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Perspective of vaccination in veterinary medicine: A review

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Abstract
Veterinary vaccines have had, and continue to have, a major role in protecting animal health and public health, reducing animal suffering, enabling efficient production of food animals to feed the burgeoning human population, and greatly reducing the need for antibiotics to treat food and companion animals. Clearly, disease prevention by vaccination is recognized by all as a superior strategy to manage diseases. Recently vaccine can be categorized into live attenuated, inactivated (killed vaccine), sub unit (purified antigen), and toxoid (inactivated toxin) based on the antigen they used for preparation. The major mechanism action of vaccine is by training the immune systems to recognize and combat pathogens, either virus or bacteria. To prevent and control infectious livestock diseases which have a major public health effect; veterinary vaccine is primarily used. There is an urgent need to emphasize this approach by providing incentives to continue the well-established methodologies and, in addition, to promote fresh ideas in a new direction beyond the established framework. Livestock vaccination have varieties of advantages in human health through prevention of emerging and re-emerging zoonotic diseases. Veterinary vaccines will continue to be an important tool to protect human health, animal health, food safety, and food security and must be accessible and economical.

Keywords: Animal, health, human, prevention, vaccine, veterinary

Introduction
The population's ability to survive depends entirely on the livestock industry for supplies of meat, milk, energy during droughts, and income. In order to fulfill the rising demand for protein to support human nutritional needs, there has been a corresponding, unprecedented development and growth of food animal production, which is expected to reach 9.8 billion people by the year 2050 (Lewis and Roth, 2020) [20]. The move towards high volume, animal dense systems, which offer many potentials for the rapid spread of illness in both industrialized and developing countries, has been pushed by this growing demand (Roth and Galyon, 2019) [28].

Animals raised for food are vulnerable to a variety of illnesses brought on by bacteria, viruses, fungus, and parasites. It makes sense to protect animals from these threats whenever possible. The health and welfare of animals as well as the accessibility of wholesome food for consumers will improve as sickness and the misery it causes are reduced. The immunization of cattle is one of the most important steps in the development of the animal industry for overcoming these obstacles. Additionally, a number of bacterial, viral, fungal, and parasitic infections have been re-emerging and posing a hazard to the global population (Mark *et al*., 2016) [21].

A crucial element of all disease preventive and control methods is the vaccination of livestock. The promotion of good animal welfare, good health, and economic stability for farmers and communities can all be achieved through immunizations (Yohannes, *et al*. 2020) [36]. In order to optimize vaccination tactics, it may be necessary to consider the evidence of low vaccine adherence by farmers and communication between farmers and veterinarians. The drawback of antimicrobial resistance (AMR) of infectious and non-infectious diseases of the animals could be used to overcome with an enhanced understanding of farmers' opinions of the veterinarian and animal vaccination (Richens, 2015) [26].

In contrast to human immunizations, vaccines for animals have a variety of applications. The primary benefits of veterinary vaccinations are safe and effective food production, zoonotic disease control, prevention of new and exotic animal and human diseases, decreased demand for antibiotics, food safety vaccines, and disease control in horses and companion animals (Roth, 2011) [29].

The use of several bacterial as well as viral vaccines in animal populations has been shown to significantly reduce the need of antibiotics, according to a number of recent studies (Hoelzer, *et al*., 2018) [15]. The potential financial returns for veterinary vaccines are far lower than for human vaccinations, and they also have lower sales prices and a smaller potential market value. Additionally, there is a lower investment in research and development for animal vaccines than human vaccines, although the range of hosts and pathogens are greater (Mark. *et al.,* 2016) [21]. The critical challenges of veterinary vaccines are also lack of developing new vaccines due cost and licensing the product (Bayne and Riviere, 2014) [4]. This paper is an attempt to review the perspective of vaccination in veterinary medicine.

1.1. Background of vaccine development

The terms "vaccine" and "vaccinology" came into use soon after an English Physician, Scientist Edward Jenner (1749-1823) discovered the smallpox vaccine, and he was referred as father of immunology. Jenner called the smallpox vaccine "variola vaccinae'' (Bailey, 1996) [2]. The word "vaccine" comes from Latin term ''Vacca'' meaning cow. Its concept was also pioneered by Jenner's. His work is said to have "saved more lives than the work of any other human". He postulated that the pus in the blisters that milkmaids received from cowpox (a disease similar to smallpox, but much less virulent) protected them from smallpox. He was tested this hypothesis by inoculating James Phipps, an eight-year-old boy who was the son of Jenner's Gardener on 14 May 1796 (Jivani *et al.,* 2016) [16]. However, the term "vaccine" was used for first time by Swiss Physician Louis Odier (1748-1817), and the terms "to vaccinate" were first used by Richard Dunning (1710- 1797) (Lahariya, 2016) [18].

1.2. Classification of vaccines

Vaccines can be categories into different types, but ultimately work on the same principles (Dai *et al*., 2019) [9]. The administered vaccination shouldn't result in serious illnesses but should instead boost the immune system of the vaccinated host to enable the body's immune system to identify and eliminate the pathogen when infection later arises. Compared to the expense of chemotherapies and prophylaxis against many infectious diseases that can be prevented by vaccination, vaccination is the most highly cost-effective strategy to prevent or minimize clinical manifestations after infection and to eliminate infectious diseases. Recently, vaccines can be categorized into live attenuated, inactivated (killed vaccine), sub unit (purified antigen), and toxoid (inactivated toxin) based on the antigen they used for preparation (Lee *et al*., 2012) [19].

1.2.1. Live attenuated vaccines

These types of vaccine are antigenic substances composed of a viable (living) pathogen, such as a virus or bacterium which have been "weakened" (attenuated) so that they create a protective immune response but do not cause disease in healthy people or animals. The pathogens are altered so that it is less virulent or avirulent (attenuated). When administrated they elicit protective immunity against the pathogen (Bass and Goel, 2020) [3]. This "weakening" of the pathogen is accomplished through genetic change of the pathogen, either as a naturally occurring event or as a modification, for the majority of contemporary vaccinations. Live vaccines tend to create a strong and lasting immune response. However, live vaccines may not suitable for people or animals whose immune system does not work, either due to drug treatment or underlying illness. This is because the weakened viruses or bacteria could in some cases multiply too much and might cause disease in these individuals (Lee *et al.,* 2012) [19].

1.2.2. Inactivated (killed vaccines)

Inactivated vaccines are less dangerous than live vaccines since there is little chance that they may revert to a virulent form that can spread diseases because they cannot reproduce at all in a vaccinated host. However, compared to live viral vaccines, they often offer less protection for a shorter period of time and elicit weaker immunological reactions, particularly cell-mediated immunity. For this reason, inactivated vaccines are administered with potent adjuvant, and require boosters to elicit satisfactory and a long-term immunity (Bass and Goel, 2020) [3]. Killed vaccines are generally created by inactivating propagated viruses by treatment with heat or chemicals such as formalin or binary ethyleneimine. This procedure can destroy the pathogen's ability to propagate in the vaccinated host, but keeps it intact so that the immune system can still recognize it. Although inactivated virus vaccines have been used for preventing various types of viral diseases over the decades, they need further development for controlling newly emerging diseases (Pollard and Bijker, 2020) [25].

1.2.3. Subunit/recombinant vaccines

Bacterial or yeast cells are used in the production of subunit or recombinant vaccines. The producing cells are given a small amount of DNA from the virus or bacteria that we want to protect ourselves from. Subunit/ recombinant vaccines can be classified as a type of inactivated vaccine that contains only part of the virus or other microorganisms. Subunit vaccines for pathogens can be generated as recombinant proteins in various expression systems, as long as appropriate immunogenic antigens of the target pathogen are empirically determined (Bass and Goel, 2020) [3].

Recombinant proteins may be used in non-replicating subunit vaccinations that are secure. By modifying the DNA that codes for these proteins, a significant number of proteins can be produced, purified, and then administered to a specific host to trigger an immune response against the pathogen. Generally speaking, vaccination with antigens alone only produces mild immune responses, necessitating the use of powerful adjuvants and repeated injections. Subunit vaccines would become less competitive with regard to other types of vaccinations as a result of the high production costs. Despite this restriction, a number of subunit vaccines have been released, and a different subunit vaccine can be produced through genetic engineering (OVG, 2020) [22].

1.2.4. Toxoid (Conjugated vaccines)

Conjugated vaccines resemble recombinant subunit vaccines, which typically have two distinct components, to some extent. They were developed to combat infections that are shielded from phagocytosis by polysaccharide capsules. Due to the polysaccharide's low immunogenicity, joining it with an immunogenic protein makes it possible for the immune system to detect it as if it were a protein antigen. They are created by chemically joining the polysaccharide to a carrier protein, which intensifies the immune reactions against both the carrier protein and the bacteria-derived component. Immunity to a piece of the bacteria can protect from future infection (OVG, 2020) [22].

1.3. Mechanism of immune development after vaccination

The major mechanism action of vaccine is by training the immune systems to recognize and combat pathogens, either virus or bacteria. To do these certain molecules from the pathogens must be introduced into the body to triggers an immune response. The molecules are called antigens and they are present on all virus and bacteria. By injecting these antigens into the body, the immune systems can safely learn to recognize them as hostile invaders, produce antibody, and remembers them for future use. Once the antigen specific antibodies are produced, they work with the rest of the immune systems to destroy the pathogen and stop diseases. However, antibody to one pathogen generally don't protect against other pathogens except when two pathogens are very similar to each other's, like cousin (WHO, 2020) [34].

1.4. Factors hinder the development of response against pathogens after vaccination

The vaccines are effective and least cost method in restoring of healthy and productivity of diseases, ideally veterinary vaccines are safe, efficacious, and provides robust and durable protection against a broad spectrum of pathogens (Jores *et al*., 2013) [17]. However, many currently available veterinary vaccines have various limitations that reduce their usefulness for preventing diseases and decreasing the need for antibiotics (Lee *et al.*, 2012) [19]. The major factors enhancing the animal vaccine failures can be raised from shortage of knowledge about the vaccine, improper storage and handling of vaccine, improper vaccine schedule, administering expired vaccine, and absence of vaccine demarcation with treatment drugs (Seid and Ahmed, 2017) [30].

Among the different factors which hinders the development of response of the cells of the human or animals to different pathogens, intrinsic host factors (age, sex, genetics and comorbidity), extrinsic factors (infection, parasites, antibiotic, prebiotics and probiotics, microbiota, preexisting immunity, food/feed status), environmental factors (season, geographical location), vaccine factors (vaccine type, product, and strain, adjuvant, doses) and administration factors (vaccination site, vaccination route, needle size, co-administered vaccine and drugs) are the major one (Zimmermann and Curtis, 2019).

1.5. Public healthy importance of animal vaccination

Vaccination (immunization) is a tried and tested method of assisting in the continual fight against disease in man and animals (Jivani *et al.*, 2016) [16]. An emerging and re-emerging animal disease are a growing threat to human and animal health and jeopardize food security specifically, an emerging zoonotic disease (Roth *et al*., 2010; Pal, 2018) [27, 24]. To prevent and control such livestock diseases, which have a major public health effect; veterinary vaccine is primarily used (Roth, 2011) [29]. Livestock vaccination have varieties of advantages in human health through prevention of emerging and re-emerging zoonotic diseases. On other hand it's also used in prevention of drug residue that indirectly involved AMR which is irritating issues of recent decades (Rodrigues and Plotkin, 2020).

The maintenance of animal health depends on the use of high-quality veterinary vaccinations. They are an important means of control for many animal diseases, and crucial components of many national disease-controls or eradication of disease (Yohannes *et al.*, 2020) [36]. In addition to control zoonotic diseases in food animals, companion animals, and vaccines reduce the need for antibiotics to treat infections in food producing and companion animals. Recently, an increasing concern related to antibiotic resistance associated with the extensive use of antibiotics in veterinary and human medicine (Frost *et al.*, 2019) [12]. Moreover, vaccination along with sanitation and clean drinking water, are public health interventions that are undeniably responsible for improved health outcomes and in past decade it is estimated that vaccines have prevented million deaths from vaccine preventable diseases (Buchy, 2020) [7].

Pathogens that are confined to human reservoirs can be eradicated globally. For eradication of infectious diseases, high levels of population immunity are required (Andre *et al.*, 2008) [1]. The traditional measures of vaccine impact include vaccine efficacy, the direct protection offered to a vaccinated group under optimal conditions and indirect effect of vaccine on the population in a real-life setting (Wilder-Smith *et al*., 2017) [35]. They are promising alternatives to antibiotics because numerous studies have shown that their animal agriculture use can result in a large decrease in antibiotic consumption. To be widely used in food producing animals, vaccines have to be safe, effective, easy to use, and cost-effective (Hoelzer *et al*., 2018) [15].

1.6. The economic importance of vaccination

Livestock and poultry are a significant contributor to the economy of many countries, accounting for over half of United States agricultural cash receipts, often exceeding $100 billion per year (Lewis and Roth, 2020) [20]. The increasing human population is also leading to an increase in "backyard" animal production in both rural and urban environments. The United Nations Food and Agriculture Organization (FAO) estimates that, to meet this increased demand by 2050, food production must increase by approximately 70% compared to 2005 production levels (FAO., 2009) [11]. As a consequence of the expansion of both the global human and production animal populations, there has been an increase in the emergence and reemergence of animal diseases which can diminish the economy of the country through banning international trade of the livestock, cost vaccination and others related. (Hassell *et al.*, 2017) [14].

The economic impacts of vaccine used in livestock contribute the commercial livestock, smallholder and traditional production systems integrated into markets systems, and the extra income source of keeping livestock. Because, vaccination is widely recognized as one of the most efficient tools for animal and public health, showing obsessions cost benefit advantages for all the target population involved (Thomas *et al.*, 2019) [33]. Despite the widespread availability of vaccines against many animal diseases, Ethiopia has the fewest and lowest immunization rates of any country for veterinary vaccines. Thus, to mitigate the ever-increasing trends of disease threats posed to the animal agriculture and public health risks (Endalew and Wakene, 2020) [10].

A vaccination program has clear direct costs including:

vaccine purchase, infrastructure to run the program and maintain the cold chain, and healthcare. Governments invest in these with the goal of enhancing health, occasionally with assistance from charities and non-governmental organizations. Through a combination of direct and indirect protection, successful immunization programs have decreased morbidity and mortality, which has decreased disease incidence, the need for treatment, and the expense of healthcare (Bonanni *et al*., 2015) [6].

The majority of immunization programs cost less than $50 per life gained, according to cost effectiveness assessments, which show that they are overwhelmingly worth the effort. But in Ethiopia livestock losses due zoonotic diseases like rabies, health and the corresponding benefits of controlling the diseases are often not considered when the cost-effectiveness of the rabies evaluated (Beyene *et al*., 2019) [5]. It has been suggested that the economic impact of vaccine should be considered more broadly than just the averted healthcare costs from prevented illness episodes and associated cares costs (Gessner *et al*., 2017) [13].

1.7. Role of vaccination in the prevention and control of infectious disease

Vaccination is essential for preventing the spread of infectious diseases and aids in their control and eradication (Pal, 2017) [23]. Only a small number of infectious diseases can be controlled by preventive vaccination due to the sporadic and limited efforts to develop vaccines (Stern and Markel, 2005) [31]. The effectiveness of preventive vaccination in pediatric immunization programs around the world is demonstrative of the necessity and practicality of producing more prophylactic vaccinations. This is due in part to their non-availability for the vast majority of infectious diseases brought on by known pathogenic species of viruses, bacteria, protists, fungi, and helminths, but it is also due to the estimated three new pathogens that develop each year (Butcher, 2008) [8].

Given the persistence of infectious diseases in various forms, it becomes even more necessary to make serious investments in vaccine development. First off, the majority of them are zoonotic illnesses, which frequently spread by vector transmission between domestic and wild animals and are therefore impossible to eradicate. Second, as infections gain medication resistance, our reliance on treatment, such as chemotherapy, rather than prevention for illness management has become untenable. Finally, since no chemotherapeutic agent is expected to reach all the desired targets, regardless of dosage and frequency of application, durable cure of infectious diseases has long been thought to need post-therapeutic establishment of efficient immunity (Stern and Markel, 2005) [31].

Conclusion and recommendations

Vaccination (immunization) is a tried and tested method of assisting in the continual fight against disease in man and animals. Vaccination (Immunization) plays a pivotal role to protect the health of humans and animals by preventing and controlling many infectious diseases, which are prevalent in developing as well as in developed countries of the world. Immunization is considered as the most successful and cost-effective public health interventions throughout the world.

The direct protection provided to a group that has received vaccinations under ideal conditions and the vaccine's indirect effects on the population in a real-world context are the classic measurements of vaccine impact. They are promising antibiotic substitutes because, according to various studies, using them in animal agriculture can significantly reduce the need for antibiotics. Vaccines must be secure, efficient, simple to administer, and affordable for them to be extensively utilized in animals raised for human consumption.

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Author's contribution

Both the authors contributed equally. They read the final version, and approved it for the publication.

Conflict of interest

The authors declare that they do not have any conflict of interest.

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