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Review Article

Gene Transfer between Human Bacteria and Pets Bacteria

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Abstract

Many individuals are exposed to bacteria especially those who are raising pets. This interaction between household pets such as cats and dogs and human gives the chance for bacteria to transmit easily. Thereby, these bacteria could transfer from pet's food and scratching to the owners. In this review, a bacteria gene transmission between pets and human is introduced and discussed. This transmission is happened due to the raising and owning these small animals. In addition, studies on Zoonotic diseases transfer between humans and animals especially pets are presented. Furthermore, the risk of pet ownership by people is reviewed and how should they interact with each other. Also, researches on how Antimicrobial-resistant pathogenic bacteria transmitting between human and pets are discussed. Eventually, gene transfer types between human and pet are explained with their consequences.

Keywords: Zoonotic, Bacteria, Pathogens, Gene Transfer, Antimicrobial-resistant and Horizontal Gene Transfer.

1. INTRODUCTION

Zoonotic infections are kind of diseases that can be transferred from pets to humans by vectors. There are thousands of pathogens that infect humans and about 61% of these pathogens are caused zoonotic diseases [1]. Therefore, the dynamical interaction between pathogens, humans, and animals that share the same place must be healthy and sanitized within what called the One Health method. In addition, the world climate changed many of antimicrobials in medical affairs which can be seen in farms and the owning guides of small animals [2].Consequently, the evolution of antimicrobial-resistance and antibiotics misuse may cause a global health issue. More importantly, these diseases are affecting the commerce, economics and travel worldwide. Many countries are suffering from zoonotic diseases and groups such as old, young, pregnant and immune-compromised individuals are under the risk [3].

Moreover, bacterial zoonotic infections are able to transmitted from pet to human in many ways: *i.* it could transmit through pet's bites and scratches [4]; *ii.* It is originating in pet's food that can reach human through cooking, bad food handling, contaminated pet's food products, and direct fecal oral route; *iii.* it can affect health workers and farmers (i.e., veterinarians) which are in danger because they are exposed to certain zoonotic pathogens also they could become carriers of the zoonotic bacteria in the environment [5]; *iv.* Vectors (i.e. arthropods) such a sticks, mosquitoes, lice, and fleas that can actively or passively transfer bacteria infections to human [6]; *v.* Water and soil recourses, that are polluted with manure implied a variety of bacteria. These approaches and areas that creating a great risk for zoonotic diseases such as bovine, tuberculosis, Listeriosis, brucellosis, …, etc. for bacterial genes that are ready for transfer and cause human diseases [7].

Many researches are found many differences such as economic and social differences between people who do not have pets and those who have pets in terms of healthiness. This lead to the fact that ownership of pets are very beneficial to the human being. On the other hand, the researchers have many things to raise the awareness of the people who attach their pets. In addition, there is relationship between allergic sensitization and small animals (pets) that have conflict results for cat ownership on account of dog ownership in term of protected against certain allergic sensitization [8].

The rest of the review paper is organized as follows. In Section 2, the benefits and risks of ownership pets is included. The zoonotice diseases are illustrated in Section 3 the pathogenic bacteria in pets

that are antimicrobial-resistant is reviewed. In Section 4, a discussion with details of the transfer of bacterial antimicrobial-resistant between pets and humans is made. In Section 5, zoo notice diseases and antimicrobial-resistant pathogenic in small animals like pets are introduced. Gene transfer and gene transfer mechanism are explained in Section 6. Eventually, the conclusion is presented at the end of the article in Section 7.

2. Benefits and Risks of Ownership Pets

There are many advantages of owning pets which effect on human lifestyle especially on adulthood [9]. In recent reviews, the raising of pet is shown several benefits that motivating people to interact with an active and healthy lifestyle [10].In addition, many studies is founded the relationships between the ownership of the pet and the owner increases the mobility maintenance and physical activity of the older adults [11]. This could also have included the cognitive functioning by maintain cardiovascular fitness grow up the oxygen delivery and blood flow to the brain which increases the maintaining brain volume and neuron formation [12]. Furthermore, pets are made the structured daily life require such as walks, regular meals, attention, and grooming all of these factors helped to structure a day with meaningful activities as self-care activities [13]. Pets are brought up positive energies like increase the feeling safe and happiness both inside/outside the home [14]. Thereby, dogs are considered such as the security guards, safety and protection with older people by making them feeling safer when they are strolling with dogs even at home [15]. Also, dogs and cats are factors to make chances to their owner people to create new social relationships of various socioeconomic and demographic backgrounds [16]. Further, they are acted as social catalysts and help to estate and stabilize the social networks. Moreover, it is discovered that approximately 40% of pets owners are recorded to be supported by people that they met with their companion pets because pets with individuals are realizing their neighbor [17]. Among community dwellings of older adults, pets are stimulated the communication that often served as a conversation topic [18]. Pets are able to directly provide a real social support by reducing the negative energy of the disinheritance and reduce the depression [19].

The above mentioned are the benefits that pets and small animals can brings to their owners. Despite of small animal's ownership that can be beneficial in all stages of life; it is also risky and challenges with the older people such as issues in the economic aspect that costs money [20]. In addition, pet care and pet healthcare may cause a financial problem for older ones and it could be worse than the one before retirement [21]. Moreover, health insurance of pets may afford the bills of veterinaries but still may not mange and afford other financial stuff [22]. Furthermore, there are other challenges that may be reasons for older people to not own a pet is that the attitude of a family member that may not like pets or caregivers may have bad experiences with small animals [23]. However, the problems of some diseases such as zoo noses diseases that may transfer between humans and small animals for those who have weak immune systems [24].

3. Zoo notice Diseases and Antimicrobial-Resistant Pathogenic Bacteria in Pets

Zoonotic diseases are infections which can be transferred from humans to pets with/without carriers or vectors. There are about 1500 pathogens that could infect people and about 61% of them may cause zoonotic diseases [25]. Furthermore, humans who spent more of the day with the small animals such as abattoir workers, veterinarians, zoo/pet-shop workers and farmers are exposed to the zoonotic disease. Moreover, people in the bigger community are also at the risk of those diseases that may be transmitted by the family of these pets. The immunity system protects people who are at the danger to be infected by zoonotic bacterial diseases. Thereby, humans are able to either temporarily suppressed in their immunity due to infant age, pregnancy or long-term immuno-suppressed such as the result of the organ transplant, diabetes, alcoholism, cancer treatment or an infectious disease (i.e., AIDS) [26].

Many researches are stated that pets could be containers of resistance genes and bacterial species in people such as Methicillin-resistant Staphylococcus aureus (MRSA), vancomycin-resistant enterococci (VRE) and multidrug-resistant *Salmonella* Typhimurium (DT104). Consequently, MRSA was first described and found in a dog back in 1994 while it had been described in cats by studying the staphylococcal flora for approximately 148 cases in Brazil [27]. Recently, MRSA in United Kingdom are reported that the isolation from small animals makes people less exposure to the disease [28]. In addition, MRSA carriers can be a hazard to their owners because it increased the chance of the infection. However, it has to be noticed that pets are seemed to become containers of MRSA by exposing to the infected people. Therefore, those people may not be constituted the main container of MRSA but behave as a secondary container. Also, methicillin-resistance is founded in *S. intermedius*, coagulase-variable and coagulase negative staphylococci (CoNS) species like *Staphylococcusschleiferi* that showed the occurrence of methicillin-resistant *S. intermedius* and coagulase-negative staphylococci in uninfected Brazilian cats [29]. After that, reports are made in USA about the isolation of the methicillin-resistant *S. Schleiferi* that stated nearly about eleven dogs with recurrent pyoderma Although, *S. schleiferi*is magnificently seemed to be the reason of the infections that acquired in hospitals [30]. Thus, infections of canine/carriage likewise organisms

referred as a danger for people who are in touch with dogs. VRE are another concern for people because of the important of vancomycin therapy for nosocomial infections that is caused by multi-resistant gram-positive bacteria. Consequently, the use ability of avoparcin in small animals production was stopped in Europe in 1997 due to its responsibility for induce resistant to the vancomycin [31]. Recently in Europe, researches are documented of a highly relative incident (7–23%) of VRE (mainly *Enterococcus faecium*) in dogs that are farm animals and urban area dogs. In addition, canine VRE contained the *vanA*-resistance gene cluster and exhibit multi-resistance to other antimicrobials like macrolides (*erm*(B) gene), aminoglycosides and tetracycline (*tet*(M) gene) [32]. Thus, vancomycin does not applied in pets veterinary practice while VRE is selected by using of such antimicrobials [33].

4. Transfer of Antimicrobial-Resistant Bacteria between Pets and People

The touches and connections between people and household pets make favorable situations of the bacteria to either contact directly or by local environment. In addition, children are in danger more than elders because they are closer to these pets. However, a horizontal transmission of resistant genes could happen in the opposite direction to bacterial normal transfer. For instance, a bacteria in human transferred to pet could gain a resistant gene from the pet's commensal flora and it could be chosen by the antimicrobial treatment in this pet. Consequently, if a bacteria transferred from pet to human, therefore the pet participates in the propagation of the gained resistance bacteria using faecal shedding which leads to enhance their spread in the public [34]**.** Figure 1 is shown the major routes of how bacteria could transfer from pets to human.

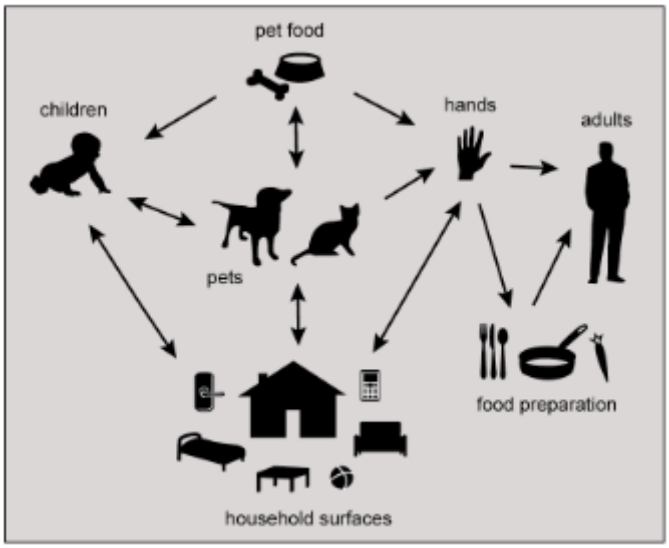

Figure 1: Main routes of transmission the bacteria from pet to owner

Recently, it is approximated that about 6% of enteric *Campylobacteriosis* transferred from small animals to people. Different researches are explained that the ownership of a pet is risky to *Campylobacter-jejuni*infections for people especially to young citizens. The same Pulsed-field gel electrophoresis (PFGE) cases have been defined in *C. jejuni*isolates in cats, dogs and people living in various geographic places. Consequently, the evidence of transferring of *C. jejuni* between pets and people who lives in the same place which is shown using amplified-fragment length polymorphism (AFLP) [35]. Even if the pet is eaten a commercial diet acquired from a normal food source; it is possible for a *C. jejuni* to transfer to the dog that is given a occasionally given a human scraps of the food. Many different researches are documented about the MRSA transmission between sick people (or their families) and pets who are living in the same house [36]. Although, *E. coli* strains that may cause Urinary tract infections (UTI) in pets are related phylogenetically to people exhibit virulence genes and extra intestinal pathogenic *E. coli* (ExPEC). Moreover, these are considered as the features of people clinical isolates for more than 15% of canine faecal in the environment deposits of been discovered to contain *E. coli* strains that are associated to people virulent ExPEC clones [37]. Thereby, direct proof of transfer is not documented yet and these data gives an indication that canine faeces may refer to an importance container for the acquired ExPEC using people. Also, pets are addressed potentially as an important source of VRE for patients in hospital according to the similarity of the AFLP patterns among people and pet clinical isolates [38].

Many researches indicate a possibility of association between the use of antimicrobial and the emergence of antimicrobial resistant in small animals.

For instance, the increased use ability of the lincosamides noticed in Sweden during the 90s corresponding with an increasing in lincosamide resistant among staphylococcal insulates from caninepyoderma [39]. This research is also showed that the resistant of lincosamides, tomacrolides, tetracycline, streptomycin and fusidic acid are commonly in insulates from the first-time cases than the recurrent cases. Probably, these differences are caused by the selective pressure exerted using recent antimicrobial treatment in recurrent cases of pyoderma. Extra research is made at a teaching veterinary hospital in USA that is shown an increasing in enrofloxacin resistant among the *E. coli* insulates from pets with Urinary Tract Infection (UTI) [40]. In mid of 90s, the increased enrofloxacin resistance is followed by an increase in the enrofloxacin use ability at the hospital of veterinary from 1334g to 2358g. Consequently, the prevalence growing of the enrofloxacin-resistance *E. coli* in urine of the pets with UTI is not confined to one enrofloxacin-resistance clone but it is over to acquire the resistance in not related strains. After that, Nosocomialinfections with *Salmonella enterica*serovars and *Acinetobacterbaumannii E. coli* had been noticed in hospitalized pets in intensive care places [41]. The emergence of multi-resistant nosocomial pathogens in pets is reflecting the abundant usage of the broad-spectrum antimicrobials in intensive care places at hospitals of veterinary [42].

5. Gene Transfer and Gene Transfer Mechanism

The transmission of the genetic information between humans is made in two ways: vertical, from fathers (parents) to children (siblings) and horizontal (HGT) between the individuals of the same or different species [43]. The gene transfer in bacteria is described by Griffiths and his team (200) that they can be accomplished through the viral transduction, conjugation and transformation. Furthermore, the inheritance of the genetic of the parents are using the conjugative transfer of the DNA throughout High-frequency recombination (Hfr) strains that showed the one important characteristic that the generalized transduction and donor chromosome's share. Moreover, a process proposes fragment of a DNA into the receiver cell; and a double-crossover occurrence should be divided into the subsequently inherited and recipient genome. Although, the unincorporated fragments are not able to be duplicated and diluted out away from the of daughter cell's population. Consequently, the conjugative transmission of F′ elements which are genes of a bacteria carriers and specialized conversion of a certain markers of the genetic are similar procedures in that a specific and limited set of bacterial genes. Moreover, inheritance does not require normal recombination, as in the inheritance of DNA fragments. However, the F′ element replicates in the bacterial cytoplasm as a separate object. Thereafter, the specialized converting bacteriophage DNA is combined again into the bacterial chromosome by a recombination system for that certain bacteriophagev. Hfr crosses are first applied to localize a certain mutation for a certain spot of the chromosome [44]. Then, the generalized transduction offers a more exactness localization. Eventually, the horizontal gene transfer mechanism is shown below in figure 2.

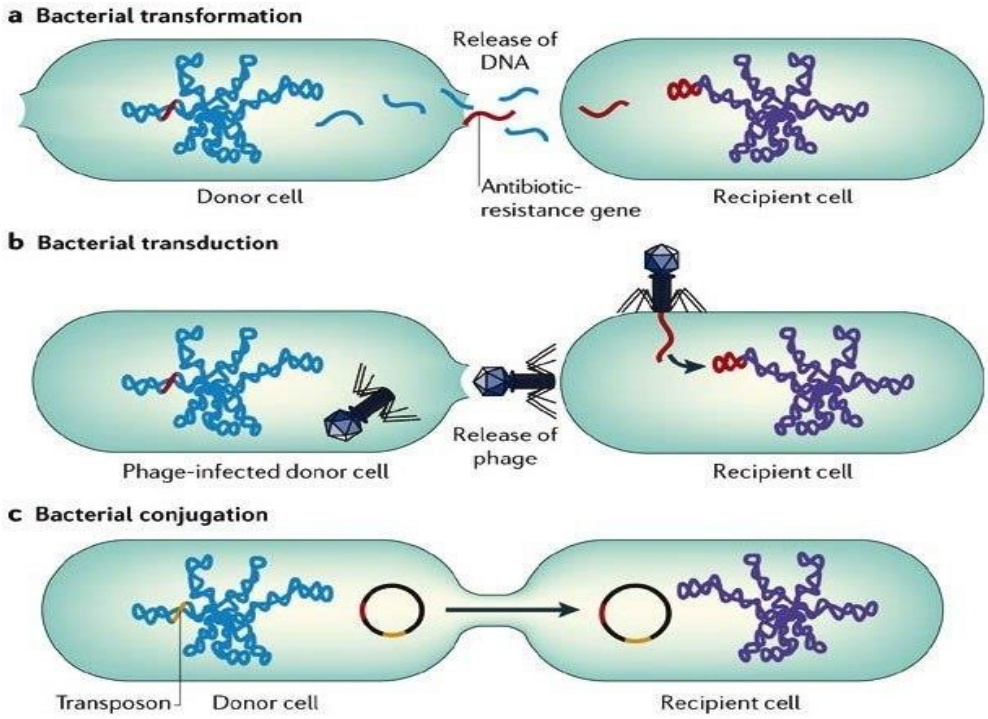

Figure 2: Horizontal gene transfer mechanisms

HGT plays an important role in the spread of multi-genetic traits; more importantly it participated actively in the successful adaptation of bacteria to new niches [45]. Furthermore, HGT raised a fascinating problem when it was considering that prokaryotic mobile-genetic elements (MGE) affected not only bacterial lifestyle but also evolution of eukaryotic complex organisms since the gene transfer between bacteria and eukaryotes [46]. Moreover, the mechanisms of HGT spread among species or bacterial strains were often viewed to be the primary moderators of antibiotic resistance. However, mutational resistant is invaluable in researches of the bacterial genetics also; it has a primary clinical key role in a particular species of bacteria such as *Helicobacter pylori* and *Mycobacterium tuberculosis.* In addition, it is considered as a resistant to particular antibiotics, especially to the synthetic agents like oxazolidinones and fluoroquinolones [47].Consequently, mutation is necessary for the continuity of the evolution of acquire-resistance genes that have increased to over a hundred variants of the TEM β-lactamases. Also, Hyper mutator strains of the bacteria mutations in gene affecting the replication fidelity and DNA repair that had increased the mutation rates [48].

CONCLUSION

The antibiotic resistant is the major common problem for veterinary and human medicine. In addition, the potential impact of antibiotics usage in pets on resistant in humans was frequently the debate focus point. In this review, the transfer path ways of resistance bacteria between humans and pets were described and the question is addressed whether a reduction in antibiotics usage in pets that contributed to the development of the resistant situation in humans. Moreover, the direct contact between people and their pets caused this issue such as transmission of bacteria via food while the indirect transmission was via emissions in the environment and the subsequent exposure of people to the environment were the major transfer ways to be discussed. Thus, it can be established that the relevance of these various transmission ways were differs significantly among bacterial species. Furthermore, numerous investigations were made that confirmed that the exact significance of transfer pathways and the bacteria transferred for the resistant situation in humans cannot yet be precisely quantified. Finally, here are some recommendations for people to follow when they want to own or raise a pet:

a) Before owning pets, people must be sure that this pet are undergo a vaccination programs or submit the pet to a one of those.
b) Appointment a veterinarian at regular times to check that these pets are free of diseases.
c) Do not overuse antibiotics that may cause issues.
d) Owners must cover their mouth and wearing gloves when they are cleaning the faces of these pets.

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