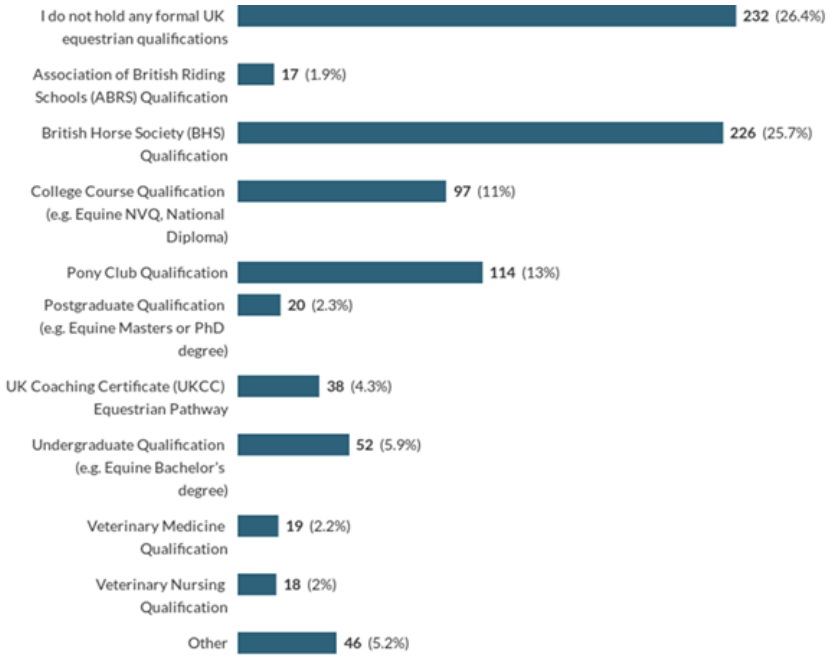
Of the 600 respondents, 96.5% (n= 579/600) were female, 2.5% (n= 15/600) were male and 1% (n= 6/600) preferred not to say. The vast majority (97.7%, n= 586/600) of respondents lived in the United Kingdom. Fourteen respondents were not from the UK, with two from British Crown Dependencies, and the remainder from countries including the USA, Canada, Australia, New Zealand and Israel.

Participants reported varying levels of experience with 89.2% (n= 530/594) respondents having greater than 10 years' experience caring for horses. The median years' experience caring for horses was 30 years, the minimum was 0.5 years and the maximum 65 years. Less than 1% (n= 2/594) of respondents had less than 1 years' experience of caring for horses.

Figure 2 highlights the distribution of UK equestrian qualifications held by participants. Examples of other qualifications held by respondents include veterinary physiotherapy MSc, Worshipful Company of Farriers Diploma and National Stud Diploma.

When qualifications were grouped by level (excluding "Other"), 38.7% (n= 232/600) had no qualifications, 5.2% (n= 31/600) held Pony Club only, 22.2% (n= 133/600) held mid-level equestrian certifications (ABRS, UKCC, or BHS), 18% (n= 108/600) had college or undergraduate degrees, and 8.3% (n= 50/600) held postgraduate, vet nursing, or veterinary qualifications.

Figure 2: Distribution of UK equestrian qualifications held by participants of an online survey which was used to determine horse owner/carer knowledge and first aid treatment of equine wounds.

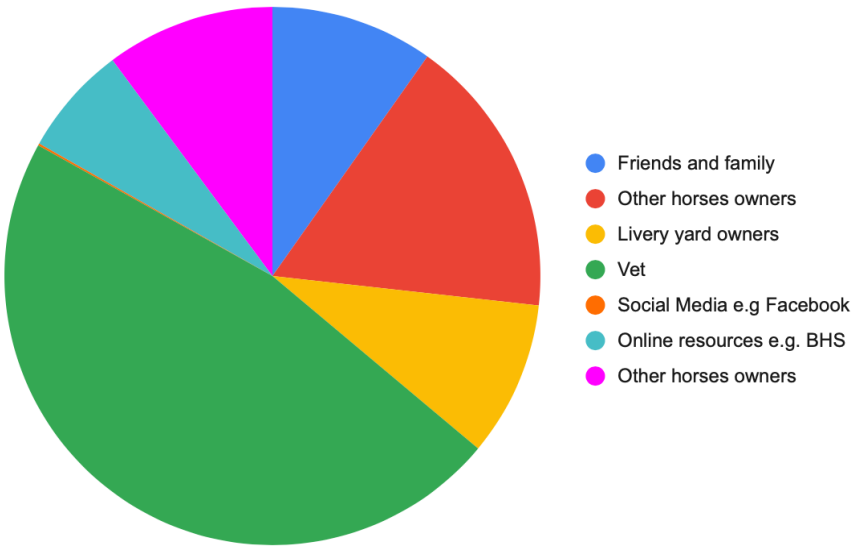


14.3 Sources of information/advice

The source of information/advice used by horse owners/carers in the event of their horse sustaining an injury was not limited to a single source, with many owners choosing to seek advice from multiple sources (Figure 3). In total 595 participants provided an answer to this question, generating a total of 815 responses. Of the total responses, 47% (n= 383/815) would seek advice from their veterinarian, 23.2% (n= 138/815) from other horse owners, 13.4% (n= 80/815) from friends and family, 12.8% (n= 76/815) from their livery yard owner, 10.2% (n= 83/815) from other sources, 9.1% (n= 54/815) from online resources e.g., BHS website and 0.2% (n= 1/815) from social media sources. Other sources of information/advice used by participants in the event of injury to their horse include their own knowledge, veterinary books, and a farrier. Of those participants who selected a single response (n= 447), 58% (n= 258/447) would seek advice from their veterinarian, 13% (n= 57/447) from other horse owners, 11% (n= 51/447) from other sources, 9% (n= 40/447) from friends and family, 6% (n= 28/447)

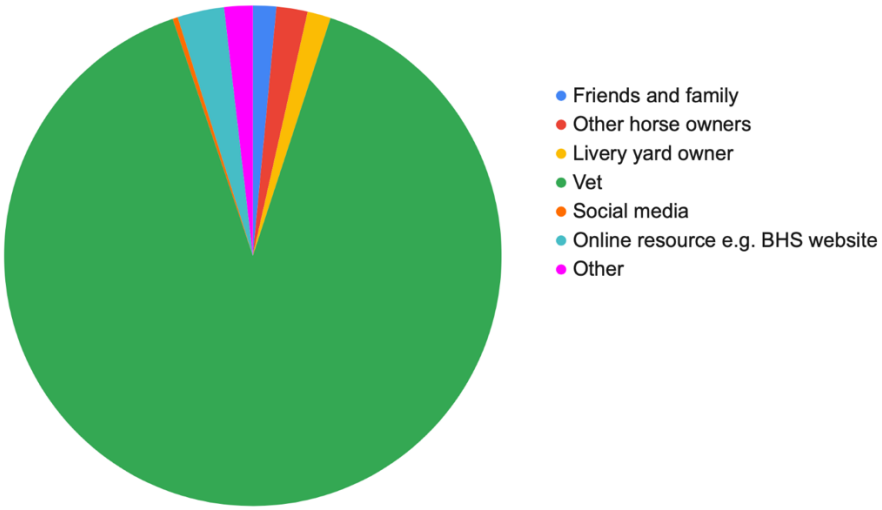
from livery yard owners, 3% (n= 13/447) from online resources e.g. BHS website and no participant selected social media e.g. Facebook as a single response.

Figure 3: Distribution of sources participants of the online horse owners/carers survey seek advice from when their horse sustains a wound.



The source of information/advice considered the most trustworthy by respondents (n= 593) was their vet (89.7%, 532/593). The proportion of respondents which considered all other sources of information/advice most trustworthy varied between 0.3 – 3% (Figure 4).

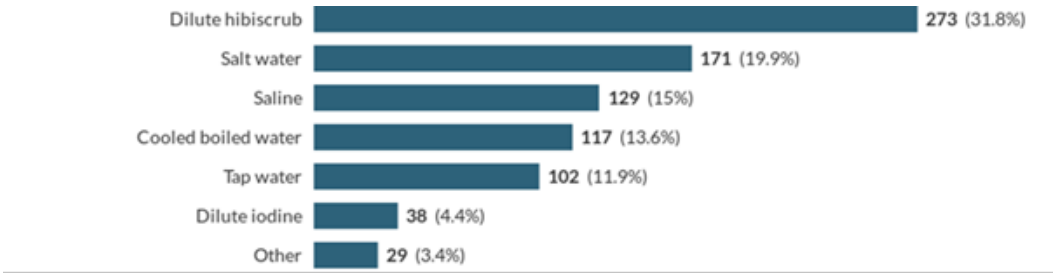
Figure 4: Distribution of sources participants of the online horse owner/carer survey consider to be most trustworthy when seeking advice regarding their horse's wounds.



14.4 Wound cleaning solution

The wound cleaning solution used by horse owners following injury to their horse was not limited to a single option. In total 598 participants provided an answer to this question (Table 4). Of the total selections (n= 859), 31.8% (n= 273/859) used dilute hibiscrub to clean wounds, 19.9% (n= 171/859) used salt water, 15% (n= 129/815) used commercial saline, 13.6% (n= 117/859) used cooled boiled water, 11.9% (n= 102/859) used tap water, 4.4% (n= 38/859) used dilute iodine and 3.4% (n= 29/859) used other solutions. Other solutions used by respondents included Dettol ®, Leucillin and tea tree. Of those participants who selected a single solution, 39.6% (n= 169/429) used dilute hibiscrub to clean wounds, 16.4% (n= 70/429) used salt water, 12.9% (n= 55/429) used tap water, 12.6% (n= 54/429) used commercial saline, 12.5% used cooled boiled water, 3% (n= 13/429) used dilute iodine and 3% (n= 13/427) used other solutions.

Table 4: Distribution of solutions used by participants of the online horse owner/carer survey to clean equine wounds.

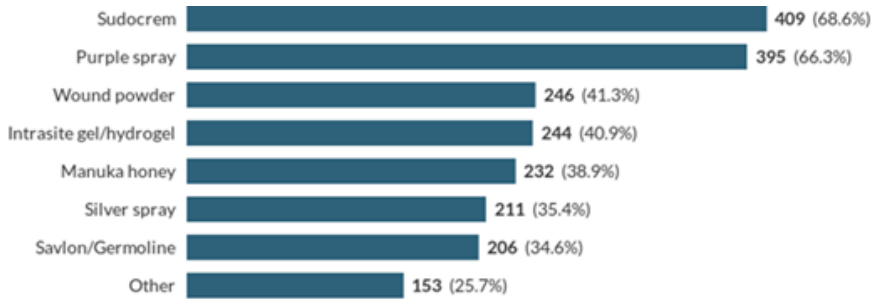


14.5 Topical wound treatments

The topical wound treatments present in horse owners first aid kits were not limited to a single treatment. In total 596 participants provided an answer to this question. 68.6% (n= 409/596) of respondents had Sudocrem in their first aid kits, 66.3% (n= 395/596) had "purple spray", 41.4% (n= 246/596) had wound powder, 40.9% (n= 244/596) had intrasite gel/hydrogel, 38.9% (232/596) had manuka honey, 35.4% (n= 211/596) had silver spray, 34.6% (n= 206/596) had Savlon or Germoline and 25.7% (n= 153/596) had other topical wound treatments. Other topical wound treatments used by the carers of horses included: Flamazine, Alamycin Spray ('Blue' spray), aloe vera gel, Filtabac and Summer Fly Cream (Table 5).

Among all respondents, 43.8% (n= 263/600) had at least one beneficial item (hydrogel or manuka honey) in their first aid kits. Conversely, 72.5% (n= 435/600) had at least one potentially inappropriate item (purple spray or wound powder). Only 15.3% (n= 92/600) had exclusively beneficial items without the presence of any inappropriate items.

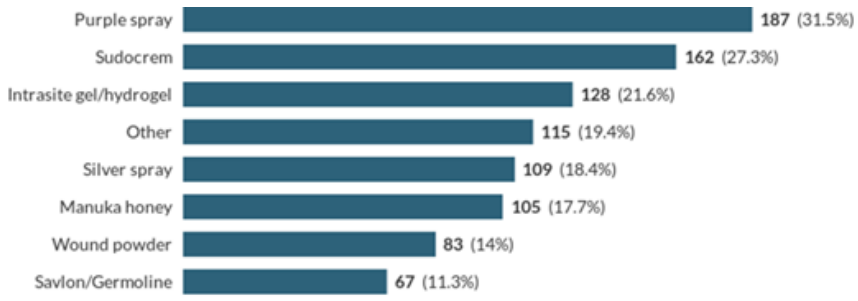
Table 5: Distribution of solutions found in the first aid kits of participants of the online horse owner/carer survey.



Of the 395 respondents who had purple spray in their first aid kit, 87% (n= 344/395) also had either wound powder or Sudocrem, indicating that combinations of suboptimal products were common.

The distribution of topical wound products found in horse owners first aid kits did not mirror the topical wound products applied to wounds by horse owners in the event of their horse sustaining a wound. Of the total respondents 31.5% (n= 187/593) would apply purple spray to a wound, 27.3% (n= 162/593) would apply Sudocrem, 21.6% (n= 128/593) would apply Intrasite gel/hydrogel, 19.4% (n= 115/593) would apply other topical wound treatments, 18.4% (n= 109/593) would apply silver spray, 17.7% (105/593) would apply manuka honey, 14% (n= 83/593) would apply wound powder and 11.3% (n= 67/593) would apply Savlon or Germoline (Table 6).

Table 6: Distribution of topical wound treatments applied to wounds by participants of the online horse owner/carer survey.



Participants with veterinary-related qualifications were significantly more likely to include beneficial items. Of those with veterinary or vet nursing credentials, 76.9% (n= 30/39) included manuka honey or hydrogel, compared to only 41.5% (n= 233/561) of others (Chi squared statistic (χ^2) = 18.6; $p < 0.001$). Furthermore, 48.7% (n= 19/39) had exclusively beneficial items, compared to 13% (n= 73/561) of non-vets ($\chi^2 = 35.8$; $p < 0.001$).Those holding a veterinary degree alone were also more likely to include beneficial items (75%, n= 15/20; $\chi^2 = 8.2$, $p = 0.004$), and were significantly more likely to have only beneficial items in their kits (65%, n= 13/20; $\chi^2 = 39.3$; $p < 0.001$).

When analysed by broader qualification level, individuals with no qualifications or only Pony Club credentials were significantly less likely to have beneficial items in their kits ($\chi^2 = 33.2$; $p < 0.001$). Specifically, only 33.7% (n= 82/241) of those with no qualifications had beneficial items, compared to 50.1% (n= 181/359) with higher qualifications ($\chi^2 = 15.7$; $p < 0.001$). No significant difference was found for Pony Club qualification alone ($\chi^2 = 2.22$; $p = 0.136$), but a clear pattern emerged indicating that respondents with qualifications above Pony Club level were more likely to have beneficial items ($\chi^2 = 8.29$; $p = 0.004$).

While most participants had inappropriate items in their kits, veterinarians and vet nurses were less likely to include them. Only 46.2% (n= 18/39) of veterinary-qualified respondents had these items, compared to 74.3% (n= 417/561) of others ($\chi^2 = 14.5$; $p < 0.001$). The trend was also evident among those with veterinary degrees alone (35%, n= 7/20 vs. 73.8%, n= 428/580; $\chi^2 = 14.6$; $p<0.001$).

However, there was no significant difference in the inclusion of inappropriate items among those with no qualifications ($\chi^2 = 0.97$; $p = 0.325$) or between Pony Club-only and higher-level qualifications ($\chi^2 = 0.21$; $p = 0.651$).

14.6 Stages of wound healing

When presented with a picture of a wound in the proliferative phase of wound healing, nearly half the respondents (n= 47.4%, 242/511) were able to correctly identify the stage of wound healing. The

remodelling phase was selected by 21 .9% (n= 112/511), 17% (n= 87/511) selected inflammation and 13.7% (n= 70/511) selected haemostasis.

When presented with a picture of a wound in the remodelling phase of wound healing, most respondents (53.8%, n= 275/511) were able to correctly identify the stage of wound healing. The proliferative phase was selected by 26.6% (n= 136/511), 12.7% (n= 65/511) selected haemostasis and 6.8% (n= 35/511) selected inflammation.

14.7 Wound management

When presented with a picture of a wound to the dorsal aspect of the carpus, most respondents (84.1%, n= 497/591) were able to correctly identify that the wound pictured required emergency veterinary attention due to the likelihood of synovial involvement. An additional 8% (n= 47/591) would ring the vet for advice and 2.4% (n= 14/591) would ring the vet for a routine visit. First aid would have been administered by 4.7% (n= 28/591) of respondents, 0.7% (n= 4/591) selected 'other' and 0.2% (n= 1/591) would do nothing when presented with this wound. 'Other' responses in this instance were variations of administering first aid, with the only addition being the assessment of lameness. When respondents were asked to explain their reasoning for selecting the above option, those who selected emergency veterinary attention most commonly cited the possible requirement of stitches and synovial involvement as the explanation for their selection.

14.8 Complications of wound healing

When presented with a picture of a wound showing excessive granulation tissue, a common complication of wound healing, and asked how to describe management of such a wound, 72.6% (n= 403/555) of responses contained the word 'vet'.

Most respondents (64.4%, n= 335/520) were able to correctly identify excessive granulation tissue as the complication of wound healing – responses containing 'proud flesh', 'granulation tissue' and 'excessive granulation tissue' were accepted.

Equine wounds- the latest evidence

The last section of the survey provided the latest evidence and recommendations for wound management and asked participants if they already knew this information to be true and if not, how likely they would be to change their approach to wound management.

14.9 Evidence on wound cleaning

'Cleaning wounds with tap water is just as good as cleaning wounds with sterile saline. Recent studies found no difference in healing for wounds cleaned with tap water when compared to wounds cleaned with sterile saline. Removing debris inc. mud, wood, bedding etc. quickly is important in decreasing the risk of infection.' – 42.8% (n= 254/594) of respondents did not know this information at the time of conducting the survey. Of those who did not know this information, 93% (n= 236/254) went on to say that they 'will now start to use tap water to clean wounds', 'might consider using tap water to clean wounds' or 'will continue to use tap water to clean wounds'. The majority (76.8%, n= 261/340) of respondents who knew this information at the time of conducting the survey responded they 'will continue to use tap water to clean wounds'. 4.9% (n= 29/594) of respondents 'probably won't use tap water to clean wounds' and 1% (n= 6/594) of respondents 'will never use tap water to clean wounds'.

14.10 Evidence on topical wound treatments

'Purple Spray: The ingredients in Purple Spray vary significantly, with most containing alcohol and purple dye, both of which are cytotoxic substances.' – 56% (n= 329/587) of respondents did not know this information prior to conducting the survey. Of those who did not know this information, 96% (n= 316/329) went on to say that they 'will now not use purple spray on wounds', 'might now consider not using purple spray on wounds' or 'will continue not to use purple spray on wounds'. 65% (n= 168/258) of respondents who knew this information previously 'will continue not to use purple spray on wounds'. 5.3% (n= 31/587) of respondents 'will probably continue to use purple spray on wounds' and 0.9% (n= 5/587) of respondents 'will always use purple spray on wounds'.

‘Wound Powder: When applied to open wounds, Wound Powder can cause a foreign body reaction which causes inflammation. This inflammation can impede wound healing.’ – 56% (n= 326/582) of respondents did not know this information prior to conducting the survey. Of those who did not know this information, 53.4% (n= 174/326) went on to say that they ‘will now not use wound powder on wounds’, ‘might now consider not using wound powder on wounds’ or ‘will continue not to use wound powder’. 72.3% (n= 185/256) of respondents who knew this information previously ‘will continue not to use wound powder on wounds’. 4.1% (n= 24/582) of respondents ‘will probably continue to use wound powder on wounds’ and 0.2% (n= 1/582) of respondents ‘will always use wound powder on wounds’.

‘Silver Spray: Although it has antibacterial properties, Silver can also be cytotoxic, therefore should only be used on wounds where controlling infection is the main aim.’ – 55.4% (n= 317/572) of respondents did not know this information prior to conducting the survey. Of those who did not know this information, 90% (n= 285/317) went on to say that they ‘will now not use silver spray on wounds’, ‘might now consider not using silver spray on wounds’ or ‘will continue not to use silver spray on wounds’. 55% (n= 140/255) of respondents who knew this information previously ‘will continue not to use silver spray on wounds’. 11% (n= 63/572) of respondents ‘will probably continue to use silver spray on wounds’ and 1.7% (n= 10/572) of respondents ‘will always use silver spray on wounds’.

‘Oil-based creams: These creams form a barrier of the surface of the wound which can protect it. However, this barrier can trap bacteria in the wound bed, therefore shouldn't be used in wounds where infection is a risk. The barrier created by these creams also prevents oxygen from getting to the wound which is required for the new cells to grow.’ – 55.6% (n= 325/585) of respondents did not know this information prior to conducting the survey. Of those who did not know this information, 92.3% (n= 285/317) went on to say that they ‘will now not use oil-based creams on wounds’, ‘might now consider not using oil-based creams on wounds’ or ‘will continue not to use oil-based creams on wounds’. 45.8% (n= 119/260) of respondents who knew this information previously ‘will continue not

to use oil-based creams on wounds'. 14.2% (n= 83/585) of respondents 'will probably continue to use oil-based creams on wounds' and 1.4% (n= 8/585) of respondents 'will always use oil-based creams on wounds'.

14.11 Evidence on excessive granulation tissue

'Excessive granulation tissue ('proud flesh') is a common complication of wound healing. Excessive granulation tissue (EGT) is a product of excessive fibroplasia resulting in granulation tissue sitting proud above the level of the skin, which in-turn impedes wound healing. Although not a medical emergency, wounds with EGT require veterinary attention, most commonly surgical excision in order to promote wound healing.' – 18.6% (n= 109/586) of respondents did not know this information prior to conducting the survey. Of those who did not know this information, 100% (n= 109) went on to say that they 'will now start to call their vet when granulation tissue becomes excessive', 'might now consider calling my vet when granulation tissue becomes excessive' or 'will continue to call their vet when granulation tissue becomes excessive'. 81.4% (n= 477/586) of respondents who knew this information previously 'will continue to call their vet when granulation tissue becomes excessive'. 1% (n= 6/586) of respondents 'will probably continue to not to call their vet when granulation tissue becomes excessive' and 0.2% (n= 1/586) of respondents still 'wouldn't call their vet when granulation tissue becomes excessive'.

14.12 Evidence on wounds involving synovial structures

'Small puncture wounds have the potential to be severe if they are located over synovial structures. Synovial structures include joints and tendon sheaths. 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 and result in euthanasia.' – 9.3% (n= 55/591) of respondents did not know this information prior to conducting the survey. Of those who did not know this information, 98.2% (n= 54/55) went on to say that they 'will now call their vet out/call their vet

for advice when their horse sustains a puncture wound', 'might consider calling their vet out/calling their vet for advice when their horse sustains a puncture wound' or 'will continue to call their vet out/call their vet for advice when their horse sustains a puncture wound'. 0.2% (n= 1/591) of respondents who knew this information previously 'will continue to call their vet out/call their vet for advice when their horse sustains a puncture wound'. 0.8% (n= 5/591) of respondents 'probably wouldn't call their vet out/call their vet for advice when their horse sustains a puncture wound' and 0.2% (n= 1/591) of respondents 'would always manage a puncture wound by themselves'.

15.0 Discussion

15.1 Summary of main results

The aim of this study was to establish current horse owner/carer knowledge on equine wounds and whether dissemination of equine wound resources has the potential to positively adapt management of wounds. There were 600 participants in this survey, predominantly from the UK. The study highlighted that horse owners/carers chose vets as their main (64.4%) and most trusted (89.7%) source of advice, but often consulted other owners, friends and family. Questions around current approaches to wound management highlighted that chlorhexidine was most commonly used for wound lavage (31.8%). The most frequently identified wound treatments in participants' first aid kits were 'Sudocrem' (68.6%), 'Purple Spray' (66.3%) and 'Wound Powder' (41.4%), but their most commonly used products were 'Purple Spray' (31.5%), 'Sudocrem' (27.3%), and 'Intrasite/hydrogel' (21.6%). Approximately half of owners could correctly recognise the proliferative (47.4%) and remodelling (53.8%) stages of wound healing. There were 15.9% of participants who did not recognise the need for an emergency vet call for a synovial wound, and 27.6% who did not recognise this for a wound with granulation tissue. When presented with the latest evidence and guidelines surrounding wounds, many horse owners were unaware of current evidence or advice around wound lavage (42.8%) and potential adverse effects of topical treatments (55-56% depending on treatment). A small proportion were unaware of the need for veterinary intervention for excessive granulation tissue

(18.6%) and synovial involvement (9.3%). The majority of horse owners/carers showed willingness to modify their habits with regard to wound management in accordance with the latest recommendations. The survey again highlighted the necessity for further guidance on wounds to aid horse owners/carers when approaching and managing wounds and receptiveness to such resources, and highlighted specific knowledge gaps and areas for future action.

15.2 Study methodology

This section of the study adopted the use of an online survey to capture data, a method which has previously been successful (Field et al., 2017; Hotchkiss, Reid and Christley, 2007; and Mellany and Hertgage, 2004). The advantages of using this method includes ease of widespread dissemination and collation of data, the ability to collect a breadth of data types and the relatively low cost associated with doing so. The response rate to this study was lower compared to that seen for previous online survey studies of equine health conditions (Bowden et al., 2020; Bowden et al., 2019 and Bambra et al., 2017). Bowden et al. (2019) conducted an online survey of horse owners' knowledge and perceptions of colic, targeting the general horse-owning public through equestrian networks and veterinary practices. This study achieved a notably higher response, with a total of 1564 participants. Similarly, Bambra et al. (2017) surveyed UK horse owners regarding equine influenza vaccination, achieving 4837 participants, recruited through equestrian events and veterinary channels. In comparison, the current study achieved 595 participants. This lower figure may reflect differences in topic salience, survey length, or recruitment strategy, and such limitations should be considered when interpreting the findings.

There are a number of possible inherent biases to note when using online surveys for data collection. The present study relied upon access to the internet along with access to a mobile phone, tablet, or computer, therefore limiting responses to those with such commodities. Distribution of a hard copy of the survey along with a free-post return envelope would have gone some way to resolve this issue.

However, collecting addresses of and distributing surveys to prospective respondents could be both troublesome and expensive (QuestionPro Collaborators, 2024; NHS Surveys, 2020).

It is possible that respondents were limited to those horse owners/carers with an interest in equine wounds or who have had previous experience managing a wound, creating a selection bias. A survey which collected data from a broad spectrum of equine illnesses, rather than the specifically wounds may have provided a more representative horse owner population. Additionally, response bias may occur if respondents provide socially desirable answers or misinterpret questions without the opportunity for clarification (Evans and Mathur, 2005).

15.3 Main findings

The vast majority of participants (89.7%) thought vets were the most trustworthy sources when seeking advice regarding wounds, however only 47% of participants selected 'vet' as the first places they would seek advice from in the event their horse sustained a wound. The discrepancy between these values suggests there is a potential barrier to horse owners/carers seeking and subsequently receiving advice from the source of information they deem most valuable.

Although most participants were selecting appropriate wound lavage solutions, there were incongruencies between the answers between different sections. When participants were asked what solution they would use to clean wounds, 31.8% answered dilute hibiscrub, with only 11.9% using tap water. However, 57.2% of participants claimed to know that cleaning wounds with tap water was comparable to cleaning wounds with sterile saline. Possible explanations for this incongruence are, that owners/carers may be using a combination of solutions when cleaning wounds, or that despite reassurance throughout the survey that they would be thought poorly upon for having not already known such information and therefore answered the question falsely. As touched on previously, there is potential for participants to not answer untruthfully when asked directly about their knowledge, having been presented with the information. Asking a question to ascertain participants' level of knowledge of wound lavage, or for their reasons behind using different solutions prior to presentation

of the evidence would perhaps mitigate this issue. The issue of bias in answering questions could be addressed by studies either asking about what they had used on their most recent wound, or conducting an observational study and recording what actually happened, rather than relying on recall or survey response.

Purple spray and sudocrem were the most commonly used topical wound treatments found in participants first aid kits and subsequently applied to wounds. After being presented with the latest guidelines regarding the use of Purple spray in the management of wounds, which states that ingredients of Purple spray vary significantly, with most containing alcohol and purple dye, both of which are cytotoxic substances, 21.2% (n=125) of respondents stated that they would no longer use Purple spray on wounds and 27.3% (n= 161) of respondents stated that they would consider not using Purple Spray on wounds. A small percentage of participants stated that they would continue to use Purple Spray. A very similar small percentage of clients stated that they would continue to use wound powder, oil based creams and silver spray on open wounds despite being informed of their negative effects on wound healing. These results show that there is a strong willingness from horse owners / carers to modify their habits of topical wound treatments when educational resources are provided. The survey showed that 84.1% (n= 600) of owners were able to correctly identify that a laceration over the carpus required an emergency vet visit and when asked to describe their reasoning for selecting this course of management, 62.3% (n=502) of respondents correctly identified the proximity of the wound to a joint as the reason for the wound requiring emergency veterinary. The ability of horse owners/carers to identify a wound over a synovial structure was much improved compared to data reported by Birnie (2020). This may be attributed to the size of the wound presented to participants. In the present study, the image depicted a large laceration over the carpus, whereas the previous study showed a small puncture wound over the digital flexor tendon sheath. Both the size of the wound and the familiarity of the synovial structures affected are likely to explain the difference in these percentages. A large proportion of owners (35.6%) were not able to identify excessive granulation tissue (EGT) as a complication of wound healing - similar to findings in previous work

conducted by Birnie (2020). Both results support the production and publication of further guidance on the management of wounds for horse owners/carers.

15.4 Next steps

Having identified a willingness of the horse owners/carers population to change their approach and management of wounds in response to the latest evidence-based guidelines, this study supports the publication and wider distribution of such resources. Research on equine wound management is somewhat limited, further research is required to determine the outcome of implementing the wound guidelines on healing outlined in this thesis, particularly in relation to primary or secondary closure. A prospective study where owners initially report their horse's wound, followed by a detailed account of the management, and finally present the outcome on a large sample of wounds would allow representative conclusions to be drawn. This type of study would require a large investment of time and follow up by the primary researcher, but would allow identification of a potential positive correlation between implementation of the described wound guidelines and wound healing.

15.5 Conclusion

This study identified a strong willingness from horse owners/carers to adapt their approach and management of equine wounds. In conjunction with previous work conducted, the results of this study paves the way for the production and distribution of impactful resources to horse owners/carers that will ensure wounds that require veterinary attention are seen more promptly and wounds that do not require veterinary attention are also managed appropriately improving first aid and therefore by default improve the overall health and welfare of numerous horses.

CHAPTER 4: Future recommendations and conclusions

16.0 Future recommendations and conclusions

The lack of literature on the management of equine wounds has resulted in the majority of relevant equine wound advice being extrapolated from human literature. This study has formed the initial stages of a campaign to improve horse owner/carer management of equine wounds. Many educational campaigns in both human medicine and veterinary medicine are released, with a large proportion of those failing to reach the desired outcomes (Coleman, 2010; Summerbell et al., 2005). Poor understanding of target behaviours, suboptimal use of behavioural theories and the absence of a systematic approach when designing intervention are some of the reasons reported to result in failure of medical educational campaigns (Michie et al., 2011; Davies et al., 2010; Michie et al., 2009; Johnston and Dixon, 2008). A series of frameworks have been created to aid the successful implementation of evidence-based guidelines. Eldredge et al. (2016) developed the intervention mapping (IM) framework to guide the design and evaluation of behaviour change interventions. More recently, Abraham and Denford (2020) have built upon the IM framework to produce a Ten-task guide to optimise interventions. The guide involves the understanding of the problem and the needs of the target, determining whether behaviour change can resolve the problem, identification of behaviours which need to change, understanding of current behaviours, developing the mechanisms required to change behaviour, testing, refining and implementation of the intervention, followed by evaluation and testing for generalisability (Abraham and Denford, 2020).

This study has focused on identifying the behaviours of horse owners/carers which require change to improve management of wounds and understanding the current behaviours of horse owners/carers when managing wounds (stages three and four of the Ten-task guide).

The next step in producing a successful behaviour change campaign is to establish the methods of behaviour change required and develop the first draft of campaign material. Again, involvement of veterinary professionals, horse owners/carers and other stakeholders will optimise the impact these

resources deliver. This study suggests that vets are the most trusted source of information that horse owners/carers seek advice from in the event of their horse sustaining a wound, however the percentage of horse owners/carers who seek advice from their vet for their wounds horse is disappointingly low (47%, n= 383/815). However, a key behavioural issue that emerged from this study, and must be addressed at this stage, is the apparent reluctance of some horse owners/carers to seek advice from veterinarians, despite vets being identified as the most trusted source of information. Understanding this discrepancy is vital. It is possible that cost concerns, perceived accessibility, past negative experiences, or uncertainty about when it is appropriate to contact a vet may be contributing to this hesitancy (Keller and Lehmann, 2008; Rose et al., 2018). Therefore, early-stage focus group work or qualitative interviews with horse owners/carers should be used to explore these barriers further (Michie et al., 2011). Incorporating these insights into the campaign design will allow for targeted messaging that not only educates owners on when and how to involve a vet, but also addresses emotional, social, and practical concerns that may prevent them from doing so (Furtado et al., 2022; Lightfoot et al., 2024). Without addressing this gap between trust and action, the campaign risks missing a crucial opportunity to influence wound care outcomes through earlier and more consistent veterinary involvement.

The final recommendations for a wound educational campaign identified by the study covers three main areas: content of the wound campaign, delivery of the content and who the content will be delivered to.

Content of the wound campaign should be focused on ensuring equine wounds which require veterinary attention receive the necessary veterinary intervention in a timely manner and wounds which do not require veterinary attention are managed appropriately by horse owners/carers. The statements generated during the multi-disciplinary workshops covered both the decision-making process of ‘when to call the vet’ for either advice or a visit and wound first aid. Both topics are hugely important and should be represented in any future resources or material released as part of the

Equine Wound Project. The 32 statements developed provide a complete guide to aid horse owners/carers when faced with the scenario that their horse has sustained a wound. As per the statements, main areas for wound campaign resources to focus on include lameness, depth and location of wound, bleeding, wound complications, wound lavage and topical wound treatments. A clear line of communication between horse owners/carers and veterinary professionals would significantly improve the management of equine wounds. Some horse owners/carers have developed relationships with their own vet which would allow them to send a photograph of a wound for an opinion, this is not the case for everyone. A service/application which allows open communication for horse owners/carers and veterinarians on appropriate wound management would help improve the health and welfare of injured horses.

The delivery of resources released as part of the wound campaign should be focused on sharing information, building knowledge, understanding, and using that to drive behaviour change. The study showed that providing horse owners/carers with new information and enabling them to understand the effects of the treatments they have been using to manage wounds has a significantly positive impact on changing behaviour. Simply dictating new guidelines for the management of equine wounds would do very little to change horse owners/carers behaviour. A combination of factsheets and an interactive learning platform would provide the balance between presenting the information to horse owners/carers and engaging them. Although the wound campaign is targeted at horse owners/carers, to aid its success, it will be imperative to include veterinary professionals and other industry stakeholders in the production and dissemination of resources for the campaign.

This body of work has focused on three key areas to help generate the framework for a future educational campaign. The literature review collated and summarised the evidence on two key areas: normal physiology and complications of wound healing (to help inform recommendations on recognising and responding to different wound types), and aspects of first aid, including wound

preparation and lavage, and topical treatments (to help inform recommendations on first aid for horse owners).

The workshops presented this evidence to a group of horse owners/carers, veterinary practice professionals and professionals involved in other aspects of equine health and welfare, and asked them to discuss, debate current evidence, practice, experiences, and opinions to generate recommendations. The workshops generated recommendations around the recognition and response to different types of wounds, and the most appropriate first aid for horse owners. The workshops were followed by a Delphi process, but there was a high level of agreement with all statements, and all were accepted within a single round. This was surprising considering the lack of high level evidence in the equine veterinary literature for many aspects of wound management, but demonstrated a high level of consensus for current best practice in wound care.

The final stage of the project, the online survey, tested how horse owners/carers might respond to the recommendations, using a behaviour change model to evaluate current approaches, and whether disseminated information was likely to change behaviours. The survey focused on wound cleaning, topical wound treatments, and two major complications of distal limb wounds in horses (synovial involvement and excessive granulation tissue). The results highlighted potential gaps in horse owner/carer knowledge which would impair their ability to manage a wound successfully. The frequent use of inappropriate topical wound treatments that may be detrimental to wound healing by horse carers was highlighted in this study, and also their inability to recognise excessive granulation tissue. The questions themed around behaviour change showed a positive response when horse owners/carers were presented with the underlying information or evidence as a rationale for considering other options. The majority of owners/carers who were previously unaware of information surrounding lavage, topical treatments and wound complications stated they would change their current approaches in accordance with the presented information. This suggested that

the major barrier to change was a lack of underlying knowledge or understanding, and no other major issues or barriers were raised.

Key future research recommendations include the following:

- The development of factsheets and an interactive elearning platform to provide horse owners/carers with the knowledge to manage equine wounds, with input from horse owners/carers, veterinary professionals, and industry stakeholders
- The development of an online application which allows horse owners/carers to receive advice on wounds their horse has sustained, similar to the current service of human skin lesions being assessed by dermatology telemedicine.

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18.0 Appendices

18.1 Appendix 1

Vet Typography Questionnaire

Page 1: Equine Wound Project Vet/Nurse Survey

The British Horse Society and University of Nottingham's Equine Wound Project is looking for a group of equine vets and nurses to be involved in an upcoming research workshops in January 2021. This workshops will bring together a wide range of veterinary professionals, horse charities/organisations and horse owners/carers. The aim of the workshops is to improve the recognition of wounds which require veterinary attention and to work with horse carers/owners and veterinary professional to improve first aid treatment of equine wounds.

This short questionnaire is designed to help recruit a range of vets and nurses with varying experiences to take part in the workshops. We then intend to select a number of vets and nurses with diferent experiences to assist us with the next phase of research.

Due to the current circumstances surrounding Covid-19, the workshops will take place online via Microsoft Teams. All you need to be able to participate is internet access. Participants will need to spend approximately 1-2 hours reading and watching webinars prior to the workshops and each of the 2 workshops will last approximately 1-2 hours.

Page 2: Consent Form

The following questionnaire should take about 2 minutes to complete.

Participation in this research is entirely voluntary and there is no obligation to take part.

This study has been approved by the University of Nottingham School of Veterinary Medicine and Science's ethics committee.

Further information about the study can be obtained by contacting the team: **equinewoundproject@nottingham.ac.uk** OR visit our Facebook page: **www.facebook.com/nottinghamequineresearch**

Thank you in advance for your help with this study,

The Equine Wound Project Team

Consent:

Completion of this form indicates that you agree to participate in The Equine Wound Project and that you understand any information collected by the researchers:

- will be annonymised and treated confidentially
- will only be accessed by research colleagues
- will be used as part of a research study
- may be included in research publications
- may be presented at research meetings or conferences

As a participant of this study you can request a copy/summary of the completed study and/or request a copy of information obtained during the data collection process.

1. If you are willing to participate in this study, please give formal consent by filling in the section below. * *Required*

◦ I have read and fully understood all information regarding consent and agree to the terms of participation in this study

Page 3: Contact details and availability

The aim of this questionnaire is to gather a balanced range of vets and nurses who we will contact individually with regards to involvement in the research workshop. Please provide your name and email address in the spaces provided below. NOTE: If you do not have an email address, please provide a telephone number.

Contact details will be treated with the strictest of confidence and only used for the purposes of communicating information about the wound project.

2. Name ✱ *Required*

3. Email address ✱ *Required*

4. Please indicate if you are available on the following dates to participate in the reseach workshop. NOTE: Due to current circumstances surronding Covid-19, the research workshops will be held online via Microsoft Teams ✱ *Required*

Please select at least 1 answer(s).

- ☐ 11/01/2021
- ☐ 12/01/2021
- ☐ 13/01/2021
- ☐ 14/01/2021
- ☐ 15/01/2021

5. Of the dates you have selected above, what time of day for the research workshop would suit you best? ✱ *Required*

Please select at least 1 answer(s).

- ☐ 7- 8am
- ☐ 8- 9am
- ☐ 12- 1pm
- ☐ 1- 2pm
- ☐ 5- 6pm
- ☐ 6- 7pm

Page 4: Demographics and personal experience

6. How many years have you been a member of RCVS or an RVN? ✱ *Required*

7. Please give the name of the practice which you are currently employed at

8. Of the following statements, which best describes the practice you are currently employed by?

- ○ First opinion ambulatory equine practice
- ○ Second opinion ambulatory equine practice
- ○ First opinion equine hospital
- ○ Second opinion equine hospital
- ○ Mixed ambulatory practice
- ○ Mixed practice hospital
- ○ Other

8.a. If you selected Other, please specify:

9. Since qualifying, have you completed any further qualifications? ✱ *Required*

- ○ Yes
- ○ No

9.a. If yes, please give details of any further qualifications you have completed since qualifying

Page 5: Final page

Thank you!

Your participation in this survey is very much appreciated.

If you are one of the respondents to be selected to be involved in the workshop we will contact you using the details you have provided.

Further information regarding The Equine Wound Project can be found on our Facebook page: **www.facebook.com/nottinghamequineresearch**

Should you have any further questions, please contact The Equine Wound Project Team. Email: **equinewoundproject@nottingham.ac.uk**

18.2 Appendix 2

Horse Owner Typography Questionnaire

Page 1: Equine Wound Project Horse Owner/Carer Survey

The British Horse Society and University of Nottingham's Equine Wound Project is looking for a group of horse owners/carers to be involved in an upcoming research workshop in January 2021. This workshop will bring together a wide range of veterinary professionals, horse charities/organisations and horse owners/carers. The aim of the workshop is to improve the recognition of wounds which require veterinary attention, and to work with horse carers/owners and veterinary professional to improve first aid treatment of equine wounds.

This short questionnaire is designed to explore and define the human-horse relationship for each owner/carer, in order to find a range of horse owners with various views of the role of horses in their lives. We then intend to select an equal number of owners with a range of experiences to assist us with the next phase of research.

The method of defining the human-horse relationship was developed by Claire Scantlebury and fellow researchers at the University of Liverpool as part of study which focused on horse-owner decision making and practices in response to colic (you can use the link below to read the research article yourself for free).
http://biomedcentral.com/content/pdf/1746-6148-10-S1-S1.pdf

Due to the current circumstances surrounding Covid-19, the workshops will take place online via Microsoft Teams. All you need to be able to participate is internet access. Participants will need to spend approximately 1-2 hours reading and watching webinars prior to the workshops and each of the 2 workshops will last approximately 1-2 hours.

Page 2: Consent Form

The following questionnaire should take about 5 minutes to complete.

Participation in this research is entirely voluntary and there is no obligation to take part. Please note you must be over 18 years of age to take part.

This study has been approved by the School of Veterinary Medicine and Science's ethics committee.

Further information about the study can be obtained by contacting the team: **equinewoundproject@nottingham.ac.u**k OR visit our Facebook page: **www.facebook.com/nottinghamequineresearch**

Thank you in advance for your help with this study,

The Equine Wound Project Team

Consent:

Completion of this form indicates that you agree to participate in The Equine Wound Project and that you understand any information collected by the researchers:

- will be annonymised and treated confidentially
- will only be accessed by research colleagues
- will be used as part of a research study
- may be included in research publications
- may be presented at research meetings or conferences

As a participant of this study you can request a copy/summary of the completed study and/or request a copy of information obtained during the data collection process.

1. If you are willing to participate in this study, please give formal consent by filling in the section below. * *Required*

○ a. I have read and fully understood all information regarding consent and agree to the terms of participation in this study

Page 3: Contact details and availability

The aim of this questionnaire is to gather a balanced range of owners/carers who we will contact individually with regards to involvement in the research workshop. Please provide your name and email address in the spaces provided below. NOTE: If you do not have an email address, please provide a telephone number.

Contact details will be treated with the strictest of confidence and only used for the purposes of communicating information about the wound project.

2. Name * *Required*

3. Email address * *Required*

4. Please indicate if you are available on the following dates to participate in the research workshop. NOTE: Due to current circumstances surrounding Covid- 19, the research workshop will be held online via Microsoft Teams. Don't worry if you have never used Microsoft Teams before. To be able to take part in the workshop, all you need is internet access. * *Required*

- ☐ 11/01/2021
- ☐ 12/01/2021
- ☐ 13/01/2012
- ☐ 14/01/2021
- ☐ 15/01/2021

5. Of the dates you have selected above, what time of day for the research workshop would suit you best?

- ☐ 7- 8am
- ☐ 8- 9am
- ☐ 12- 1pm
- ☐ 1- 2pm
- ☐ 5- 6pm
- ☐ 6- 7pm

Page 4: Demographics and personal experience

6. With regards to equine wounds, how many horses with wounds have you cared for?
*Required

- ☐ None
- ☐ 1-2
- ☐ 3-4
- ☐ 5-7
- ☐ 8-10
- ☐ 11-20
- ☐ 21-30
- ☐ 30+

7. How confident would you be in recognising if a wound requires veterinary attention?
*Required

- ☐ I would be confident recognising every wound which requires veterinary attention despite depth, size and location
- ☐ I would be confident recognising most wounds which require veterinary attention
- ☐ I would be confident recognising some wounds which require veterinary attention
- ☐ I wouldn't be confident recognising wounds which require veterinary attention unless it was very deep and/or large
- ☐ I wouldn't be confident recognising any wound which requires veterinary attention

8. Assuming a wound does not require veterinary attention, how confident would you be administering First Aid? *Required

- ☐ I would be confident administering first aid to every wound despite depth, size and location

- [ ] I would be confident administering first aid to most wounds unless it was very deep and large
- [ ] I would be confident administering first aid to some wounds
- [ ] I wouldn't be confident administering first aid to a wound unless it was very minor
- [ ] I wouldn't be confident administering first aid to any wound

9. Which region do you currently live in? ✱ *Required*

- [ ] Scotland
- [ ] Northern Ireland
- [ ] Wales
- [ ] UK North East
- [ ] UK North West
- [ ] UK Yorkshire and Humberside
- [ ] UK East Midlands
- [ ] UK West Midlands
- [ ] UK South West
- [ ] UK South East
- [ ] UK East of England
- [ ] UK Greater London
- [ ] Isle of Man
- [ ] Other

9.a. If you selected Other, please specify:

Page 5: Human-horse relationship

10. Please read each of the following statements carefully and provide your answer that best corresponds to your agreement or disagreement. ✱ *Required*

Please don't select more than 1 answer(s) per row.

Please select at least 6 answer(s).

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
"I consider my horse/pony to be a pet"	☐	☐	☐	☐	☐
"I consider my horses/ponies to be working animals"	☐	☐	☐	☐	☐
"Working with horses is part of my profession"	☐	☐	☐	☐	☐
"I keep my horse for a sense of achievement (e.g. bringing on a youngster, becoming an accomplished rider etc.)	☐	☐	☐	☐	☐
"I keep horses for the satisfaction gained from the relationship I have with my horse"	☐	☐	☐	☐	☐
"I keep horses in order to compete and win"	☐	☐	☐	☐	☐

Page 6: Final page

Thank you!

Your participation in this survey is very much appreciated.

If you are one of the respondents to be selected to be involved in the workshop we will contact you using the details you have provided.

Further information regarding The Equine Wound Project can be found on our Facebook page: **www.facebook.com/nottinghamequineresearch**

Should you have any further questions, please contact The Equine Wound Project Team. Email: **equinewoundproject@nottingham.ac.uk**

18.3 Appendix 3

The Equine Wound Project Workshop - Evidence Pack

January 2021

- Overview of the workshop/Delphi process
- What to expect on the day?
- How to prepare for the workshop
- Critical reading- a guide on how to interpret the evidence
- Q&A- A guide for participants
- Contact information- what to do if you need help
- Essential reading- summaries of presentations

This workshop is kindly supported by the British Horse Society (BHS)

What is a Delphi Process?

A Delphi process is a structured means of developing consensus on a topic through discussion, feedback and agreement amongst individuals who understand the current research surrounding the topics, along with various experiences and expertise. The "end product" of a Delphi process is a list of statements which can be used to guide practitioners. In this case, the "end product" will be a list of statements which can used to guide owners/carers of horses.

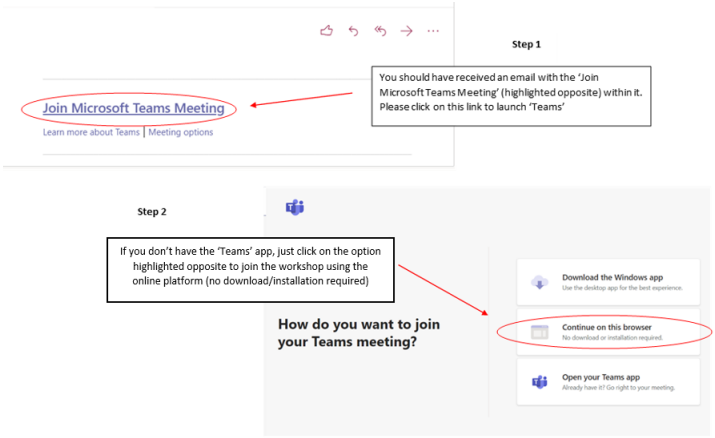
Overview of the workshop/Delphi process for The Equine Wound Project

- Research and important findings surrounding equine wounds are collated.
  Stakeholders will be arranged into small mixed groups for the discussions. Each group will be facilitated by a member of the research team, who will guide discussions towards the objectives of the workshop. Due to the current circumstances surrounding Covid-19, the workshop will be held online, via Microsoft Teams.
  Each group will generate a set of statements for each objective based on the conclusions of the group discussion and research evidence.
  The Delphi process involves recruiting a panel of experts will review the evidence statements generated from the workshop. Panel members will rank their agreement with the evidence statements using a 9-point scale. Feedback will be provided on each of the statements, particularly for those with which invoke disagreement. Evidence statements with a consensus level >70% will be accepted. Those where consensus is not achieved will either be removed or modified and reissued in a process of 3 rounds to define consensus. The output of this process being a set of evidence-based guidelines.
- Decreases potential for individual bias when interpreting results
- Engages a variety of stakeholders including practitioners and horse owners/carers
- Facilitates dissemination and implementation of outcomes

What to expect on the day?

- Due to current circumstances surrounding Covid-19, the workshop will be held via Microsoft Teams. If you do not already have Microsoft Teams downloaded, don't worry, we will send everyone an invitation to the workshop via email. If you have not received this email invitation 48 hours prior to workshop, please contact the Equine Wound Project team and we will be able to solve any issues.

- On the day, follow the instructions on the illustration below to join the workshop. To join the workshop, all you need is internet access. Download/installation of Microsoft Team is not required. When joining the meeting please ensure you camera and speakers are turned on.



- As highlighted above, the workshop will consist of a facilitator and a variety of stakeholders including horse owners, vets, nurses and representatives from equine charities and organisations. Each of the 2 workshops will last approximately 1-2 hours.

Aims and objectives

The multi-disciplinary nature of these workshops ensures that the outcomes have a wide relevance and impact on the care and welfare of the horse. Evidence-based guidelines for wounds will help owners to recognise wounds which require veterinary attention and improve first aid treatment.

Overall aim of the wound workshop and Delphi process:

"The aim of the workshop is to improve the recognition of wounds which require veterinary attention and to work with horse carers/owners and veterinary professional to improve first aid treatment of equine wounds"

- As mentioned previously, each group will be facilitated by a member of the research team who will guide discussions towards meeting the workshop objectives, as well as ensuring that everyone has a fair opportunity to be involved in the conversation.

Workshop objectives:

- To describe the approach for determining whether or not an equine wound requires veterinary attention
- To describe the first aid treatment of equine wounds
- To identify where further education / training / research is required

How to prepare

- In order to participate fully in the wound workshops, we would like you to understand the current evidence available on equine wounds. This awareness will allow you to contribute an informed opinion to the group discussion in addition to your views and experiences.

- Please take your time to read through the short summaries at the end of this booklet. Each summary presents a piece of research in the field of equine wounds and will help to supplement your current understanding of the topic. We will also be releasing a series of webinars about equine wounds for you to watch prior to the workshops.

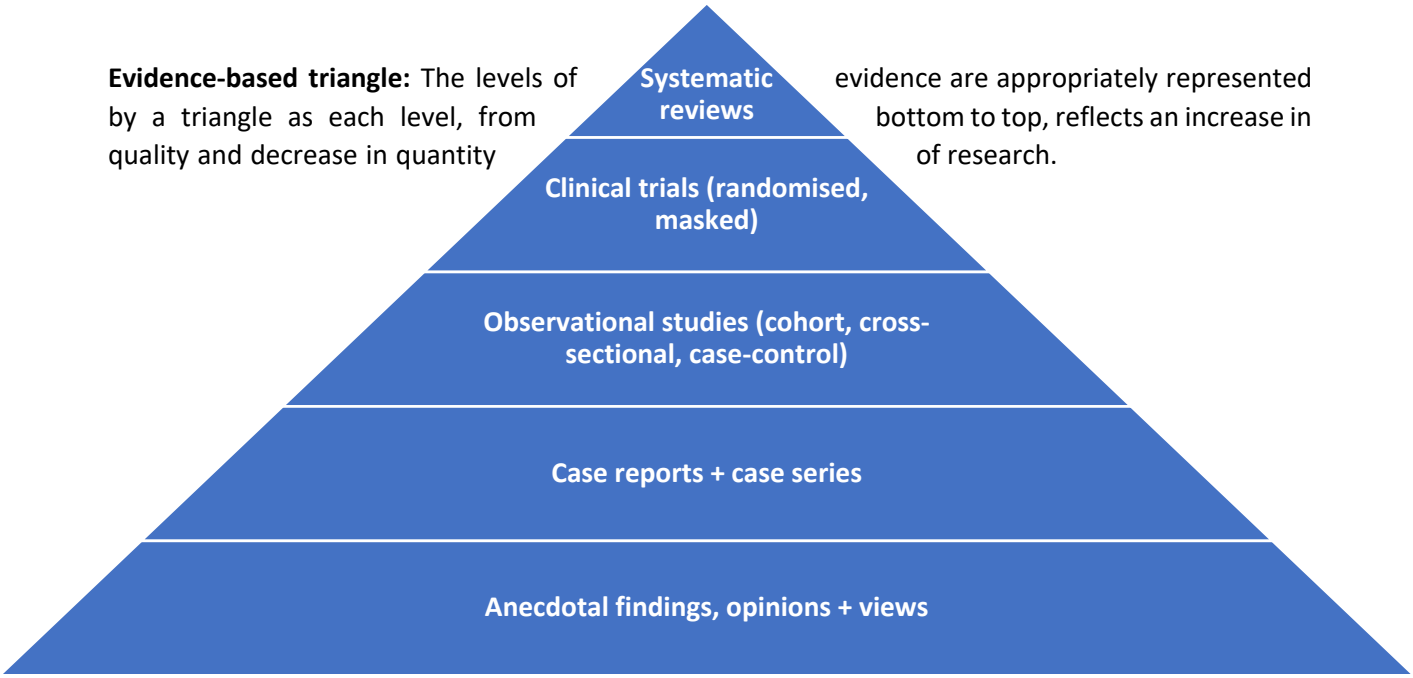
- During the discussions, your facilitator will be there as a source of 'expert information' and can help answer any questions you have. This evidence pack should help you develop an understanding of what we are aiming to achieve and prepare you to be involved in group discussions.

- It is worth mentioning that some evidence provided is brand new research which has not been published yet, therefore please treat the content of the summaries with complete confidentiality

Critical reading- a guide on how to interpret the evidence

- Evidence-based medicine entails evaluating all the current evidence and using this to make the best decision with regards to a patient's care.
  There is usually a lot of different sources of information about a particular disease or topic. These sources can vary in both quality and in what they recommend.
  Evidence-based medicine involves weighing up all available information to conclude on what course of action will provide the best possible care for animals.
  Sources of information vary in quality and level, with the different levels of evidence often being described as a triangle. The diagram below shows a simplified version of this, with the highest levels of evidence being systematic reviews and the lowest levels of evidence being individual opinions and ideas. The highest levels of evidence will be most reliable, as any conclusions drawn are the consequence of critical appraisal of several different studies. The triangle shape reflects the amount of information at each level i.e. there are lots of people with opinions and ideas but only a small number of systematic reviews. Your facilitator can advise on the level of different sources of information during the workshop discussions, so you don't need to be an expert on this, but its important to have a basic understanding of the key principles of why there are different levels of information and why this is important.
  There are 2 reasons why every research question is not answered with a clinical trial:
    1. Different types of studies are required to be able to answer different types of questions. For example, a clinical trial would be used to determine which topical treatments are best to apply to wounds at different stages of wound healing, whereas a cohort study would be used to determine the prognosis of wounds which involve synovial structures.
    2. A large amount of time and funding is required to conduct large controlled studies and unfortunately is not always readily available, meaning that researchers and practitioners will use the best information that is readily available to them which may involve using a type of study which is lower down the evidence triangle.

Evidence-based triangle: The levels of evidence are appropriately represented by a triangle as each level, from bottom to top, reflects an increase in quality and decrease in quantity of research.



Q & A

Why do you need me to help produce guidelines?

- The aim of the workshops is to help develop evidence-based guidelines to improve the recognition of wounds which require veterinary attention and to work with horse carers/owners and veterinary professional to improve first aid treatment of equine wounds.

- Evidence-based guidelines are used frequently in human medicine to improve diagnosis and/or treatment of conditions, examples of these include the 'act FAST' for recognising strokes. Our vision is to develop such guidelines for equine wounds.

- Scientists and researchers have a role to play in developing the information and evidence, however the people who will use the guidelines on a day-to-day basis should play a major role in deciding how the information and evidence is used; this is where you come in.

- As mentioned earlier, a range of different people (stakeholders) will be involved in the workshop:
    - Horse carers/owners with various experience (typographies)
    - Veterinary practitioners from a range of types of practice
    - Equine veterinary specialists
    - Veterinary Nurses
    - Equine charities and organisations

- People with varying levels of experience have to been chosen to take part, in order to allow those with more experience to share their knowledge and for those with slightly less experience to highlight which aspects of wound management, including seeking veterinary attention can be difficult.

- We need your help to produce guidelines which are practical and useful for everyone, irrespective of experience. We have developed research on how horse owners/carers currently approach and manage wounds; we need your help to determine how best to use this research in order to improve wound management and ultimately animal welfare.

What do I need to do before the workshop?

- Please take your time to read through the short summaries at the end of this booklet. Each summary presents a piece of research in the field of equine wounds and will help to supplement your current understanding of the topic.

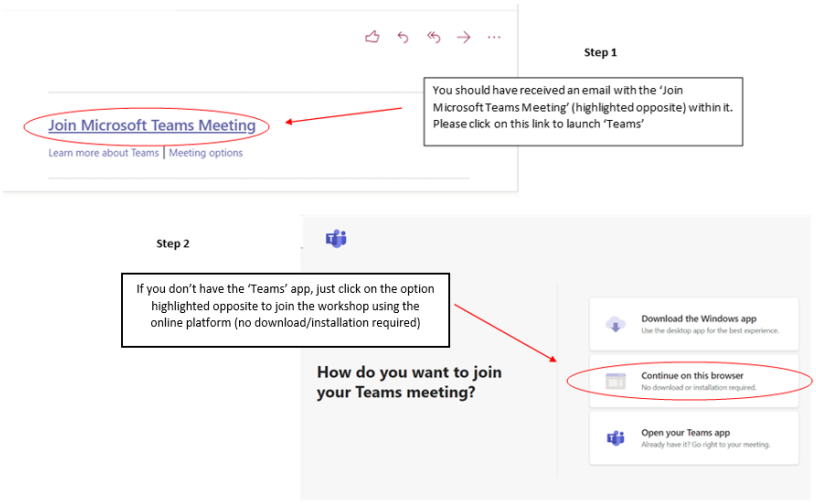
- Before the small group discussions begin, we will give short presentations, summarising the key points of the summaries supplied at the end of this booklet, therefore don't worry if you haven't had time to review the summaries of research before the workshop.

- During the discussions, your facilitator will be there as a source of 'expert information' and can help answer any questions you have. This evidence pack should help you develop an understanding of what we are aiming to achieve and prepare you to be involved in group discussions.

- Due to current circumstances surrounding Covid-19, the workshop will be held via Microsoft Teams. If you do not already have Microsoft Teams downloaded, don't worry, we will send everyone an invitation to the workshop via email. If you have not received this email invitation 48 hours prior to workshop, please contact the Equine Wound Project team and we will be able to solve any issues.

What will I have to do on the day?

- On the day of the workshop, follow the instructions on the illustration below to join the workshop. To join the workshop, all you need is internet access. Download/installation of Microsoft Team is not required. When joining the meeting please ensure you camera and speakers are turned on.



Do I have to attend?

- If you can no longer attend the workshop, please let us know as soon as possible.
- If having read the information in this booklet you have any concerns, please don't hesitate to get in contact with us. We hope that we can give you further information to reassure you, however if you wish to withdraw from the workshop you are welcome to at any time.

What happens after the workshop?

- Following the workshop, all the evidence statements generated by each of the groups will be pooled together. Using an online questionnaire, these evidence statements will then be reviewed by larger group of people, who will vote in agreement or disagreement of the statements (Delphi Process).
- Questionnaire responses will be analysed by the research team and statements will be accepted or modified depending on whether consensus has been reached. Statements where consensus is not reached are modified and then redistributed (for a maximum of 3 times) until consensus is achieved. Statements are removed if consensus is not reached following 3 rounds of modification and redistribution.
- It is important to mention at this point that, disagreement regarding the evidence statements is fine; it highlights areas which require more research or information.
- Your involvement in this first stage is critical in starting this process and from this point lots of people will be involved in voting on and modifying the statements. If you would like, we'd love for you to remain involved in the process after the workshop. We will send updates via email and all the latest work and developments will be posted on our Facebook page (Nottingham Equine colic and Wound Project).

Contact information- what to do if you need help

Research team members:

- Dr Hannah Cunningham
- Professor Sarah Freeman
- Dr John Burford
- Dr Julia Dubuc
- Dr Katie Lightfoot

As a member of the wound workshop you have the full support of the research team should you have any questions. Please do not hesitate to contact us in advance or your facilitator will be there to answer any questions you have on the day.

Email: svxhc3@nottingham.ac.uk

Summaries of presentations – SUMMARIES RELEVANT TO WORKSHOP 1

Summary 1: Cohort study of factors affecting wound healing and outcome for 219 horses

The aim of this study was to generate primary evidence on the healing and outcomes of wounds in horses and identify factors which have a significant impact on the duration of healing, cosmetic or functional outcome and treatment cost.

The results of this study showed that:

- Age, gender, height, and location of wound were all factors that were significantly associated with rate of healing or outcome.
- Mean time from injury to return to work was 12.1 weeks for limb wounds compared to 7.7 weeks for other body regions

Abstract

Background: Wounds are the second most common emergency condition in the horse. Several factors are reported as potentially impacting the rate of healing and outcome; however the current evidence is predominantly expert opinion and retrospective studies specific to referral hospital populations.

Objectives: To generate primary evidence on the healing and outcomes of wounds in horses and identify factors which have a significant impact on the duration of healing, cosmetic or functional outcome and treatment cost.

Methods: Snowball sampling was used to recruit owners whose horse had recently suffered a traumatic wound. Data was collected using recording forms from the time of initial injury through to when the wound had healed. Data collected included the horse's demographics, cause and treatment of wound, duration of wound healing and final functional and cosmetic outcome.

Results: Data for 219 wounds were obtained, with outcome data available for 139 (64%) of cases. The average age of cases was 12.4 years (range 1-30 years), 61% were geldings and the mode height was 16-16.3 hands. Eight percent of horses were not vaccinated for tetanus, 16% did not have access to emergency equine transport and 52% were not insured for veterinary fees. Factors significantly associated with rate of healing or outcome were horse's age, gender, height (mean duration of healing was 11.8 weeks for horses over 14.3hh compared to 6.4 weeks for horses under 14.3hh), and location of the wound (mean time from injury to return to work was 12.1 weeks for limb wounds compared to 7.7 weeks for other body regions).

Conclusions: This study identified factors significantly associated with duration and outcome of wound healing from a cross section of the general horse population and identified areas for further owner education.

Summary 2: BEVA primary care clinical guidelines: Wound management in the horse

Sarah L. Freeman, Neal M. Ashton, Yvonne A. Elce, Anna Hammond, Anna R. Hollis, Greg Quinn

The aim of this study was to develop evidence-based guidelines on wound management in the horse.

The results of the study were categorised into 3 groups:

A. Wound lavage and topical treatments: (i) Tap water should be considered instead of saline for lavage; (ii) Povidone iodine lavage should be considered for contaminated wounds; (iii) Topical silver sulfadiazine may not be suitable for acute wounds; (iv) Optimal lavage pressures are around 13 psi.

B. Wound debridement and closure: (i) Debridement pads should be considered for wound preparation; (ii) Larvae debridement should be considered in selected cases; (iii) Hydrosurgery should be considered in acute contaminated wounds.
C. Therapeutics for wound healing: (i) Honey may reduce duration of some phases of wound healing.

Abstract

Background: There are currently no evidence summaries on wounds in the horse.

Objectives: To develop evidence-based guidelines on wound management in the horse.

Study Design: Evidence review using the GRADE framework.

Methods: Research questions were proposed by a panel of veterinarians and developed into PICO format. Evidence in the veterinary literature was evaluated using the GRADE evidence-to-decision framework. Searches for human evidence summaries were conducted in the NICE, Cochrane and JBI databases. Final recommendations were based on both veterinary and human evidence.

Results: The research questions were categorised into three areas: A. Wound lavage and topical treatments; B. Wound debridement and closure; C. Therapeutics for wound healing. Three hundred and six veterinary publications were identified across thirteen different topics. Fourteen papers were assessed using the GRADE criteria. Twenty-five human evidence summaries were reviewed. The results were developed into recommendations:

D. Wound lavage and topical treatments: (i) Tap water should be considered instead of saline for lavage; (ii) Povidone iodine lavage should be considered for contaminated wounds; (iii) Topical silver sulfadiazine may not be suitable for acute wounds; (iv) Optimal lavage pressures are around 13 psi.
E. Wound debridement and closure: (i) Debridement pads should be considered for wound preparation; (ii) Larvae debridement should be considered in selected cases; (iii) Hydrosurgery should be considered in acute contaminated wounds.
F. Therapeutics for wound healing: (i) Honey may reduce duration of some phases of wound healing.

There was insufficient evidence to draw conclusions on the use of chemical debridement, therapeutic ultrasound, laser therapy, wound closure with staples compared to sutures, or identify optimal concentrations of antiseptic lavage solutions.

Conclusions: These findings should be used to inform decision-making in equine primary care practice.

Summary 3: Tenoscopic surgery for treatment of lacerations of the digital flexor tendon

B. S. L. Fraser, B. M. Bladon

The aim of this study was to ascertain whether laceration of the DFTS carried a better prognosis if treated by tenoscopic lavage, debridement and repair within 36 hours of the original injury.

The results of this study showed that: Treatment with 36 hours of of initial laceration carried a significantly better prognosis for return to intended athletic use than treatment after 36 h

Abstract

Reasons for performing study: Lacerations to the digital flexor tendon sheath (DFTS) are a common injury in the horse, but little information is available in the literature regarding prognostic indicators.

Objectives: To ascertain whether laceration of the DFTS carried a better prognosis if treated by tenoscopic lavage, debridement and repair within 36 h of the original injury.

Methods: A retrospective analysis of 39 horses treated surgically for lacerations to the DFTS was performed over a 3 year period. The injury-to-surgery interval was recorded as <36 or >36 h. The structures damaged by the injury were also recorded, as well as age, sex, use and outcome.

Results: Sixteen horses had laceration and contamination of the DFTS alone, of which 15 (94%) returned to their original or intended use. Sixteen horses had lacerations involving the superficial digital flexor tendon, of which 12 (75%) made a full recovery. Six horses had lacerations to both superficial and deep digital flexor tendons, 5 were subjected to euthanasia intraoperatively and one is paddock sound. Treatment within 36 h of initial laceration carried a significantly better prognosis for return to intended athletic use (25 of 28 horses allowed to recover from anaesthesia) than treatment after 36 h (2 of 5 P = 0.03; Fisher's Exact Test).

Conclusions: If sepsis is treated early using tenoscopic visualisation, lavage and repositol antibiotics, the limiting factor in return to athletic function is tendon damage.This study supports anecdotal evidence that early treatment of synovial sepsis improves the prognosis for return to intended use. It also provides information on prognostic indicators including extent of damage to collateral structure

Summary 4: Factors associated with survival to hospital discharge following endoscopic treatment for synovial sepsis in 214 horses

P. I. Milner. D. A. Bardell, L. Warner, M. J. Packer, J. M. Senior, E. R. Singer, D. C. Archer

The aim of this study was to investigate pre-, intra- and post operative factors involved in short-term survival of horses undergoing endoscopic treatment for synovial sepsis.

The results of this study showed that:

- The presence of a wound on admission to hospital was associated with short-term survival

Abstract

Reasons for performing study: To determine risk factors involved in survival to hospital discharge of cases of synovial sepsis.

Objectives: Investigate pre-, intra- and post operative factors involved in short-term survival of horses undergoing endoscopic treatment for synovial sepsis

Study design: Retrospective case series.

Methods: Clinical data were obtained for horses (>6 months old) undergoing endoscopic surgery as part of management for synovial sepsis over a 7-year period in a single hospital population. Descriptive data were generated for pre-, intra- and post operative variables. Multivariable logistic regression analysis was used to develop 3 models related to presurgical, surgical and post surgical stages of management with outcome defined as survival to hospital discharge.

Results: Two hundred and fourteen horses were included. In Model 1 (preoperative variables), increased preoperative synovial fluid total protein (TP) was associated with nonsurvival (OR 0.88, 95% CI 0.83–0.94, P<0.001) whereas the presence of a wound on admission was associated with survival (OR 4.75, 95% CI 1.21–18.65, P = 0.02). Model 2 (intraoperative variables) revealed that factors associated with decreased survival were anaesthetic induction outside of normal working hours (OR 0.36, 95% CI 0.15–0.88 P = 0.02) and presence of moderate/severe synovial inflammation at surgery (OR 0.28, 95% CI 0.12–0.67, P = 0.004). Model 3 (post operative variables) showed that increased post operative synovial fluid TP (OR 0.94, 95% CI 0.90–0.98, P = 0.013) and undertaking more than one endoscopic surgery for treatment (OR 0.19, 95% CI 0.05–0.70, P = 0.005) were associated with nonsurvival. Cut-off values for predicting survival were 55–60 g/l for preoperative and 50–55 g/l for post operative TP measurements.

Conclusions: This study has identified factors associated with altered likelihood of survival to hospital discharge following endoscopic surgery for synovial sepsis. Prognosis for survival to hospital discharge can be based on evidence from this study at the key stages of management of horses with synovial sepsis.

SUMMARIES RELEVANT TO WORKSHOP 2

Summary 5: Owner experience, knowledge and attitudes towards different aspects of equine wound management: A survey of 1037 horse owners

R. Birnie, J. Dubuc, J.H. Burford, G.C.W England, E.C. Hannelly and S.L. Freeman

The aim of this study was to gain an insight into horse- owners' experience, knowledge and attitudes towards different aspects of equine wound management.

The results of this study showed that:

- Most participants had previous experience of wounds
- 13% of participants cared for horses that were not appropriately vaccinated for tetanus
- 21% of horse owners selected that a puncture wound over the digital flexor tendon sheath required emergency veterinary treatment
- 26% of horses did not correctly identify the presence of excessive granulation tissue in a chronic non-healing wound and 23% of participants said that it did not require veterinary attention

Abstract

Background: Wounds are one of the most common conditions seen in the horse and vary greatly in terms of presentation and severity. Effective management relies on owners being able to recognise injuries which require veterinary treatment and apply appropriate first aid.

Objectives: To gain an insight into horse- owners' experience, knowledge and attitudes towards different aspects of equine wound management.

Methods: An online survey was distributed using snowball sampling. Data collected included the owners' demographics, preventative care for their horse, prior wound experience and how they would manage seven case scenarios (puncture wound, kick injury, flank wound, haemorrhage, degloving injury, exuberant granulation tissue (EGT) and infection), including whether they would call a vet and any first aid measures they would apply.

Results: There were 1037 responses. The majority of participants had previous experience of managing wounds in horses (95%). Thirteen percent of participants cared for horses that were not appropriately vaccinated for tetanus, 37% of participants had all horses under their care insured for veterinary fees. Less than a quarter of owners (21%) selected that a puncture wound over the digital flexor tendon sheath required emergency veterinary treatment. Over a quarter (26%) did not correctly identify the presence of EGT in a chronic non- healing wound, and a similar proportion (23%) said that it did not require veterinary treatment. There was a significant difference between participants which had their own horses insured and whether they would call the vet for several scenarios.

Conclusions: This study identified that many owners do not recognise the significance of wounds over synovial structures or sequela such as EGT. These should become the focus of further education, to improve the health and welfare of horses with wound injuries.

Summary 6: Wounds in UK primary-care equine practice: prevalence, clinical presentation, management, outcomes, and risk factors for occurrence

S. Allen, D. Brodbelt, J. Slater, K. Verheyen

The aim of this study was to estimate wound prevalence in a cohort of veterinary-attended horses/ponies, describe their clinical presentation, management and outcomes and explore risk factors for veterinary-attended wound occurrence.

The results of this study showed that:

- Distal limbs are the most common site of injury
- Systemic antimicrobials were prescribed in 79.5% of cases
- Bandaging was performed in 31.1% of cases
- Complications including cellulitis/lymphangitis, excessive granulation tissue and synovial sepsis occurred 12.5%, 3.8% and 3.2% respectively
- Wounds were more common in summer and less common in older horses and draught and pony breeds

Abstract

Background: Equine wounds are a common reason for veterinary attendance, yet little information exists describing their occurrence, treatment, outcomes or associated risk factors.

Objectives: To estimate wound prevalence in a cohort of veterinary-attended horses/ponies, describe their clinical presentation, management and outcomes and explore risk factors for veterinary-attended wound occurrence.

Study design: Retrospective analysis of electronic patient records (EPRs).

Methods: Anonymised EPRs for all horses/ponies attended by five UK equine practices between 14 October 2016 and 13 October 2017 were collected via a bespoke data-capture system, Equine

VetCompass™. Wound cases were identified using electronic keyword searches and manual EPR review. Wound prevalence and associated 95% confidence interval (CI) were calculated. Location, treatments and complications were reported by percentages and 95% CIs. A nested case-control study evaluated risk factors for veterinary-attended wound occurrence, with data analysed using mixed effects multivariable logistic regression.

Results: Of 25 693 horses/ponies, 1363 presented with wounds (prevalence 5.3%, 95% CI 5.0%-5.6%). A total of 1444 wound events were reported, with 94.9% of wounded horses seen for a single event only. The distal limb was the most common site of injury (n = 595/1376, 43.2%, 95% CI 40.6%-45.9%). Systemic antimicrobials were prescribed in 1148 (79.5%, 95% CI 77.3%-81.5%) wound events. Bandaging was performed in 449 (31.1%, 95% CI 28.8%-33.5%) events. Complications included cellulitis/lymphangitis (n = 180, 12.5%, 95% 10.9-14.3), exuberant granulation tissue (n = 55, 3.8%, 95% CI 2.9%-4.9%) and synovial sepsis (n = 46, 3.2%, 95% CI 2.4%-4.2%). Wounds were more common in summer and less common in older horses and draught and pony breeds.

Conclusions: Most wounds were simple and without serious consequence. Younger animals, certain breeds and horses presented in summer had greater odds of veterinary-attended wound occurrence. Work is needed to improve clinical record keeping and explore modifiable management-level risk factors for equine wounds.

18.4 Appendix 4

Facilitator guide for wound workshops

Thank you for agreeing to facilitate the discussion groups for the wound workshop. This document has information on how the day will run, what your role as a facilitator will be, and some suggestions on how to facilitate. We can also provide guidance, training or talk through your role via Microsoft Teams before the session date. Please do not hesitate to get in touch if you would like any additional support.

Overview of the workshops.

Each of the 2 workshops will have a range of different people will be participating in the workshop, who will all be arranged into small mixed groups for the discussion sessions which will take place via Microsoft Teams.

Aims and objectives

The overall aim of the wound workshop and Delphi process:

"To improve the recognition of wounds which require veterinary attention and to work with horse carers/owners and veterinary professional to improve first aid treatment of equine wounds."

We've then split this overall aim into 2 objectives, the first we will discuss in workshop one and the second we will discuss in workshop two.

Workshop objectives:

- To describe the approach for determining whether or not an equine wound requires veterinary attention
- To describe the first aid treatment of equine wounds
- To identify where further education / training / research is required
    - Where do you think we would benefit from more undergraduate and post-graduate and client education / research / training?

The plan is for the group to generate a set of evidence statements for each objective based on the conclusions of the group discussion and research evidence that have been provided.

Evidence statements are short summaries of evidence, which in this case are going to be used to guide owners/carers of horses on the topic of wounds.

When generating evidence statements its important to ensure they are specific and provide enough detail to be clearly interpreted.

Example 1:

"*A horse that suddenly lame probably has a fracture"*

- This statement does not explain what 'very lame' is, and there are many different causes of 'very lame' horses and different types of fracture and 'probably' is difficult to interpret.
- This statement could be improved by being more specific and sometimes more than once statement is needed to cover different areas

"A fracture should be considered as a possible cause of lameness in a horse which presents with acute onset, severe (non-weight-bearing) lameness"

<u>Time management</u>

Each group should work through the objectives in the order outlined above, as they follow a logical progression. The discussion is schedule for approximately 2.5- 3 hours but do not worry if you finish early. All we ask is that you ensure the group has discussed all three objectives thoroughly. We anticipate that the first session to be reasonably straightforward, there will be some debate but probably not too contentious. The first one is always a little more difficult as the group will be getting to know each other and getting used to the process, so don't worry if it takes a while to get everyone warmed up. It is important to remember that you can also go back and revisit this or any of the objectives at any point. Disagreement is fine and we want to capture debate/

<u>How to facilitate on the day</u>

Introduction: introduce everyone to each other- this should include their name and job role/experience. Depending on whether or participants have the Microsoft Teams app downloaded, they may be able to see everyone participating or may only be able to see the person who is talking, this consider it is important that you lead the introductions. Each group will contain a mixture of people with varying levels of knowledge and experience. Regardless of experience, everyone's opinions are important to generate guidelines that are useful for everyone.

Topic: introduce the aims of the workshops and explain what evidence statements are

- The plan is for each group to generate a list of evidence statements for each objective based on the conclusions drawn from group discussions and the evidence which has been provided to all participants prior to the workshops
- Evidence statements are short summaries of evidence, which in this case are going to be used to guide horse owners/carers of horses on the topic of wounds
- When generating evidence statements its important to ensure they are specific and provide enough detail to be clearly interpreted

Stimulating the discussed: a good way to start is to ask everyone to brainstorm and throw out lots of ideas and opinions as a starting point. You can then write all these down and ask the group to discuss each one- you will find some that everyone agrees on, some which need improving or modifying to achieve agreement and some that people don't agree on. A suggestion of how to work through these are:

- Get one person to read through each one
- Sort into piles according to agreement from everyone
- As discussions and differences of opinion arise make sure they are recognised and included in your sorting NB if people disagree about things, then try and pick a detail to focus on e.g. does this clinical sign only occur in certain types of cases, is it difficult for some owners to recognise. You may need to make some assumptions/read between the lines.
- Don't worry about getting everyone to agree – disagreement is fine, and the next stage involves getting a larger number of people to vote on the statements, and this is where we determine consensus

Deciding which statements to include: the next stage is to come up with the list of evidence statements that you want to keep. These can be ones where everyone agrees and also ones where there is disagreement, or where people think more research / information is needed. You can generate this list by:

a. Ask the group to identify which they consider to be most important and should be included
b. If there is disagreement or discussion on this, then ask everyone to vote or tick each statement that they think should be included for areas where there is disagreement / issues with the evidence or recommendations, ask the group to consider solutions
    i. Is more research needed to decide on this?
    ii. Is this something vets / owners should be doing but more training is needed?
c. For each final evidence statement, please include information on the source of this evidence (e.g. research study, personal experience, opinion etc)

<u>Basic principles of facilitation</u>

Key principles of facilitation:

- Keeping the group focused on one item at a time until decisions are reached
- Monitor the flow of discussion- encourage quiet people, or those with the most relevant expertise and limit those who tend to do a lot of talking
- Clarify and summarise points, check for consensus and formalise decisions
- Help the group deal with any conflicts which may occur
- Ensure the group keep on track and to time

- As a facilitator you are not required to make decisions for the group
- A good facilitator stays neutral and helps the members of the group work together to achieve their aims

Basic skills for facilitation:

- Patience and listening skills
- Managing personalities if necessary
- Giving factual information if required but avoiding your own opinion influencing discussions
- Ensuring loud people don't dominate discussions
- Being flexible with how the session is going

Examples of evidence statements

Please ensure evidence statements generated by the group are specific and provide enough detail to be clearly interpreted. Creating such statements is where you group will really require your guidance and facilitation as the majority of participants will have limited experience in this area.

Example 1:

"*A horse that suddenly lame probably has a fracture"*

- This statement does not explain what 'very lame' is, and there are many different causes of 'very lame' horses and different types of fracture and 'probably' is difficult to interpret.
- This statement could be improved by being more specific and sometimes more than once statement is needed to cover different areas

"*Horses that have a complete displaced fracture which affects a major weight-bearing structure in the leg will present with acute onset, severe (non-weight-bearing) lameness"*

"Horses that have non-displaced or 'stress fractures' or fractures of a non-weight-bearing structure can present with varying degrees of lameness (and may be able to weight-bear with only a mild lameness when trotted)"

"A fracture should be considered as a possible cause of lameness in a horse which presents with acute onset, severe (non-weight-bearing) lameness"

- Try to avoid making 'rules' as there are always exceptions

Example 2:

"Horses with fractures must not be moved without a Kimzey splint being applied"

- This can again be improved by being more specific and giving guidance. Kimzey splints are only appropriate for certain types of injury

"If an unstable load-bearing fracture is suspected, then an appropriate limb support or splint should be applied before transporting the horse to facilities for further assessment"

Example 3:

The examples below are statements from a Delphi process on imaging and referral for brain tumours in children, which were then used to develop guidelines for families, doctors and health care professionals. The examples illustrate that you need to generate statements that confirm the obvious points that everyone agrees on e.g. the use of MR imaging and highlight areas which are not valuable e.g. ultrasound imaging.

“MR imaging is the modality of choice for making the diagnosis”

“Ultrasound has no place in the exclusion of CNS tumours in infants”

“For MR imaging, contrast enhancement is not routinely required”

“Results of imaging should be fed back to family within a week by the clinical team requesting the scan”

“Practice nurses and health visitors should be training in red flag symptoms”

- These statements were generated from the workshops and then circulated through a Delphi Process, where a larger group of people were asked to vote on whether they agreed or not
- Remember that your group’s statements are the starting point for this process. They don’t have to be perfect, as we will combine and develop the statements from all groups to generate statements to be used in the Delphi Process. During this stage, they will be voted on and modified if necessary.
- It is important that everyone in the group is involved in generating these statements and that they are both specific and achievable in order to be able to use them in the next stage

Thanks again for agreeing to help with the Equine Wound Project workshops! If you have any questions or problems, please contact me (Hannah Cunningham) via email: svxhc3@nottingham.ac.uk OR Mobile: 07588607648

18.5 Appendix 5

University of Nottingham
UK | CHINA | MALAYSIA

Equine wounds- what do you do?

Page 1: Equine Wound Project

Thank you for taking time out of your day to take part in the next step of The British Horse Society and The University of Nottingham's Equine Wound Project!

The following survey aims to establish what horse owners/carers know about wounds and what they would do if their horse sustained a wound.

The final part of this survey will provide you with up to date evidence on wound first aid, which we hope you will find extremely useful.

The following questionnaire should take about 10 minutes to complete. This is not a test, so if you don't know some of the answers to any of the following questions, please just leave them blank. If you have any additional comments, please leave these in the comments section you will find at the end of the survey.

Further information about the study can be obtained by contacting the team: **equinewoundproject@nottingham.ac.uk** OR visit our Facebook page:
www.facebook.com/nottinghamequineresearch

Thank you in advance for your help with this study,

The Equine Wound Project Team

Contact details:

Principal Researcher: Dr Hannah Cunningham (MRes student) svxhc3@nottingham.ac.uk

Lead Supervisor: Professor Sarah Freeman sarah.freeman@nottingham.ac.uk

Additional Supervisors: Dr Julia Dubuc, Dr John Burford, Professor Gary England

Research Ethics Officer: Professor Richard Lea richard.lea@nottingham.ac.uk

Page 2: Consent Form

Participation in this research is entirely voluntary and there is no obligation to take part. Please note you must be over 18 years of age to take part.

This study has been approved by the School of Veterinary Medicine and Science's ethics committee.

Completion of this form indicates that you agree to participate in The Equine Wound Project and that you understand any information collected by the researchers:

- will be anonymised and treated confidentially
- will only be accessed by research colleagues
- will be uploaded into a secure database on a computer
- will be stored for 7 years after the study has ended and then deleted
- will be used as part of a research study
- may be included in research publications
- may be presented at research meetings or conferences

As a participant of this study you can request a copy/summary of the completed study and/or request a copy of information obtained during the data collection process.

1. If you are willing to participate in this study, please give formal consent by filling in the section below. *
Required

Please select at least 2 answer(s).

- [ ] I confirm that I am over 18 years of age
- [ ] I have read and fully understood all information regarding consent and agree to the terms of participation in this study

Page 3: Personal information

The following section is about you and your involvement with horses. Your answers will be treated with the strictest of confidence and only used for the purposes of communicating information about the wound project.

2. If you are happy to do so, please tell us your gender

- ☐ Female
- ☐ Male
- ☐ Transgender
- ☐ Non-Binary
- ☐ Prefer not to say

3. Do you live in the United Kingdom? (this includes Scotland, England, Wales and Northern Ireland)

- ☐ Yes
- ☐ No

3.a. If yes, please indicate where in the UK you currently live?

- ☐ East Midlands
- ☐ East of England
- ☐ Greater London
- ☐ North East
- ☐ North West
- ☐ Northern Ireland
- ☐ Scotland
- ☐ South East
- ☐ South West
- ☐ Wales
- ☐ West Midlands
- ☐ Yorkshire and the Humber

3.b. If no, please let us know in which country you live in.

4. How long have you been involved in the care of horses? (Please enter a number followed by years, months, etc.)

5. Do you hold any of the following UK Equestrian qualifications? (Please tick all that apply)

- ☐ I do not hold any formal UK equestrian qualifications
- ☐ Association of British Riding Schools (ABRS) Qualification
- ☐ British Horse Society (BHS) Qualification
- ☐ College Course Qualification (e.g. Equine NVQ, National Diploma)
- ☐ Pony Club Qualification
- ☐ Postgraduate Qualification (e.g. Equine Masters or PhD degree)
- ☐ UK Coaching Certificate (UKCC) Equestrian Pathway
- ☐ Undergraduate Qualification (e.g. Equine Bachelor's degree)
- ☐ Veterinary Medicine Qualification
- ☐ Veterinary Nursing Qualification
- ☐ Other

5.a. If you selected Other, please specify:

5.b. Thinking about the equine qualification/s you have told us about, which of the following statements best describes how the topic of equine wounds was covered during your equine course/s?

- ☐ The topic of wounds was extremely well covered during my equine course/s
- ☐ The topic of wounds was fairly well covered during my equine course/s
- ☐ The topic of wounds was not well covered during my equine course/s
- ☐ The topic of wounds was not covered at all during my equine course/s

Page 4: Equine Wounds- What are your thoughts?

In this section of the survey, we would like to know what you know about wounds and first aid. Every owner's knowledge and experience will be different, so please answer all questions as honestly as possible.

NOTE: The following section contains images of wounds that some people may find distressing.

6. If your horse sustained a wound, where's the first place you'd seek advice from?

- ☐ Friends and family
- ☐ Other horse owners
- ☐ Livery yard owner
- ☐ Vet
- ☐ Social media e.g. Facebook
- ☐ Online resources e.g. BHS website
- ☐ Other

6.a. If you selected Other, please specify:

6.b. Of the following sources of information/advice, which would you consider the most trustworthy?

6.b.i. If you selected Other, please specify:

6.c. Of the following sources of information/advice, which would you consider the least trustworthy?

- ☐ Friends and family
- ☐ Other horse owners
- ☐ Livery yard owner
- ☐ Vet
- ☐ Social media e.g. Facebook
- ☐ Online sources e.g. BHS website

- [ ] Other

6.c.i. If you selected Other, please specify:

7. When cleaning a wound which solution are you most likely to use in order to clean the wound?

- [ ] Dilute hibiscrub
- [ ] Dilute iodine
- [ ] Saline
- [ ] Cooled boiled water
- [ ] Tap water
- [ ] Salt water
- [ ] Other

7.a. If you selected Other, please specify:

8. Of the following topical wound treatments, which are currently in your first aid kit? Please select all that apply.

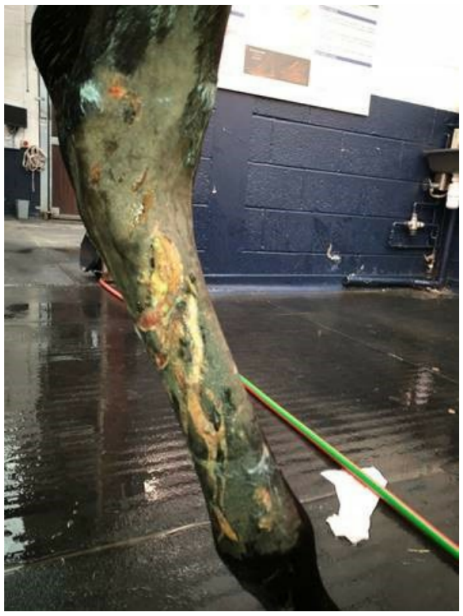
- [ ] Purple spray
- [ ] Silver spray
- [ ] Manuka honey
- [ ] Intrasite gel/hydrogel
- [ ] Savlon/Germoline
- [ ] Sudocrem
- [ ] Wound powder
- [ ] Other

9. Of the following topical wounds treatments, which would you most commonly apply to wounds?

- ☐ Purple spray
- ☐ Silver spray
- ☐ Manuka honey
- ☐ Intrasite gel/hydrogel
- ☐ Savlon/Germoline
- ☐ Sudocrem
- ☐ Wound powder
- ☐ Other

9.a. If you selected Other, please specify:

10. What stage of wound healing does the picture below represent?



- Haemostasis
- Inflammation
- Proliferation
- Remodelling

10.a. How would you manage this wound?

- Do nothing
- Administer first aid
- Ring the vet for advice
- Ring the vet for a routine visit
- Ring the vet for an emergency visit
- Other

10.a.i. If you selected Other, please specify:

10.b. If you selected 'administer first aid', please describe the first aid treatment you would administer in the text

box below.

11. What stage of wound healing does the picture below represent?

- Haemostasis
- Inflammation
- Proliferation
- Remodelling

11.a. How would you manage this wound?

- Do nothing
- Administer first aid

- Ring the vet for advice
- Ring the vet for a routine visit
- Ring the vet for an emergency visit
- Other

11.a.i. If you selected Other, please specify:

11.b. Please explain your reasoning for selecting the option chosen above.

12. What would you do if your horse sustained the wound shown in the picture below? (the wound is located

on the forelimb over the front of the knee/carpus)

- Do nothing
- Administer first aid
- Ring the vet for advice
- Ring the vet for a routine visit
- Ring the vet for an emergency visit
- Other

13. How would you manage the wound in the picture below? (Please give as much detail as possible)

13.a. Name the complication of wound healing shown in the picture above

Page 5: Equine Wounds- the latest evidence

The final section of this survey contains up to date facts about equine wounds, based on recent evidence and recommendations from stakeholder and expert workshops. For each wound 'fact' we would like to know whether you knew this information already and whether this information would change what you would do if your horse sustained a wound. We are interested in your thoughts and opinions, so there are no right or wrong answers. (If you would like to provide us with more information regarding any of your answers in this section, please use the free-text box at the bottom of the page).

NOTE: Evidence and further information regarding each of the topics discussed in this section can be found at the end of the survey.

14. **Cleaning wounds with tap water is just as good as cleaning wounds with sterile saline.** Recent studies found no difference in healing for wounds cleaned with tap water when compared to wounds cleaned with sterile saline. Removing debris inc. mud, wood, bedding etc. quickly is important in decreasing the risk of infection.

- I knew this information before
- I didn't know this information before

14.a. After reading the information above, how do you think your approach to cleaning wounds will change?

- I will continue to use tap water to clean wounds
- I will now start to use tap water to clean wounds
- I might now consider using tap water to clean wounds
- I probably won't use tap water to clean wounds
- I will never use tap water to clean wounds

14.b. Please use the space below to add any further information on why your approach to wound care would not change after reading the information above.

15. **Wounds heal by growing new skin/epithelial cells which close the deficit created by the wound.** These new cells are fragile and therefore products which are cytotoxic will slow down growth or even kill these cells. Some commonly used topical treatments may contain substances which can be detrimental to wound healing. *Purple Spray:* The ingredients in Purple Spray vary significantly, with most containing alcohol and purple dye, both of which are cytotoxic substances. *Wound Powder:* When applied to open wounds, Wound Powder can cause a foreign body reaction which causes inflammation. This inflammation can impede wound healing. *Silver Spray:* Although is has anti-bacterial properties, Silver can also be cytotoxic, therefore should only be used on wounds where controlling infection is the main aim. *Oil-based creams:* These creams form a barrier of the surface of the wound which can protect it. However, this barrier can trap bacteria in the wound bed, therefore shouldn't be used in wounds where infection is a risk. The barrier created by these creams also prevents oxygen from getting to the wound which is required for the new cells to grow.

- I knew this information before
- I didn't know this information before

15.a. After reading the information above, how do you think your use of Purple Spray will change?

- I will continue not to use Purple Spray on wounds
- I will now not use Purple Spray on wounds
- I might now consider not using Purple Spray on wounds
- I probably will continue to use Purple Spray on wounds
- I will always use Purple Spray on wounds

15.a.i. After reading the information above, how do you think your use of Wound Powder will change?

- I will continue not to use Wound Powder on wounds
- I will now not use Wound Powder on wounds
- I might now consider not using Wound Powder on wounds
- I probably will continue to use Wound Powder on wounds
- I will always use Wound Powder on wounds

15.a.ii. After reading the information above, how do you think your use of Silver Spray will change?

- I will continue not to use Silver Spray on wounds
- I will now not use Silver Spray on wounds
- I might now consider not using Silver Spray on wounds
- I probably will continue to use Silver Spray on wounds
- I will always use Silver Spray on wounds

15.a.iii. After reading the information above, how do you think your use of Oil-based Creams will change?

- I will continue not to use Oil-based Creams on wounds
- I will now not use Oil-based Creams on wounds
- I might now consider not using Oil-based Creams on wounds
- I probably will continue to use Oil-based Creams on wounds
- I will always use Oil-based Creams on wounds

15.b. Please use the space below to add any further information on why your approach to wound care would not change after reading the information above.

16. **Excessive granulation tissue ('proud flesh') is a common complication of wound healing.** Excessive granulation tissue (EGT) is a product of excessive fibroplasia resulting in granulation tissue sitting proud above the level of the skin, which in-turn impedes wound healing. Although not a medical emergency, wounds with EGT require veterinary attention, most commonly surgical excision in order to promote wound healing.

- I knew this information before
- I didn't know this information before

16.a. After reading the information above, do you think your approach to excessive granulation tissue will change?

- I will continue to call my vet when granulation tissue becomes excessive
- I will now start to call my vet when granulation tissue becomes excessive
- I might now consider calling my vet when granulation tissue becomes excessive
- I probably wouldn't call my vet when granulation tissue becomes excessive
- I wouldn't call my vet when granulation tissue becomes excessive

16.b. Please use the space below to add any further information on why your approach to wound care would not change after reading the information above.

17. **Small puncture wounds have the potential to be severe if they are located over synovial structures.** Synovial structures include joints and tendon sheaths. 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 and result in euthanasia.

- I knew this information before
- I didn't know this information before

17.a. After reading the information above, how do you think your approach to puncture wounds will change?

- I will continue to call my vet out/call my vet for advice when my horse sustains a puncture wound
- I will now call my vet out/call my vet for advice when my horse sustains a puncture wound
- I might consider calling my vet out/calling my vet for advice when my horse sustains a puncture wound
- I probably wouldn't call my vet out/call my vet for advice when my horse sustains a puncture wound
- I would always manage a puncture wound myself

17.b. Please use the space below to add any further information on why your approach to wound care would not change after reading the information above.

18. If you have any comments on the survey, please leave them in the box below.

Page 6: References and further information

Below are the links to the latest research on the areas discussed throughout the survey. If you have any further questions, please feel free to contact a member of the research team.

Tap water Vs. Sterile saline

Wound management in the horse. https://beva.onlinelibrary.wiley.com/doi/10.1111/evj.13289

Topical wound treatments

How do I clean a wound? https://www.nhs.uk/common-health-questions/accidents-first-aid-and-treatments/how-do-i-clean-a-wound/

Effect of different wound dressings on cell viability and proliferation https://pubmed.ncbi.nlm.nih.gov/16799377/

Consensus on Wound Antisepsis https://pubmed.ncbi.nlm.nih.gov/29262416/

Excessive granulation tissue

Treatment of exuberant granulation tissue. Treatment of exuberant granulation tissue - ScienceDirect

Wounds with synovial structure involvement

Meta- analysis of cilnical factors affecting synovial structure infections and prognosis. Meta-Analysis of Clinical Factors Affecting Synovial Structure Infections and Prognosis - ScienceDirect

Page 7: Final page

Your participation in this survey is very much appreciated. Our continued research wouldn't be possible without you.

We hope that you have found the information in this survey useful.

Further information regarding The Equine Wound Project and future events and projects can be found on our Facebook page: **www.facebook.com/nottinghamequineresearch**

Should you have any further questions, please contact The Equine Wound Project Team.
Email: **equinewoundproject@nottingham.ac.uk**

Thanks again for taking the time to participate!