Caspian Journal of Environmental Sciences
Online ISSN: 1735-3866
Print ISSN: 1735-3033

Human and animal bites

Mohammad Darvishi[1], Ali Omrani nava[2], Ebrahim Karimi[2], Majid Nouri[3], Saeed Solaiman Meigooni[3], Seyed Zia Hejripoor[4]*

1. Infectious Diseases and Tropical Medicine Research Centre (IDTMRC), Department of Aerospace and Subaquatic Medicine, AJA University of Medical Sciences, Tehran, Iran
2. Department of Emergency Medicine, Besat Hospital, AJA University of Medical Sciences, Tehran, Iran
3. Infectious Diseases and Tropical Medicine Research Centre (IDTMRC), AJA University of Medical Sciences, Tehran, Iran
4. Department of Emergency Medicine, Besat Hospital, AJA University of Medical Sciences, Tehran, Iran

** Corresponding author's Email: ziahejri@gmail.com*

ABSTRACT

Humans and animal bites are a significant public health problem, with the majority of bites coming from dogs, cats and humans. According to the Centres for Disease Control and Prevention (CDC) data, 250,000 human bites, 400,000 cat bites, and 4.7 million dog bites occur each year in the United States in adults and children, and 20% of these victims require medical care for injuries sustained. The estimated healthcare cost associated with management of cat and dog bites in the United States is > $ 850 million annually and does not take into account the costs to the patient in terms of time off work, rehabilitation, and permanent impairment. Infection is the most common bite-associated complication. The relative risk is determined by the species of the inflicting animal, bite location, host factors, and local wound care. Most infections bring about by mammalian bites are poly-microbial, with mixed aerobic and anaerobic species. The clinical presentation and appropriate treatment of the infected bite wounds vary according to the causative organisms. Human bite wounds have long had a bad reputation for severe infection and frequent complication. This article reviews the dog, cat and human bite. The content of this article provide a comprehensive overview of the types of bites, epidemiology, risk factors, microbiology, as well as using clinical guidelines and treatment through antibiotic therapy.

Keywords: Human bite, Animal bites, Infection, Epidemiology, Microbiology, antibiotic therapy.
Article type: Review Article.

INTRODUCTION

Approximately half of individuals are bitten by animals or other humans during their lifetime. The human and animal bites are ordinary injuries, considering as one of the frequent reasons for receiving primary care and referring to emergency centres (Griego *et al.* 1995; Bula-Rudas & Olcott 2018; Khoobdel *et al.* 2020). Annually, 330,000 emergency visits are associated with bites in the United States. According to the World Health Organization (WHO), 10 million people around the world get rabies prevention treatment after animal bites (especially dogs), and about 55,000 people die from bites every year (Gelvez *et al.* 2017). In the United States, an average of 15-20 people die every year after dog bites, most are infants. Most of the bite incidents are attributed to dogs, cats and humans, respectively. Findings from studies have indicated that about 60-80% of the bites are associated with dogs, 20-30% to cats, 1-3% to other animals (rabbits, guinea pigs, hamsters, and mouse). In addition, in urban areas, 20% is related to one person being bitten by another person. Of course, the exact amount of the human and animal bites is not known with great certainty due to the fact that partial injuries are treated without consultation with health care professionals (Kennedy *et al.* 2015). Apart from the harmful health effects, human and animal bites and diseases resulting from such bites impose a great financial burden on the country. So,

this matter has frequently been one of the concerns of the relevant authorities. Increasing the number of human and animal bites forces the government to purchase and store medicine and vaccines for the prevention, treatment of bites, related diseases, and subsequently the government's expenses decline. Findings from studies conducted in the United States have indicated that approximately 10% of human bites would end in infection in infants. The rate of infection after the dog and cat bites in infants has been computed by 20% and 50%, respectively. Infected wounds after bites with swelling and erythema may cause serious complications. Most wounds coming from animal bites are poly-microbial. *Pasteurella* spp. are the most prevalent organisms isolated from dog and cat bites. The human bite microbiology includes aerobic and anaerobic bacteria. Primary medical measures to control bite wounds include perfect cleansing and removing lesions from the bite area, washing and dressing. In addition, it seems necessary to obtain a microbial culture depending on the type of bite wound, the appearance of the wound and the time of medical evaluation after the initial injury. Amoxicillin-clavulanic acid is the first line of defence for the prevention and treatment of human and animal bites in individuals having not allergy to penicillin. Historically, mortality from bite wounds has been significant. Results of the studies have shown that a third of the patients needed amputation if care was delayed more than 24 h after the initial injury (Bula-Rudas & Olcott 2018). Therefore, the current study discusses the types of wounds, epidemiology, risk factors, bacteriology, and the use of clinical guidelines and treatment with antibiotic drugs to prevent side effects after bites.

MATERIALS AND METHODS

The present paper aims to investigate the relationship between human and animal bites through grouping researched topics from 1980 to 2019. The evaluation has been conducted in 2019 and PubMed, Medline, Cochran Library, WHO, IranMedex databases were applied to achieve the desired articles. To gather required information related to human and animal bites, a study was conducted using the keywords including dog, cat, human bite, animal bite, bite, wounds, infection, epidemiology, risk factors, bacteriology, application of clinical guidelines and antibiotic therapy. Amongst 345 articles, 54 ones have been reviewed here. So that, they were appropriate as to the topic coverage, content structure, and aspect of communication.

Epidemiology

It is estimated that approximately 250,000 human bites (an individual bitten by another), 400,000 cat bites, and 4.5 million dog bites occur for infants and adults in the United States each year. In general, 50% of the society experiences an animal or human bite once in their lifetime. Over 90% of such bites are bring about by domestic animals and in childhood. Dogs are assumed to bring about 80-90% of these bites. Though communicating with dogs potentially has many merits from a mental and physical view points, such a close communication may come to danger (Dhillon *et al.* 2019). The risk of dog bites is a general public health concern. In general, nearly 20 deaths are reported after dog attacks in the United States annually. Sepsis and intracranial infections were the most considerable bring about. In general, about 20% of all wounds brought about dog bites lead to infection. It is difficult to accurately estimate the amount of dog bites, the severity of injuries and the breeds that bring about the most bites. According to data published by the Centres for Disease Control and Prevention (CDC), 4.7 million people are bitten by dogs annually in the United States, and almost 20% of them require medical care due to injury. Meanwhile, bite wounds in infants appear a more serious problem, and results from the research indicate that they are more at risk (Essig *et al.* 2019). The prevalence and incidence of bite wounds vary depending on geographic location, industrialization, and cultural factors. The incidence of dog bites in infants is 1-3 per 1000 individuals in developed countries per year. Men are twice as likely to be bitten by dogs as women. Most dog bites occur within the ages of 5 and 9 years. The results from a research conducted by Dwyer *et al.* (2007) indicate that dog bites involved 1.5% of all individuals visited in the trauma department of the Red Cross War Memorial Children's Hospital in Cape Town in a 13.5-year period (Dwyer *et al.* 2007). In 2006, over 31,000 people in the United States needed reconstructive surgery due to dog bites. Such bites has been estimated to cost around 250 million dollars directly and indirectly (Dwyer *et al.* 2007; Engelbrecht 2012). Similar results have been reported in England (Morgan & Palmer 2007), Belgium, Spain, Switzerland, Australia, the Republic of Tanzania (Dhand *et al.* 2011) and India (Sudarshan *et al.* 2006). The pit bull dog breed has bring about to make most of these injuries. Of course, findings from other articles indicated that hybrid dogs bring about most bites due to their popularity among their owners. However, the risk of being bitten by German shepherd, Pit Bull, Rottweiler and Doberman dogs is higher than other breeds due to the high force they exert when biting. The relative danger of a

Doberman or German Shepherd attack is five times higher than that of hybrid and retriever breeds. Indeed, big dogs bring about more serious injuries in comparison with small ones. In general, the severity of a dog bite depends on the dog's size, breed, training, and the circumstances of the bite. Large breeds, especially those trained for attack, guarding and as police dogs, bring about more and more serious injuries. The jaws of an adult dog can exert a force equal to 3 thousand pounds. Canine teeth have variable shapes, including long sharp teeth, very round front teeth, small Asian teeth and molars with a wide surface (Fig. 1). Such distinct shapes of teeth have evolved, so that they easily help the dog holding, tearing and crushing the prey. Crushed and torn wounds with an unpleasant appearance are the result of pressure and cutting above the teeth (Fig. 1; Kennedy *et al.* 2015). After dogs, cats appear to bring about the most bites among pets, which comprise 5-15% out of all bites. A study conducted in Texas found that there would be 2,177 dog bites versus 343 cat bites per year, indicating that injuries after cat bites were more vigorous than those after dog bites (Ward 2013). As mentioned in the previous section, dog bites are more prevalent in men than women, however, on the contrary, cat bites are more common in women (Kennedy *et al.* 2015). Cat bites are equally distributed in different age groups and without a tendency towards a particular group. At first glance, injuries after cat bites appear less than those after dog bites or human bites, due to the limited destruction of skin tissues. However, cat bites have more serious consequences due to the small, albeit deep wounds that are very difficult to clean (Bula-Rudas & Olcott 2018). Though cats do not have strong jaw in comparison with dogs, they have sharp and narrow teeth and have evolved to easily pierce and tear the prey tissue. This dental anatomy bring about penetrating and deep wounds to enter the joint capsule and damage the bone periosteum (Fig. 1). It is estimated that 30-50% of cat bites result in infection, while infections associated with dog bites are less than half of this amount (Kennedy *et al.* 2015).

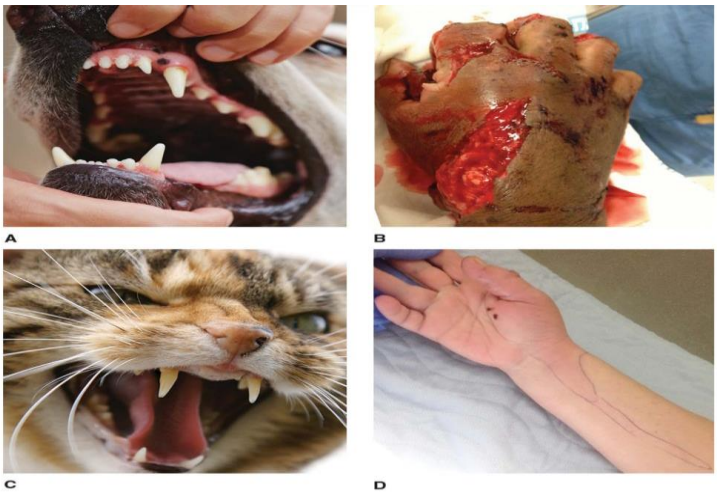

Fig. 1. Anatomy of dog (A) and cat (C) teeth and injuries resulting from their bites (B and D) respectively (Kennedy *et al.* 2015).

Human bites are the third most common type of bites, although detailed descriptive statistics are not available. In addition, most of the available data related to human bites are associated with adults. Human bites have long been known as agents of severe wounds and prone to infection. In recent studies, this issue has been questioned. As with other reports of bite wounds, those that experienced human bites often had selection biases and severe injuries, and patients sought medical attention, although very few with minor injuries were denied medical attention. Recent studies examining human bites in children have underestimated the number of infections resulting from human bites (Broder *et al.* 2004; Ward 2013). One of the main agents of death and disease, especially in tropical rural areas, is associated with snakebite which has a significant impact on human health and economy. Snakebite has been considerably overlooked as a public health problem in the world (Warrel 2010). Most of such deaths take place in poor African, Asian and Latin American countries. The estimated number of snake bites around the world is around 500,000 per year, of which 30,000-40,000 of these bites lead to death. Chippaiux estimated that snakes bring about 4.5 million bites each year, of those, 2.5 million are bring about by venomous snakes, which kill more than 125,000 people worldwide each year (Rahman *et al.* 2010). Other less common bites include monkey bites (3.2% in India, 0.7% in Israel), bear bites (2 cases per year in the United States of America), and horse bites (3.8% of all wounds). Horse-bring about wounds in England account for 17% of wounds caused by animal bites in eastern Turkey and camel bites for 25% in the United Arab Emirates

(Eslamifar *et al*. 2008; Emet *et al.* 2009; Abu-Zidan *et al.* 2012). Camel bites are common during the mating season (November to February). In a comprehensive study of 153 cases of camel bites, 83 of the victims were male, and 94% of their upper limbs were bitten. Bites associated with other animals such as sheep, pigs, ferrets, raccoons, weasels, bats and other types of mice rarely happen, but these animals are important in terms of bite-related microbiology (Langley 2009; Chhabra *et al.* 2015).

Microbiology

Commonly, bite wounds contain poly-microbial flora, which mirror the aerobic and anaerobic microbes of the mouth flora of the biting creature, the victim's skin, and the environment. Bite wounds include scratches, lacerations, and crushing. Most of these wounds may be harmless at first, but often lead to infection and serious complications. The majority of such infections appear poly-microbial. In a study applying necessary methods to identify aerobic and anaerobic bacteria, anaerobic ones were isolated in over two-thirds of wounds from human and animal bites, especially those related to purulent swelling (abscess; Brook 2009; Singh & Jain 2016). The microbiology of dog and cat bite wounds in causing infection are similar to human types and the nature of both of them is poly-microbial and includes a mixture of aerobic and anaerobic bacteria. The number of pathogen species in bite wounds depends on the type of wound. An average of 7.5 bacteria can be found in an abscess, 5 in purulent wound secretions, and 2 in non-purulent wounds. *Pasteurella*, *Streptococcus*, *Staphylococcus* (including Methicillin-resistant *Staphylococcus* (MRSA)), *Neisseria*, *Corynebacterium* and *Moraxella* species are among the most important aerobic bacteria isolated from wounds caused by mammal bites. The most common anaerobic bacteria isolated from animal bite wounds include *Fusobacterium, Bacteroides, Prevotella*, *Propionibacterium, Peptostreptococcus* and *Porphyromonas* species (Table 1). B-Lactamase production has been the most common feature among anaerobic bacteria isolated from infected bites.

Table 1. The most significant bacterial pathogens present in wounds from cat and dog bites (Abrahamian & Goldstein 2011; Bula-Rudas & Olcott 2018).

	Type of bacteria	
Type of bite	**Aerobes**	**Anaerobes**
Dog	*Pasteurella* spp.	*Fusobacterium* spp.
	Streptococcus spp.	*Bacteroides* spp.
	*Staphylococcus*spp. (incl. MRSA)	*Prevotella* spp.
	Capnocytophaga canimorsus	*Porphyromonas*spp.
	Neisseria	*Propionobacterium* spp.
	Corynebacterium	*Peptostreptococcus* spp.
	Moraxella	
	Enterococcus	
	Bacillus	
Cat	*Pasteurella*spp.	*Known Fusobacterium* spp.
	*Streptococcus*spp.	*Bacteroides* spp.
	*Staphylococcus*spp.(incl. MRSA)	*Porphyromonas* spp.
	*Moraxella*spp.	*Prevotella* spp.
	Neisseria	*Propionobacterium* spp.
	Corynebacterium	
	Enterococcus	
	Bacillus	

Pasteurella spp. seems to be the most prevalent pathogen isolated from dog and cat bites (50% in dogs and 75% in cats). *Pasteurella* spp. is known as a gram-negative and facultative anaerobic coccobacilli growing in blood and chocolate agar (Weber 2016). Such species frequently live in the upper parts of the respiratory system of many animal species. It is noticeable, in a newly-conducted study that some species of such genus were isolated from the blood of a dog with endocarditis (Kern *et al.* 2019). Dogs, cats and other mammals have a high capacity to carry *Pasteurella* species in their throats and mouths, so this microorganism brings about of a striking count of human infections. *P. canis* and *P. multocida* are the most abundant bacteria isolated in many infections resulting from dog bites and cat bites respectively. Among reports of *Pasteurella* infections, *P. canis* was an agent for 22% of infections in a four-year period in a veterinary hospital and in 50% of all dog bite wounds (Kern *et al.* 2019). Other species associated with the genus *Pasteurella*, which have been found with less frequency in wounds caused by bites, including *P. multocida* subsp. *multocida*, *P. stomatis*, *P. multocida* subsp. *septica*, *P. dagmatis* and *P.*

multocida subsp. gallicida (Chhabra *et al.* 2015). The second most prevalent pathogen isolated from wounds associated with dog and cat bites are *Streptococcus* and *Staphylococcus* species. The prevalence of these two species is higher in non-purulent wounds than in abscesses and purulent ones. Among the species related to *Streptococcus* genus, *S. mitis* is the most common species in bite wounds. Other species related to this genus that can be seen in wounds caused by cat and dog bites include *S. mutans*, *S. pyogenes*, *S. sanguis* biotype II, *S. intermedius*, *S. constellatus*, *S. equinus*, *S. sanguis* biotype I, *S. agalactiae*, *S. sanguis* and *S. dysgalactiae*. *Capnocytophaga canimorsus* is a commensal bacterium found in the saliva of 16-24% of dogs and 17% of cats. This type of bacillus-shaped and gram-negative bacteria has been observed in various diseases such as sepsis, meningitis, thrombotic thrombocytopenic purpura and endocarditis following dog bites. As reported in 1976, the first case of human infection caused by this bacterium. Although about 9% of infections are also reported from cats, the source of infection is usually dogs (Abrahamian & Goldstein 2011; Hloch *et al.* 2014). Infection from *C. canimorsus* caused by dog bites is often reported from people affected by diseases associated with the immune system. In other words, people with immune system diseases are more susceptible to infections caused by this bacteria than healthy people. This bacterium is a sticky one growing easily in blood cultures (Abrahamian & Goldstein 2011). Table 1 indicates the most striking and regular types of anaerobic bacteria found in wounds caused by the cat and dog bites. *Fusobacterium* species are the most common species isolated from the cat and dog bite wounds. Among the species associated with this genus, *F. nucleatum* is the most abundant species in these wounds. *F. russii, F. gonidiaformans* and *F. alocis* are among the other species of this genus isolated from the animal bite wounds. Other types of anaerobic bacteria include *Bacteroidestectus, Prevotellaheparinolytica, Propionibacterium acnes, Propionibacterium avidum, Prevotella intermedia, Prevotella melaninogenica, Peptostreptococcus anaerobius, Porphyromonas macacae, Porphyromonas gulae, Porphyromonas canoris* and *Porphyromonas cansulci*. Most of the infections resulting from wounds associated with human bites, like the infections from bites by other mammals, are poly-microbial and include aerobic and anaerobic species. The most common organisms isolated from human bites are species belonging to the genus Streptococci (especially *S. anginosus*) and Staphylococci (Ward 2013; Jenkins *et al.* 2018). *S. anginosus*, S. pyogenes, *Saureus*, *Ecorodens* and *Haemophilus* spp. are aerobic bacteria usually found in human bite infections. *Prevotella* spp., *Peptostreptococcus* spp., *Fusobacterium* spp., *Bacteroides* spp. and *Veillonella* spp. are anaerobic bacteria often isolated from human bite wounds (Table 2). There is a significant difference between the microbiology of animal and human bites due to the difference between animal and human oral flora and their complex interactions with human skin flora, as well as the nature of the damage. More severe diseases and infections are associated with anaerobic bacteria from human bite wounds compared to animal bites. Most of such anaerobic bacteria produce beta-lactamase, so choosing a suitable beta-lactamase inhibiting antibiotic becomes important. Cultures obtained from Paronychia (scorpion) show microbiological pathogens similar to human bite wounds despite differences in injury mechanism (Merriam *et al.* 2003; Bula-Rudas & Olcott 2018).

Table 2. The most prominent bacterial pathogens available in wounds caused by human bites (Bula-Rudas & Olcott 2018; Kennedy *et al.* 2015)

	TYPE OF BACTERIA	
TYPE OF BITE	**AEROBES**	**ANAEROBES**
Human	*Streptococcus* spp.	*Fusobacterium spp.*
	Staphylococcus spp. (incl. MRSA)	*Prevotella spp.*
	Eikenella corrodens	*Peptostreptococcus spp.*
	Haemophilus spp.	*Veillonella spp.*
	Enterobacteriaceae	*Bacteroides spp.*
	Gemella morbillorum	*Eubacterium species*
	Neisserias pecies	

Given the low amount of such wounds and the lack of systematic data, it is difficult to calculate the relative count of infectious microorganisms associated with bites by other animals. Therefore, a limited number of researches have reported different types of microorganisms that cause infection in these animals. For instance, tularemia has been reported following squirrel bites. Pig bites are associated with infectious agents including common streptococcal, staphylococcal and *Pasteurella* spp. (Ward 2013). The microbiology of wounds related to bites by wasps and monkeys is similar to bitten humans and includes a mixture of aerobic and anaerobic bacteria, including *Fusobacterium* spp., *Streptococcus* spp., *Enterococcus* spp., *Staphylococcus* spp., *E. corrodens* and *Neisseria* spp. Some of the microorganisms recovered from horse bite wounds include *S. aureus, Streptococcus* spp., *Escherichia*

coli, *Actinobacillus lignieresii*, *Pasteurella* spp., *Bacteroides sureolyticus*, *Prevotellamela ninogenica* and *P. heparinolytica* (Brook 2009; Peel *et al.* 1991). The oral flora of reptiles, including snakes, lizards, and crocodiles, includes a variety of Gram-negative microorganisms, including *Aeromonas hydrophila*, which has been reported to cause infection. In Table 3, a relatively complete set of related microorganisms or bites by these animals is presented.

Table 3. Microorganisms isolated from wounds resulting from bites of other animals (Abrahamian & Goldstein 2011; Bula-Rudas & Olcott 2018; Engelbrecht 2012)

Type of bite	Microorganisms
Monkey and Simian	***Streptococcus* spp., *Enterococcus* spp., *Staphylococcus* spp., *E. corrodens, Neisseria* spp., Enterobacteriaceae, *Fusobacterium* spp.**
Horse	*S. aureus, Streptococcus* spp., *Neisseria* spp., *Escherichia coli, Actinobacillus lignieresii, Pasteurella* spp., *Bacteroides ureolyticus, Bacteroides fragilis, Prevotella melaninogenica,P. heparinolytica*
Pig	*Streptococcus* spp., *Streptococcus sanguis, Streptococcus suis, Streptococcus milleri, P. multocida, Pasteurella* spp., *Haemophilus influenza, Actinobacillus suis, B. fragilis*
Ferrets	*S. aureus*
Bear	*Aeromonas hydrophila, Bacillus cereus, Citrobacter diversus, Enterococcus durans, Escherichia coli, Mycobacterium fortuitum, Neisseria sicca, Proteus vulgaris, Serratia fonticola, Serratia marcescens, Staphylococcus aureus, Staphylococcus epidermidis, Streptococcus sanguis*
Snakes	*Staphylococci, Proteusspecies, Morganella morganii, Aeromonas hydrophila, Enterococcus faecalis,* and *Clostridium* species, *P. aeruginosa, Proteusspecies,* coagulase-negative *staphylococci, Clostridium* species, and *Bacteroides fragilis*
Alligators/crocodiles	*Citrobacter freundii, Klebsiella oxytoca, Pasteurella haemolytica, Pseudomonas pickettii, Bacteroides thetaiotaomicron, Bacteroides vulgatus, Clostridium clostridioforme, Clostridium tetani, Fusobacterium nucleatum,* and *Peptostreptococcus* species.

Transmission of organized infections through human and animal bites

Human and animal bites have the potential to transmit pathogens that cause organized infections. Tetanus, rabies, bartonella (cat scratch disease), tularemia, maltose fever, leptospirosis and rat fever can be transmitted through human and animal bites. On the other hand, insects such as ticks, flies and mosquitoes have the potential to carry important viral, bacterial, fungal and parasitic pathogens. Important pathogens including hepatitis B and C virus, cytomegalovirus and herpes virus may be transmitted through human bites. Although it is biologically possible and several cases have been reported, transmission of AIDS through human bites seems rarely feasible. Nevertheless, when blood is available at the site of the bite injury, the risk of transmission and disease duplicates (Kennedy *et al.* 2015; Bula-Rudas & Olcott 2018).

Table 4. Pathogens resulted in organized infections after being bitten (Abrahamian & Goldstein 2011; Bula-Rudas & Olcott, 2018; Engelbrecht 2012).

Animal type	Infections
Dog	Leptospirosis (*Leptospira* spp.),Tetanus *(Clostridium tetani),* Tularemia (*Francisella tularensis*), Rabies (rabies virus)
Cat	Cat-scratch disease *(Bartonella* spp.*),* Tularemia (*F. tularensis*), Sporotrichosis (*Sporothrix* spp.), Rabies (rabies virus)
Human	Hepatitis B (hepatitis B virus), Hepatitis C (hepatitis C virus), Cytomegalovirus infection, Herpes *(Herpes simplex* virus*),* Syphilis *(Treponema pallidum),* Human immunodeficiency virus infection
Monkey	*Herpes simiae* (B virus)
Rat	Rat-bite fever (*Streptobacillus moniliformis* or *Spirillium minus*), Leptospirosis *(Leptospira* spp.*)*
Rodents	Leptospirosis *(Leptospira* spp.*),* Tularemia (*F. tularensis*)
Bat, Ferret, Raccoon, Fox	Rabies (rabies virus)

Organizing and dealing with wounds resulted from human and animal bites

Organizing wounds from human and animal bites may include (i) patient history (ii) physical examination (iii) wound management (iv) prescribing medicine and (v) specifying the patient's status. This importance starts with a detailed history of the bite events. Gathering the history of the wound from the bite may include understanding the events associated with the bite, the type of animal and its behaviour, the health status of the biting creature, the ownership and the safety status of the animal. The duration having passed is very important since the bite occurred, since a delay in providing medical services for over 6 to 12 hours increases the possibility of infection. Getting a proper record of clinical events and those related to the bite helps adopting a suitable launch for prior

wound care, the need for active or passive vaccination, and the need for culture to specify specific pathogens (Ambro *et al.* 2010; Ghezta *et al.* 2019). Symptoms of weakness and numbness indicate damage to nerve structures, and those associated with vision changes indicate damage to the area around the eyes. The patient's adequate medical records should be investigated, including conditions that may affect wound healing or make the patient more susceptible to infection (i.e., diabetes and AIDS), or those require long-term corticosteroid use, or previous splenectomy. Medical records and allergies should be specified to ensure the safety of using local anaesthesia and antimicrobials. Eventually, an individual's safety status should be manifested. Identifying patients with a higher probability to get infection helps physicians to underline who need hospitalization or antimicrobial treatment (Ambro *et al.* 2010; Bula-Rudas & Olcott 2018). After filling out the patient's records, the practitioner should begin to check up the wound. In general, bite wounds are grouped into four types as to the tissue damage: (i) puncture (ii) laceration (iii) bluntness and (iv) crushing. The physical examination performed by the physician should emphasize on the wound depth, the amount or degree of perforation, erosion, the extent or extent of the laceration, and the amount of tissue loss due to blunting. The attending physician should reveal whether deep structures including nerves, blood vessels, muscles, and bones are involved. When a bone fracture is suspected, radiographic studies should be performed. The bite wound should also be examined for signs of infection (i.e., erythema and purulent ulceration). These symptoms are not obvious in fresh wounds, however, they are more common in wounds that are treated with delay. If there is clinical evidence for the presence of infection, it is recommended to prepare aerobic and anaerobic cultures (Ambro *et al.* 2010).

Cleaning and removing lesions. Wounds from biting should be entirely cleaned. Though the optimal practice is not vivid, various solutions are recommended for washing wounds including normal saline, Ringer's lactate, fresh water, and dilute solutions of povidone-iodine. Apart from the type of solution, the wound should be washed under full pressure. An 18-19 mm needle or cutter connected to a large syringe can be used in these cases for better washing of the wound. In washing the wounds resulting from the bite, all the dead tissues should be removed and a careful search for foreign materials should be done. When there is a closed wound in the wrist with the possibility of damage to the tendon sheath or joint, an orthopedic consultation with a hand specialist should be used. Noteworthy, open wounds (containing perforations) resulting from bites should not be washed (Ward 2013; Bula-Rudas & Olcott 2018).

Suturing the wound. The premature wound closure may cause infection (Morgan 2005). Wounds from bites on the hands and feet in the farm and the places where the event occurred should not be closed, but wounds with less probability of infection (with the exception of hand wounds and foot) may be stitched by a skilled practitioner. Infected wounds should be covered with a sterile dressing (Callahan 2019). However, in any case, the initial closing of the wounds, including the face and neck, should be performed. Thin wounds should be stitched carefully and regularly. This issue covers wounds with a more probability of infection, such as bruised wounds, puncture wounds, hand and foot wounds, wounds taking over 12 hours, wounds in individuals with poor immunity and those have been bitten by cats, it should be treated with the maximum possible precision (Ward 2013).

Antibiotic therapy

Given a large number of available pathogens causing infection and the presence of several bacteria with various sensitivities to antibiotics in bite wounds, the treatment of such wounds has frequently been a challenge. Using antibiotics in bite wounds is assumed to be a solution for treatment or prevention. There will be certain practices where antibiotic prophylaxis is necessary (Chhabra *et al.* 2015). In general, prevention of rabies and tetanus should be emphasized for all wounds caused by animal bites. Newly-caused wounds from bites without symptoms of infection should not be cultured. According to the patient's status, other laboratory experiments are specified (e.g., for patients with sepsis, complete blood count and blood culture). The optimal choice of antibiotic agents should be based on the most regular pathogens, the type of bite (information about the bacterial isolates usually found in a specific type of bite), the wound area (hands, feet, face and skull), and possible patterns of resistance expressed by the bacteria to be determined. Generally, an appropriate antibiotic regimen should cover all aerobic and anaerobic bacteria in the oral flora of humans and biting animals. Some biting in a child or teenager's skull may lead to damage to the contents of the skull, so special considerations should be taken to choose antibiotic agents that not only cover all possible pathogens, but also penetrate the blood-brain barrier appropriately. For this type of injuries, intravenous injection of Cephalosporin together with metronidazole or meropenem alone is emphasized. The addition of vancomycin is also recommended if there is any concerns about infection with

methicillin-resistant *S. aureus*. Oral using amoxicillin-clavulanate provides adequate coverage for aerobic bacteria including streptococci, methicillin-sensitive *S. aureus*, *Pasteurella* and *E. corrodens*. This medicine also covers anaerobic oral bacteria such as *Prevotella* and *Porphyromonas* spp. with β-lactamase production activity. In infants with severe allergic reactions (anaphylaxis, wheezing, angioedema) to penicillin, Cephalosporin (Cefpodoxime) or Trimethoprim-Sulfamethoxazole (TMP-SMX) (Cotrimoxazole) plus Clindamycin are recommended. When the need to treat injection is diagnosed, ampicillin-sulbactam is one of the intravenous agents of choice. Piperacillin-tazobactam may be used as an alternative medicine. These agents do not provide adequate coverage for MRSA, while waiting for culture results, vancomycin may be stressed for severe infections (Aziz *et al.* 2015).

Prevention of rabies

Rabies virus is known as a mono-string RNA one attached to the *Lyssavirus* genus from the Rhabdoviridae family. The virus is transmitted to humans' body through animal bites, leading to death by causing acute and fatal encephalitis. There is no comprehensive estimate of the transmission of rabies to humans through animal bites, however, according to the World Health Organization, over 2.5 million people are at risk of contracting rabies and about 10 million people receive preventive treatment from rabies after animal bites each year (Darvishi *et al.* 2017; Jackson 2016; Wilde *et al.* 2016). The need for rabies prevention should be considered in all cases involving bites by mammals. Any biting through rabid animals including the skin damage, laceration and contamination with saliva indicates the possibility of rabies transmission (Enzler *et al.* 2011; Ward 2013).

Individuals more likely to be bitten by animals such as dogs, cats, bats, raccoons, skunks, and foxes (e.g., due to certain occupations) should be vaccinated immediately, unless it is proven that rabies present in the geographic area or animals have been examined and findings indicate that they are free of rabies. People who have been bitten by pets (including dogs and cats) in developing countries are at a higher risk of contracting rabies than in developing countries and should receive post-exposure prophylaxis. Individuals exposed to animals such as squirrels, rabbits, hamsters, rats, and other rodents approximately never need post-exposure prophylaxis, however, they should refer to local public health centres about regional guidelines (Moran *et al.* 2008).

Table 5. Antibiotic prevention against dog, cat and human bites (Moran *et al.* 2008).

Patient	Regimen
Adult or child with no penicillin allergy	Amoxicillin/clavulanate, 875 mg PO BID (20 mg/kg PO BID for children
Adult with penicillin allergy	Moxifloxacin, 400 mg PO daily, or ciprofloxacin, 500mg PO BID + clindamycin, 450 mg PO q6h
Child with penicillin allergy	Clindamycin, 10 mg/kg PO q6h + trimethoprim sulfamethoxazole, 5 mg/kg PO q12h

In spite of comprehensive plans for vaccination of pets, rabies, as deadly as it has always been, remains a global threat. Accordingly, the post-exposure prophylaxis should be emphasized for all animal bite victims. The vaccination behaviour of the biting animal should be specified, if possible, after being bitten. If the behaviour is vague, the biting animal should be kept under veterinary supervision for 10 days, and during this period, as soon as the symptoms of the disease are observed, prevention processes for the bitten person should be started. For local variations in animal and endemic vectors in each region, it is reasonable to consult with a state or local authority before deciding on an RPEP. Details of RPEP administration with rabies immunoglobulin (RIG) and human vaccine are available in current American Advisory Committee on Immunization Practices (ACIP) guidelines (Brook 2009; Kwoba *et al.* 2019). Subsequently, ACIP recommended the 5-dose rabies vaccination regimen with human diploid cell vaccine (HDCV) or purified chick embryo cell vaccine (PCECV). However, new recommendations in 2010 reduced the number of vaccine doses to four. Findings have shown that 4 doses of the vaccine in combination with RIG show a sufficient immune response and the fifth dose of the vaccine does not lead to better and higher results (Manning *et al.* 2008; Chhabra *et al.* 2015). Generally, in all RPEP regimes, both rabies vaccine and RIG should be prescribed. Rabies vaccine provides active immunity while RIG provides passive immunity to protect the patient. In the process of vaccination, an immune response is created against the vaccine. Any wound should be thoroughly cleaned and washed with soap and water. RIG is administered at a dose of 20 IU kg^{-1} body weight. If possible, the entire dose of RIG should be injected around the wound. If this is not possible (e.g., a wound on a little finger), the rest of the dose should be injected intramuscularly in the deltoid or

quadriceps muscles. To avoid the antagonistic effect of antigen and antibody, Hario RIG vaccine should not be injected at the same area or with the very syringe. The vaccine should be taken as 10 mL intramuscularly in the deltoid area for all doses (Moran *et al.* 2008).

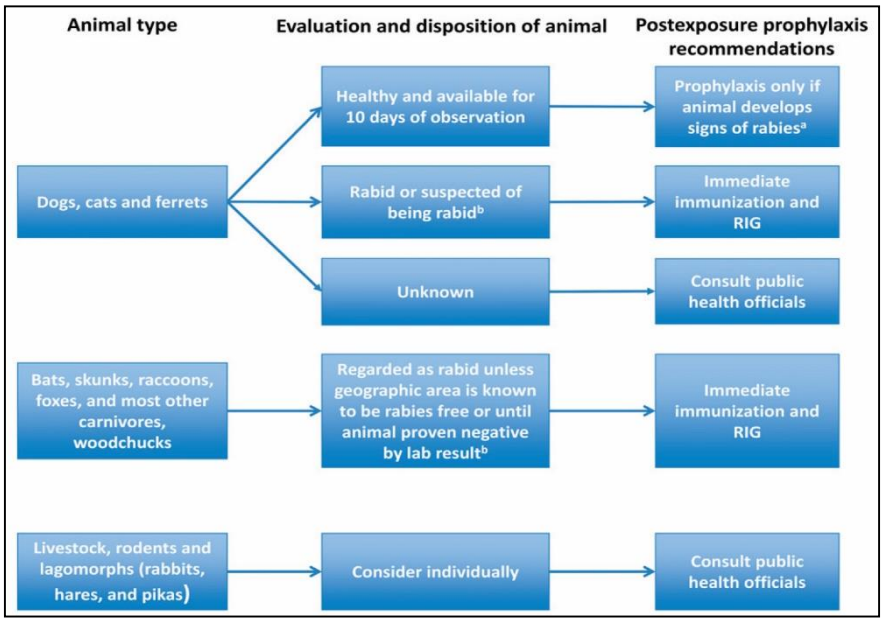

Fig. 2. Post-exposure rabies prevention (RPEP; Bula-Rudas & Olcott 2018).

Prevention of tetanus

Tetanus is considered another infection potentially resulted from human and animal bites. *Clostridium tetaniis* exists everywhere in surroundings, especially in soil, human and animal intestines. When the bacterium presents in the wound, it may duplicate and produce toxins responsible for the characteristic tetanus infection. The decision to start RPEP depends on the type and condition of the wound and the patient's vaccination history (Radjou *et al.* 2012; Harper *et al.* 2019). The need to prevent tetanus in whole bitten infants should be prioritized. Wounds from bites should be assumed infected. Hence, individuals having received less than 3 doses of tetanus toxoid or those whose immunization status is not clear, should receive tetanus immunoglobulin. Tetanus toxoid injection should also be performed for these people. In this situation, for infants younger than 7 years, the DTaP vaccine containing tetanus toxoid is recommended. For individuals 7 years of age or older with incomplete immunization status, TdaP is recommended (Abrahamian & Goldstein 2011). There is no need to be immunized against tetanus for those having received tetanus toxoid vaccines along the last 5 years. Patients whose last tetanus vaccine was more than 5 years ago, should receive a dose of tetanus toxoid. As a result, a blend vaccine containing diphtheria toxoid is suggested. Additionally, this guideline is preferred for those in the range of 10-18 years having not yet received TdaP (Ward 2013).

Antibiotic therapy of wounds from human bites

Findings have indicated that using prophylactic antibiotics declines the probability of infection after human bites (Henton & Jain 2012). By the same way, authors have announced that antibiotic therapy using a wide range of antibiotics is the best option to deal with infections from aerobic and anaerobic bacteria. Amoxicillin-clavulonate compounds are considered the first defensive obstacle to deal with infection resulting from human bite wounds. Using antibiotics has degraded the rate of infections from human bite wounds from 28% to 2% (Abubaker 2003; Taplitz 2004). The evidence relevant to the transmission of blood-borne viruses is largely relying on case reports. As long as this evidence is confined, the serum changes of hepatitis B, hepatitis C, and HIV were 5, 18, and 16%, respectively. To prohibit hepatitis B transmission, one should be immunized with hepatitis B immunoglobulin. As to hepatitis C, no vaccine or PEP has been outstretched yet (Hui *et al.* 2005; Jenkins *et al.* 2018). In contrast to hepatitis B, hepatitis C can not be diagnosed in saliva, and in this case, the infected person's blood should be blended with his own saliva and cut in the skin of the other person. Based on circumstances and primitive serology experiments, it seems essential to investigate by an expert. Though HIV can be diagnosed in the saliva of infected individuals, in most cases it is deactivated by salivary inhibitory agents. There would be some reports on HIV

transmission through human bites. The decision to take PEP medicines should be made on a case-by-case basis (Smith *et al.* 2005; Lohiya *et al.* 2013). It is assumed that monkey bites may convey the virus of herpes B, so the wound should be carefully cleaned with soap and detergent and rinsed for at least 15 minutes to decline virus inoculation. Viral culture tests should be conducted after cleaning the wound. Antiviral therapy with acyclovir, valacyclovir, or famciclovir should be stressed for individuals having experienced monkey bites (Brook 2009).

CONCLUSIONS

Human and animal bites have been considered prevalent injuries and frequent agents for primary care and emergency visits' needs, which can lead to serious and fatal infections. Every year, approximately 55,000 people around the world die from human and animal bites. More cases of bites are associated with dogs, cats and humans respectively. There are not many investigations relevant to human and animal bites. In this study, we largely stressed on microbiology, epidemiology and treatment procedures of human and animal bites. About 4.5 million dog bites, 400,000 cat bites, and 250,000 human bites are experienced in the United States yearly. Generally, over 90% of these bites are caused by domestic animals and in infants, so that, dogs cause 80-90% of these bites. About 30-60% of infections resulting from human and animal bite wounds are a mixture of aerobic and anaerobic bacteria derived from the flora of the biting animal mouth and in rare cases from the flora of the victim's skin. The bacteria available in wounds brought about mammal bites on average include 2-5 different types of bacteria. The microbiology of wounds resulting from bites by different organisms is somewhat different, and this comes to making differences in treatment procedures and preventing infection after a bite. Controlling and dealing with bite wounds begin in arranging detailed records of the bite events and preventing the extent of possible infections with antibiotic treatment.

REFERENCES

Abrahamian, FM & Goldstein, EJ 2011, Microbiology of animal bite wound infections. *Clinical Microbiology Reviews*, 24: 231-246.

Abu-Zidan, FM, Hefny, AF, Eid, HO, Bashir, MO & Branicki, FJ 2012, Camel-related injuries: Prospective study of 212 patients. *World Journal of Surgery*, 36: 2384-2389.

Abubaker, AO 2003, Management of posttraumatic soft tissue infections. *Oral and Maxillofacial Surgery Clinics* 15: 139-146.

Ambro, BT, Wright, RJ & Heffelfinger, RN 2010, Management of bite woundsin the head and neck. *Facial Plastic Surgery*, 26: 456-463.

Aziz, H, Rhee, P, Pandit, V, Tang, A, Gries, L & Joseph, B 2015, The current concepts in management of animal (dog, cat, snake, scorpion) and human bite wounds. *Journal of Trauma and Acute Care Surgery*, 78: 641-648.

Broder, J, Jerrard, D, Olshaker, J & Witting, M 2004, Low risk of infection in selected human bites treated without antibiotics. *The American Journal of Emergency Medicine*, 22: 10-13.

Brook, I 2009, Management of human and animal bite wound infection: an overview. *Current Infectious Disease Reports*, 11: 389-395.

Bula-Rudas, FJ & Olcott, JL 2018, Human and animal bites. *Pediatrics Review*, 39: 490-500, DOI: 10.1542/pir.2017-0212.

Callahan, MV 2019, Bites, stings, and envenoming injuries, *Travel Medicine*, Elsevier, pp. 437-447.

Chhabra, S, Chhabra, N & Gaba, S 2015, Maxillofacial injuries due to animal bites. *Journal of Maxillofacial and Oral Surgery*, 14: 142-153.

Darvishi, M, Shokati, B & Karimi, E 2017, Necessary care when facing patients with suspected rabies in emergency department. *Iranian Journal of Emergency Medicine*, 4: 44-45.

Dhand, NK, Gyeltshen, T, Firestone, S, Zangmo, C, Dema, C, Gyeltshen, R & Ward, MP 2011, Dog bites in humans and estimating human rabies mortality in rabies endemic areas of Bhutan. *PLoSNeglected Tropical Diseases*, 5: e1391.

Dhillon, J, Hoopes, J & Epp, T 2019, Scoping decades of dog evidence: A scoping review of dog bite-related sequelae. *Canadian Journal of Public Health*, 1-12.

Dwyer, J, Douglas, T & Van As, A 2007, Dog bite injuries in children: A review of data from a South African paediatric trauma unit. *South African Medical Journal*, 97: 597-600.

Emet, M, Beyhun, NE, Kosan, Z, Aslan, S, Uzkeser, M & Cakir, ZG 2009, Animal-related injuries: epidemiological and meteorogical features. *Annals of Agricultural and Environmental Medicine,* 16: 87-92.

Engelbrecht, A 2012, Management of common animal bites in the emergency centre: the most common animal bites to present in emergencies are dog and snake bites. *Continuing Medical Education,* 30: 401-406.

Enzler, MJ, Berbari, E & Osmon, DR 2011, Antimicrobial prophylaxis in adults, *Mayo Clinic Proceedings*. Elsevier, pp. 686-701.

Eslamifar, A, Ramezani, A, Razaghi, AM, Falahian, V, Mashayekhi, P, Hazrati, M, Askari, T, Fayaz, A, Aghakhani, A 2008, *Arch Iran Med*,11:200-2.

Essig Jr, GF, Sheehan, C, Rikhi, S, Elmaraghy, CA & Christophel, JJ 2019, Dog bite injuries to the face: Is there risk with breed ownership? A systematic review with meta-analysis. *International Journal of Pediatric Otorhinolaryngology,* 117: 182-188.

Gelvez, M, Enrique, R, Gajos, G, Bladimir, J, Carvajal, D & Luis, A 2017, Animal and human bite injuries: a 5-year retrospective study in a large urban public hospital in Venezuela. *Oral and Maxillofacial Ssurgery,* 21: 425-428.

Ghezta, NK, Bhardwaj, Y, Ram, R, Ahsan, R & Arya, S 2019, Incidence Pattern of Bear-Inflicted Injuries to the Maxillofacial Region—Soft and Hard Tissue Injuries, Their Management, and Sequelae. *Journal of Oral and Maxillofacial Surgery* 77: 1043. e1041-1043. e1015.

Griego, RD, Rosen, T, Orengo, IF & Wolf, JE 1995, Dog, cat, and human bites: a review. *Journal of the American Academy of Dermatology* 33: 1019-1029.

Harper, CM, Dowlatshahi, AS & Rozental, TD 2019, Challenging dogma: Optimal treatment of the "Fight Bite". *HAND,* 1558944719831238.

Henton, J & Jain, A 2012, Cochrane corner: antibiotic prophylaxis for mammalian bites (Intervention review). *Journal of Hand Surgery* 37: 804-806.

Hloch, O ,Mokra, D, Masopust, J, Hasa, J & Charvat, J 2014, Antibiotic treatment following a dog bite in an immunocompromized patient in order to prevent *Capnocytophaga canimorsus* infection: A case report. *BMC Research Notes,* 7: 1-4.

Hui, AY, Hung, LC, Pete ,C, Leung, W-K, Chan, PK & Chan, HL 2005, Transmission of hepatitis B by human bite-confirmation by detection of virus in saliva and full genome sequencing. *Journal of Clinical Virology* 33, 254-256.

Jackson, AC 2016, Human rabies: A 2016 update .*Current Infectious Disease Reports* 18: 38.

Jenkins, GW, Isaac, R & Mustafa, S, 2018, Human bite injuries to the head and neck: current trends and management protocols in England and Wales. *Oral and Maxillofacial Surgery,* 22: 77-81.

Kennedy, SA, Stoll, LE & Lauder, AS 2015, Human and other mammalian bite injuries of the hand: Evaluation and management. *JAAOS-Journal of the American Academy of Orthopaedic Surgeons*, 23: 47-57.

Kern, ZT, Swartley, OM, Neupane, P, Balakrishnan, N, Breitschwerdt ,EB, 2019 Pasteurella canis infective endocarditis in a dog. *Veterinary Microbiology,* 229: 14-19.

Khoobdel M, Akbari M, Aivazi AA, Moosa-Kazemi SH, Yousefi H, Akbari MR, Keshavarzi D, Moradi M 2020, An investigation on permethrin-treated military uniforms against diurnal mosquitoes under field conditions. *Advancements in Life Science*, 7: 247-251.

Khoobdel M, Akbari M, Aivazi AA, Moosa-Kazemi SH, Yousefi H, Akbari MR, Davood K & Moradi M 2020, An investigation on permethrin-treated military uniforms against diurnal mosquitoes under field conditions. *Advancements in Life Sciences* 7: 106-109.

Kwoba, EN, Kitala, P, Ochieng, L, Otiang, E, Ndung'u, R, Wambura, G, Hampson, K & Thumbi, S 2019, Dog health and demographic surveillance survey in Western Kenya: Demography and management practices relevant for rabies transmission and control. *AAS Open Research,* 2: 5.

Langley, RL 2009, Deaths from reptile bites in the United States, 1979-2004. *Clinical Toxicology,* 47: 44-47.

Lohiya, G-S, Tan-Figueroa, L, Lohiya, S & Lohiya, S 2013, Human bites: bloodborne pathogen risk and postexposure follow-up algorithm. *Journal of the National Medical Association,* 105: 92-95.

Manning, SE, Rupprecht, CE, Fishbein, D, Hanlon, CA, Lumlertdacha, B, Guerra, M, Meltzer, MI, Dhankhar, P, Vaidya, SA & Jenkins, SR 2008, Human rabies prevention - United States, 2008: Recommendations of the advisory committee on immunization practices. *MMWR Recommendations and Reports,* 57: 1-28.

Merriam, C, Fernandez, H, Citron, D, Tyrrell, K, Warren, Y, Goldstein, E 2003 *Bacteriology of Human Bite Wound Infections,* 9: 83-86.

Moran, GJ, Talan, DA & Abrahamian, FM 2008, Antimicrobial prophylaxis for wounds and procedures in the emergency department. *Infectious Disease Clinics of North America,* 22: 117-143.

Morgan, M 2005, Hospital management of animal and human bites. Journal of hospital infection 61, 1-10.

Morgan, M, Palmer, J 2007 Dog bites. *BMJ,* 334: 413-417.

Peel, M, Hornidge, K, Luppino, M, Stacpoole, A ,Weaver, R 1991, *Actinobacillus* spp. and related bacteria in infected wounds of humans bitten by horses and sheep. *Journal of Clinical Microbiology,* 29: 2535-2538.

Radjou, A, Hanifah, M & Govindaraj, V 2012, Tetanus following dog bite. *Indian Journal of Community Medicine* 37: 200.

Rahman, R, Faiz, MA, Selim, S, Rahman, B, Basher, A, Jones, A, d'Este, C, Hossain, M, Islam, Z, Ahmed, H 2010 Annual incidence of snake bite in rural Bangladesh. *PLoS Neglected Tropical Diseases,* 4: e860.

Singh, A & Jain, R 2016, *Staphylococcus xylosus* Meningitis Following Dog-bite. *Indian Pediatrics*, 53: 931-931.

Smith, DK, Grohskopf, LA, Black, RJ, Auerbach, JD, Veronese, F, Struble, KA, Cheever, L, Johnson, M, Paxton, LA & Onorato, IM 2005, Antiretroviral post-exposure prophylaxis after sexual, injection-drug use, or other nonoccupational exposure to HIV in the United States: Recommendations from the US Department of Health and Human Services. Morbidity and Mortality Weekly Report: *Recommendations and Reports,* 54: 1-20.

Sudarshan, M, Mahendra, B, Madhusudana, S, Narayana, DA, Rahman, A, Rao, N, X-Meslin, F, Lobo, D & Ravikumar, K 2006, An epidemiological study of animal bites in India: results of a WHO sponsored national multi-centric rabies survey. *Journal of Communicable Diseases* 38, 32.

Taplitz, RA 2004, Managing bite wounds: Currently recommended antibiotics for treatment prophylaxis. *Postgraduate medicine* 116, 49-59.

Ward, MA 2013, Bite wound infections. *Clinical Pediatric Emergency Medicine,* 14: 88-94.

Warrell, DA 2010, Snake bite. *The Lancet,* 375: 77-88.

Weber, DJ, Rutala, WA, Kaplan, SL, Calderwood, SB, Edwards, MS and Baron, EL, 2016 Pasteurella infections. 2016. Pasteurellosis Status in Ethiopia: A Comprehensive Review. *Journal of Tropical Diseases and Public Health,* 8: 351-355.

Wilde, H, Lumlertdacha, B, Meslin, FX, Ghai, S, Hemachudha, T 2016 Worldwide rabies deaths prevention - A focus on the current inadequacies in postexposure prophylaxis of animal bite victims. *Vaccine,* 34: 187-189.