REVIEW ARTICLE

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Vaccination principles for dogs and cats in animal shelters

Princípios da vacinação de cães e gatos em abrigos

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ABSTRACT

Animal shelters are places with a high risk of exposure to infectious diseases due to the high density, population dynamics of the shelter, and the stress to which dogs and cats are subjected. The immunization process through vaccines is an essential component in the prevention and health and welfare management program for these animals. This review aims to evaluate the guidelines on vaccination of dogs and cats in shelter environments, highlighting points of comparison with the Brazilian reality.

Keywords: Shelter medicine. Protocols. Preventive veterinary medicine. Vaccine. Immunization.

RESUMO

Os abrigos de animais são locais com um alto risco de exposição às doenças infecciosas devido à alta densidade, à dinâmica populacional do abrigo e ao estresse a que os cães e gatos estão submetidos. O processo de imunização por meio das vacinas é um componente essencial no programa de prevenção e gestão de saúde e bem-estar para esses animais. Esta revisão tem como objetivo revisar as diretrizes sobre a vacinação de cães e gatos em ambientes de abrigos, ressaltando pontos de comparação com a realidade brasileira.

Palavras-chave: Medicina de abrigos. Protocolos. Medicina veterinária preventiva. Vacina. Imunização.

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Introduction

The abandonment of companion animals is a consequence of human-animal bond breaking, which, in addition to resulting in a high number of non-domiciled animals (Hines, 2003; Lambert et al., 2015), increases the contingent of animals in shelters. This represents a serious problem for the management of these shelters, both due to the high animal density in these environments, and the lack of financial and human resources to ensure good animal welfare levels.

Shelters are places of temporary stay, whose objective is to selectively rescue animals, retrieve, re-socialize, and reintroduce them into society through responsible adoption. These facilities bring together several animals in a delimited space. So, the maintenance of dogs and cats in the collective requires different strategies to prevent diseases and maintain good levels of well-being. In Brazil, Shelter Medicine is still an incipient and challenging area for veterinarians and workers in daily practice. It requires multidisciplinary knowledge since it is an area with little diffusion, low visibility, and poor promotion of resources in the country. The major difficulty for professionals working in this area is to manage collective health management, providing quality medical care to ensure that individual

animals are physically and mentally healthy (Garcia, 2019). Animal shelters are generally characterized by a population of random origin, with predominantly unknown medical and vaccination history. There is, in addition, high animal turnover and high density of dogs and cats, resulting in groups of animals with different health conditions, or very close quarters between animals. All these conditions facilitate the spread of infectious and contagious diseases, increase animal susceptibility to disease (whether due to individual conditions, stress, or immunosuppression), or even contribute to the reactivation of pre-existing diseases, whose consequences are potentially lethal (Hurley & Miller, 2009; Larson et al., 2009; Newbury et al., 2010; Gingrich & Lappin, 2012; Dudley et al., 2015; Cossio et al., 2017; Day et al., 2020; Stone et al., 2020). Furthermore, eradication of infectious diseases in these environments, once faced with an outbreak, is extremely challenging and difficult to achieve (Hurley & Miller, 2009; Day et al., 2016). Due to the high probability of exposure to pathogens and given the fact that the consequences of infectious diseases in these environments are potentially devastating, the existence of a clearly defined shelter vaccination program is essential for proper disease control and to ensure the health and the welfare of the resident animals (Day et al., 2016).

Vaccination is an essential component in the prevention and health management of companion animals. In shelter environments particularly, when combined with practices that minimize stress and reduce the risk of exposure to pathogens, this measure helps animals stay healthy, or reduces the severity of clinical illnesses (Schultz & Conklin, 1998; Hurley & Miller, 2009; Larson et al., 2009). That way, it is possible to achieve a lower rate of permanence in the facility and a higher probability of adoption, which reiterates the shelter's objectives towards society. Furthermore, the probability of occurrence of infectious disease outbreaks decreases substantially when animals are correctly vaccinated before pathogen exposure (Greene & Schultz, 2006; Larson et al., 2009; Ford et al., 2017).

This article aimed to review the guidelines on vaccination of dogs and cats in shelter environments, highlighting points of comparison with the Brazilian reality.

Vaccination of Dogs and Cats in Shelters

One of the pillars to ensure protection, health, and quality of life for sheltered animals is immunization through vaccination. It should be considered that these are individuals housed in high population density environments, with constant exposure to animals with unknown medical histories, who had little or no preventive care before admission, including immunization. Therefore, the probability of contracting an infectious disease significantly increases in the absence of the vaccination procedure (Hurley & Miller, 2009; Spindel, 2013). Animals that fall ill in shelters have a reduced chance of survival. When recovered, these animals are less likely to be adopted (Patronek & Crowe, 2018) and, consequently, more likely to remain in the shelter. So, dedicated efforts to prevent infectious diseases should be part of the shelter medicine equation (Hurley & Miller, 2009; Gingrich & Lappin, 2012; Spindel, 2013; Day et al., 2016).

Vaccination, although essential, cannot be used as a single tool for the protection of animals, but as part of an infectious disease control program. Effective programs to control infectious diseases in shelters, therefore, include vaccination, disinfection, and segregation of healthy and sick animals. Even for canine and feline respiratory pathogens (e.g. parainfluenza virus, *Bordetella bronchiseptica*, feline herpesvirus, calicivirus, and *chlamydia*), whose vaccination is not capable of providing sterilizing immunity, the immunization procedure can reduce the severity of clinical manifestations and the frequency of clinical signs. This means that immunization is a useful complement in the shelter's management since unvaccinated animals can suffer from severe clinical manifestations and a greater chance of death (Conklin, 1998; Larson et al., 2009; Schultz & Spindel, 2013; Ford et al., 2017;).

Often, even housed animals do not receive preventive care with vaccination and, therefore, may be unprotected against common pathogens such as canine distemper virus (CDV), canine parvovirus (CPV), and feline parvovirus (FPV) (Lechner et al., 2010; Perrone et al., 2010; Day et al., 2020). Although shelter animal vaccination guidelines recommend vaccinating all animals at the time of admission or one week before admission (Larson & Schultz, 2006; Hurley & Miller, 2009; Larson et al., 2009; Lechner et al., 2010; Newbury et al., 2010; Scherk et al., 2013; Spindel, 2013; Day et al., 2016; Stone et al., 2020), this practice is not followed in many Brazilian shelters. The reasons may be a lack of knowledge of a specific protocol based on the literature, which diverges from the traditional veterinary practice of dogs and cats or for financial reasons (Lima & Garcia, 2019). Furthermore, in Brazil, there are no publications on the percentage of dogs and cats with adequate antibody titers when entering shelters. Added to this fact, there is the constant introduction of new animals that, for the most part, share an insufficient physical space, often with inadequate sanitary conditions. In this context, the length of stay of animals in shelters is extremely variable, ranging from a few months to several years. Thus, these

animals are constantly exposed to infections, both because of close contact with other animals of the same species in a high population density, as well as possible errors in preventive management. The transmission of pathogens can be potentiated in susceptible animals or exacerbated by the potential of the highest challenge from infectious diseases and isolation of these animals in the microenvironment of the shelter.

Studies conducted with shelter dogs and cats found that many had insufficient antibody titers to some species-specific diseases (Hartmann et al., 2007; Lechner et al., 2010), but also that many animals had seropositivity for pathogens that could be prevented by vaccines (Digangi et al., 2012; Litster et al., 2012; Spindel et al., 2018). The publication by Monteiro et al. (2016) showed that pathogens that affect the respiratory tract of dogs (canine viral parainfluenza, adenovirus type 2, and canine distemper virus), for example, are common in shelters. Authors also found that the pathogen frequencies seem to be related to environmental and nutritional conditions, which indicates the need for control/prevention measures, including vaccination and environmental management, to minimize such infections. A study by Andrukonis et al. (2021) found that vaccination during animal admission was able to reduce clinical signs of canine respiratory diseases during an outbreak in an animal shelter.

In the literature, vaccination coverage of 70-75% has been suggested as the minimum adequate level to prevent disease outbreaks in dog populations with guardians (Horzinek, 2006; Riedl et al., 2015; Day et al., 2016). But for shelter environments, due to the characteristics already mentioned, this vaccination coverage should probably be greater than that to be effective. Thus, it is extremely important to follow vaccination protocols in these animals according to specific published guidelines (Decaro et al., 2020).

It should be noted, however, that in any population of vaccinated individuals, absolute protection can never be guaranteed, as the immune response is a biological process influenced by several factors (genetic, environmental, individual) (Greene & Levy, 2014). Thus, the management of infectious diseases in animal shelters must have the perspective of guaranteeing a herd effect: which means indirect protection from infectious disease when a sufficient percentage of a population has become immune to it, thereby reducing the likelihood of infection for susceptible individuals. This effect can be achieved both by the strength of transmission from the previous infection and recovery, as well as by the immunity of the herd; that is, by the proportion of immune individuals in a given population. Thus, an effective immunization program aimed at the control, elimination, or eradication of vaccine-preventable infectious diseases must be rigorously applied in animal shelters (John & Samuel, 2000; Andrukonis et al., 2021).

Types and classification of vaccines

Vaccines can be of different types, and this results in different responses and duration of immunity (Tizard, 2013a; Greene & Levy, 2014). Regarding the quality of the immune response following vaccination, it is worth mentioning that a sterilizing immunity or non-sterilizing immunity may occur depending on the pathogen and vaccine technology. In immunocompetent animals, sterilizing immunity can prevent the disease and ensure the elimination of the pathogen when exposed to it in the environment (e.g., parvovirus and canine distemper virus). Non-sterilizing immunity, on the other hand, comprises those vaccines that can reduce the severity of clinical manifestations but do not completely prevent infection, and there may be mild clinical signs and/or elimination of the etiological agent (e.g.: *Leptospira*, canine parainfluenza virus) (Ford et al., 2017).

Regarding vaccine technology, these can be divided into live-attenuated or modified, also called infectious, and inactivated or dead, also called non-infectious. There are also, in veterinary medicine, the recombinant vectorial vaccines that, although alive, use a vector virus whose role is to carry the genetic information of the pathogen to which immunity stimulation is desired (Tizard, 2013a; Day et al., 2016; Ford et al., 2017). As for the duration of immunity (DOI), although pathogens play a role in the immune memory, is usually expected that live attenuated and recombinant vaccines provide a longer DOI of three years or more, whereas inactivated vaccines rarely provide a DOI greater than 1 year (Tizard, 2013b; Ford et al., 2017). Thus, knowledge of the type of vaccine and the particularities of the etiological agents is essential for choosing a protocol that meets the demand of each individual and/or group of individuals, in the case of shelters.

Per international vaccination guidelines, considering the risks and benefits, vaccines are classified into three categories: essential, complementary, and non-recommended. Essential vaccines are those that should be administered to all dogs and cats, regardless of lifestyle or geographic location, as they protect animals against serious or potentially fatal diseases, with high rates of morbidity and mortality and global distribution. These vaccines must therefore be prioritized by public health (Day et al., 2016; Bobadilla et al., 2017). Complementary vaccines are those whose use decision will be up to the veterinarians depending on the individual need,

based on local epidemiology, the lifestyle of the animals, and risk-benefit assessment (Labarthe et al., 2016; Bobadilla et al., 2017). Non-recommended vaccines are those with little scientific evidence to justify their use (Day et al., 2016; Bobadilla et al., 2017). Tables 1 and 2 show the vaccines recommended by the different guidelines, including those considering a shelter environment for dogs and cats.

The responsible veterinarian must evaluate which vaccines will be recommended for the shelter. Factors such as guidelines, principles of shelter medicine, financial resources, the geographic prevalence of diseases and population characteristics, current legislation, type of technology used, and the commercial availability of vaccines in the country must all be considered.

Vaccine protocol for shelter dogs and cats

Although knowledge of animal care protocols is necessary, it is very difficult to establish a single protocol or standard that can be applied in any situation. Vaccination schedules must be customized for each facility, recognizing that no

Table 1 – Guidelines for dog vaccination in shelters

Guideline	Vaccines for Shelter Dogs		Observation and Recommended Vaccine Type	Route of Administration
WSAVA -2016	Essential	Canine Distemper Virus	MLV or recombinant	Parenteral
		Canine Parvovirus	MLV	Parenteral
		Canine Adenovirus-2	MLV	Parenteral
		Rabies	Inactivated	Parenteral
	Complementary	Canine Parainfluenza Virus	Recommended in shelters MLV	Parenteral and Intranasal (preferable)
		Bordetella bronchiseptica	Recommended in shelters Live Avirulent Bacteria	Oral and Intranasal (preferable)
AAHA -2017	Essential	Canine Distemper Virus	MLV or recombinant	Parenteral
		Canine Parvovirus	MLV	Parenteral
		Canine Adenovirus-2	MLV	Parenteral and Intranasal
		Rabies	Inactivated	Parenteral
	Complementary	Canine Parainfluenza Virus	Complementary - recommended when at risk of exposure MLV	Parenteral and Intranasal
		Bordetella bronchiseptica	Complementary - recommended when at risk of exposure Live Avirulent Bacteria	Parenteral, Intranasal and Oral
		Leptospira serovars *canicola*; *icterohaemorrhagiae*; *grippotyphosa*; *pomona*	Complementary - recommended when at risk of exposure Inactivated	Parenteral
COLAVAC/ FIAVAC – Brazil* (2016)	Essential	Canine Distemper Virus	MLV or recombinant	Parenteral
		Canine Parvovirus	MLV	Parenteral
		Canine Adenovirus-2	MLV	Parenteral
		Rabies	Inactivated	Parenteral
		Leptospira interrogans	Specific serovar protection Inactivated	Parenteral
	* The guideline portrays the vaccines for *Bordetella bronchiseptica*, Canine parainfluenza virus, *Giardia,* and *Leishmania chagasi* as complementary vaccines, but they do not mention them for shelter environments.			
COLAVAC – Mexico (2017)	Essential	Canine Distemper Virus	MLV or recombinant	The guideline does not mention the administration route
		Canine Parvovirus	MLV	
		Canine Adenovirus-2	MLV	
		Rabies	Inactivated	
		Leptospira interrogans	Specific serovar protection Bacterin and purified subunit products	
	Complementary	Canine Parainfluenza Virus	Complementary - recommended in cases of potential exposure (shelter) MLV	Parenteral (in multivalent products) and Intranasal (combined with Bordetella)
		Bordetella bronchiseptica	Complementary - recommended in cases of potential exposure (shelter) Live Avirulent Bacteria	Intranasal

AAHA = American Animal Hospital Association; COLAVAC = Latin American Companion Animal Vaccinology Committee; WSAVA = World Small Animal Veterinary Association; MLV = modified live virus. Source: Adapted from Day et al. (2016), Labarthe et al. (2016), Bobadilla et al. (2017), Ford et al. (2017).

Table 2 – Guidelines for cat vaccination in shelters

Guideline	Vaccines for Shelter Cats		Recommended Vaccine Type	Route of Administration
WSAVA -2016	Essential	Feline Parvovirus	MLV (preferable) and inactivated	Parenteral (preferable) and/or intranasal* (not recommended in shelters)
		Feline Calicivirus	MLV (preferable) and inactivated	Parenteral and/or intranasal* (preferable when rapid onset – 48 h - of immunity is important)
		Feline Herpesvirus	MLV (preferable) and inactivated	
		Rabies	Essential for Brazil	Parenteral
			Recombinant* and/or Inactivated	
	Complementary	Feline Leukemia Virus (FeLV)	Only negative cats and their use should be determined by lifestyle, risk of exposure, and prevalence of infection in the local environment.	Parenteral
			Recombinant* and/or Inactivated	
		Chlamydia felis	Part of a control regimen for animals in multi-cat environments where infections associated with the clinical disease have been confirmed. Inactivated and/or Live Avirulent Bacteria	Parenteral
		Bordetella bronchiseptica	May be considered in cases where cats are likely to be at specific risk of infection.	Intranasal
			Live Avirulent Bacteria	
AAHA/ AAFA (2020)	Essential	Feline Parvovirus	MLV	Parenteral
		Feline Calicivirus	MLV	Parenteral and/or intranasal*
		Feline Herpesvirus	MLV	
		Feline Leukemia Virus (FeLV)	Recombinant* and/or Inactivated	Parenteral
		Rabies	Essential for Brazil	Parenteral
			Recombinant* and/or Inactivated	
	Complementary	*Chlamydia felis*	Recommended as part of control in shelters with confirmed infection	Parenteral
			Inactivated and/or Live Avirulent Bacteria	
		Bordetella bronchiseptica	Recommended as part of control in shelters with confirmed infection	Intranasal*
			Live Avirulent Bacteria	
COLAVAC/ FIAVAC – Brazil (2016)	Essential	Feline Parvovirus	MLV (preferable) and inactivated	Parenteral
		Feline Calicivirus	MLV (preferable) and inactivated	Parenteral
		Feline Herpesvirus	MLV (preferable) and inactivated	
		Feline Leukemia Virus (FeLV)	Essential for cats under one year of age (only animals without detectable virus antigens should be vaccinated)	Parenteral
			Inactivated	
		Rabies	Inactivated	Parenteral
	Complementary	*Chlamydia felis*	Complementary - should be considered for cats in known enzootic locations or that live in agglomeration	Parenteral
			Live Avirulent Bacteria and inactivated	

AAFA = American Association of Feline Practitioners; COLAVAC = Latin American Companion Animal Vaccinology Committee; WSAVA = World Small Animal Veterinary Association; MLV = modified live virus. *Not available in Brazil. Source: Adapted from Day et al. (2016), Labarthe et al. (2016), Cossío et al. (2017), Stone et al. (2020).

universal protocol will apply to the circumstances of all shelters (Day et al., 2016; Ford et al., 2017). It is essential to be grounded in the science of shelter medicine and understand that actions differ from traditional veterinary practice. Although there are no adequate protocols for Brazilian shelters and even knowing that the country's profile is different from the North American and European standards, it is useful to use foreign literature to support basic recommendations regarding the handling and hygienic-sanitary care of animals in the environments of shelters (Lima & Garcia, 2019).

Vaccination protocols should then take into account the circumstances found in each shelter, such as facilities management, assessment of population dynamics, financial resources, and individual or specific factors such as age, breed, lifestyle, infectious diseases occurrence, and region location of the facility (Decaro et al., 2020). Therefore, protocols proposed by international vaccination guidelines

for the use of essential and complementary vaccines for shelters can be used and adapted to Brazil's reality.

In shelters, generally, more intensive vaccination programs are recommended due to the high susceptibility of animals living there, especially to viral pathogens (Table 3). In these shelters, animals with unknown health status and vaccination conditions are commonly housed. So, as population turnover is high, the risk of exposure to such pathogens is always very high (Larson et al., 2009; Day et al., 2016; Ford et al., 2017; Rubio et al., 2018).

As a general rule, it is necessary to vaccinate the animals upon entry into the shelter preferably with a modified live virus vaccine (MLV), which is usually part of the essential vaccines for dogs and cats, according to the guidelines, as these vaccines provide a faster and more lasting immune response. For dogs and cats over 16-20 weeks of age, which should no longer have interfering maternal antibody titers (MDA), a single dose of these vaccines is sufficient to generate an immune response in immunocompetent animals. But in animal shelters, the administration of two doses, 2 to 4 weeks apart, is recommended to ensure a greater immune response (Larson & Schultz, 2006; Larson et al., 2009; Lechner et al., 2010; Newbury et al., 2010; Scherk et al., 2013; Spindel, 2013; Day et al., 2016, 2020; Stone et al., 2020).

In puppies, without specific tests, it is not possible to determine how many doses or the exact vaccine dose will be able to immunize. This is because, during breastfeeding, maternal antibodies are transferred from the mother to the offspring, mainly through colostrum, and the amount of these antibodies varies for each individual and each pathogen (Digangi et al., 2012). Therefore, for puppies housed in shelters, it is proposed that the minimum age to start the primary vaccination protocol with essential pathogens is between 4 and 6 weeks of age. Revaccination, at intervals between 2 and 4 weeks, is suggested until maternal antibodies (MDA) decline, which occurs at the estimated age between 16 and 20 weeks (Newbury et al., 2010; Day et al., 2016), increasing the chance of successful immunization without MDA interference (Stone et al., 2020). As there is evidence that some puppies will not be immunized even with the last dose at 16 weeks, due to the remaining presence of circulating maternal antibodies, the last dose at 20 weeks is ideal in situations of high exposure, such as in cases of animal shelters (Day et al., 2016; Altman et al., 2017; Decaro et al., 2020).

It is not recommended to perform the first dose of MLV vaccines before 4 weeks of age because newborns are more likely to experience vaccine virulence reversal and develop diseases associated with the pathogens present in those vaccines, in addition to not responding adequately to the vaccine application. Another important point is that intervals of less than two weeks between vaccines should not be used, as this may interfere with the vaccine immune response, especially with MLV vaccines (Stone et al., 2020).

Although the shelters should act as transit houses, many animals spend months or years in these environments. Shelters that house animals for long periods must ensure that vaccinations are repeated, in line with suggested recommendations for shelter medicine (Newbury et al., 2010).

Essential MLV vaccines should be administered within one year of the primary vaccination course or anytime between 6 months and 1 year of age (age between 26 and 52 weeks). This procedure aims to ensure that all puppies receive at least one dose of the vaccine capable of conferring immunity in the absence of maternal antibodies (MDA). Subsequent revaccinations should, therefore, be administered at intervals ranging from 1 to 3 years, depending on the guideline followed and/or according to the manufacturer's specifications (Hurley & Miller, 2009; Newbury et al., 2010; Scherk et al., 2013; Spindel, 2013; Day et al., 2016, 2020; Ford et al., 2017; Stone et al., 2020).

If prior vaccination of an adult animal is proven upon admission to a shelter, there is no reason to revaccinate it with essential canine vaccines. However, in the case of cats, feline essential vaccines, specifically for Calicivirus (FCV) and Herpesvirus type I (FHV-1), there is a recommendation for reinforcement due to the characteristics of both the vaccines (they do not generate sterilizing immunity) and of disease caused by such pathogens, which are often persistent and easily relapse in stressful situations (Day et al., 2016).

Rabies vaccination is considered essential in Brazil, being a great benefit to public health. It is recommended to perform a dose from 12 weeks of age, according to most manufacturers. Such a vaccine must be carried out

Table 3 – Essentials and complementary vaccination schedule for dog and cat in shelters

Age category	Start of Vaccination/First Dose	Revaccination/Booster Doses
Dogs and cats under 16-20 weeks	Upon admission to the shelter when at least 4 to 6 weeks of age	Every 2 weeks until they are at least 16-20 weeks old
Dogs and cats over 16-20 weeks	Before or at shelter admission	2 to 4 weeks after the first dose and then every 1 year

at least when the animal leaves the shelter for ethical and/or legal reasons (Newbury et al., 2010; Day et al., 2016; Labarthe et al., 2016; Bobadilla et al., 2017;).

Particularities of vaccinations in dog and cat shelters

Overall, vaccination guidelines recommend performing MLV multivalent essential vaccines separately from complementary vaccines (Day et al., 2016), as limiting vaccines to major components reduces the cost and incidence of adverse reactions. However, this may be a limitation according to the availability of commercial vaccines in countries like Brazil and variable according to the epidemiological profile of the prevalent diseases in each geographic region. In Latin American countries, vaccines with combinations only of essential agents, which are widely available elsewhere, are commercially scarce, with a trend towards multivalent vaccines containing both essential and complementary agents in the same product. Furthermore, there are important differences regarding the duration of immunity both concerning agents within the vaccines (MLV versus inactivated) and the products themselves licensed in markets in other countries when compared to Latin American ones (Day et al., 2020). Besides, it is important to emphasize that for a multivalent vaccine to be licensed in Brazil, the manufacturer must prove not only the safety of the product but also that each antigen component of the vaccine can induce protective immunity through challenge studies.

For the Brazilian reality, there are different commercial multivalent vaccines available in the market (Tables 4 and 5). Evaluations and decisions of which vaccines to use must be made by the veterinarian in conjunction with the management team, according to the needs of each facility.

A point of great importance in the vaccination schedule practiced in shelters, and which differs from vaccination protocols practiced in dogs and cats with guardians, is that all animals must receive vaccination with essential vaccines at the time of admission or one week before entry at the shelter, regardless of their physical and health conditions, including animals with fever, illness, or injury, pregnant or lactating. Although these animals may not have an optimal response to vaccination, the risk of exposure to pathogens

Table 4 – Commercial vaccines available in Brazil for dogs

Vaccine	Type of Vaccine	Commercial Name - Company	Route of Administration
Canine Distemper Virus Canine Parvovirus	Modified live virus	NOBIVAC® PUPPY DP – MSD SAÚDE ANIMAL	Parenteral SC
Canine Distemper Virus Canine Parvovirus Canine Coronavirus	Modified live virus for distemper and parvovirus and inactivated canine coronavirus suspension	VENCOTHREE® PUPPY – DECHRA(VENCO)	Parenteral SC/IM
		VACCINE OCTOCELL® -VAC LABOVET (National)	Parenteral SC/IM
Distemper Canine Parvovirus Canine Adenovirus Type-2 *Leptospira* (*L. Interrogans serovars Canicola, Icterohaemorrhagiae*)	Modified live virus combined with inactivated leptospira bacterin	CANIGEN® CH(A_2) P/L – VIRBAC	Parenteral SC/IM
Canine Distemper Virus Canine Parvovirus Canine Adenovirus Type-2 Canine Parainfluenza Canine Coronavirus	Recombinant technology for distemper virus and modified live virus for other agents	RECOMBITEK® C4/CV (V6) – BOEHRINGER INGELHEIM	Parenteral SC/IM
Canine Distemper Virus Canine Parvovirus Canine Adenovirus Type-2 Canine Parainfluenza Canine Coronavirus *Leptospira* (*L. Interrogans serovars Canicola, Icterohaemorrhagiae*)	Modified live virus combined with inactivated leptospira bacterin	VANGUARD® HTLP 5/CV-L (V8) – ZOETIS	Parenteral SC/IM
		NOBIVAC® CANINE 1-DAPPVL2+CV – MSD SAÚDE ANIMAL	Parenteral SC/IM
		VACCINE OCTOCELL®-VAC LABOVET (NACIONAL)	Parenteral SC/IM
		VENCOMAX ®– 8 – DECHRA(VENCO)	Parenteral SC
	Recombinant technology for distemper virus, Modified live virus for other viral agents, and inactivated leptospira bacterin	RECOMBITEK C6/CV (V8) – BOEHRINGER INGELHEIM	Parenteral SC/IM

SC = subcutaneous; IM = Intramuscular.

Table 4 – Continued...

Vaccine	Type of Vaccine	Commercial Name - Company	Route of Administration
Canine Distemper Virus Canine Parvovirus Canine Adenovirus Type-2 Canine Parainfluenza Canine Coronavirus *Leptospira* (L. *interrogans serovars Canicola, Icterohaemorrhagiae, Pomona, Grippotyphosa*)	Modified live virus combined with inactivated leptospira bacterin	VANGUARD® PLUS (V10) – ZOETIS	Parenteral SC/IM
		VENCOMAX® 11 – DECHRA(VENCO)	Parenteral SC/IM
		INOMUNE® – HERTAPE/CEVA	Parenteral SC
Canine Distemper Virus Canine Parvovirus Canine Adenovirus Type-2 Canine Parainfluenza *Leptospira* (L. *interrogans serovars Canicola, Icterohaemorrhagiae, Copenhageni*)	Modified live virus combined with inactivated leptospira bacterin	NOBIVAC® DHPPI+L – MSD SAÚDE ANIMAL	Parenteral SC
Canine Distemper Virus Canine Parvovirus Canine Adenovirus Type-2 Canine Parainfluenza Canine Coronavirus *Leptospira* (L. *interrogans serovars Canicola, Icterohaemorrhagiae, Pomona, Grippotyphosa, Copenhageni*)	Modified live virus combined with inactivated coronavirus and leptospira suspension	VACINA ELEVENCELL® VAC-V11 – LABOVET	Parenteral SC
Canine Distemper Virus Canine Parvovirus Canine Adenovirus Type-2 Canine Parainfluenza Canine Coronavirus *Leptospira* (L. *interrogans serovars Canicola, Icterohaemorrhagiae, Pomona, Grippotyphosa, Copenhageni, Hardjo, Pyrogenes*)	Modified viruses, suspension inactivated of canine coronavirus and leptospira	VENCOMAX® 12 - DECHRA(VENCO)	Parenteral SC
Canine Distemper Virus Canine Parvovirus Canine Adenovirus Type-2 Canine Parainfluenza Canine Coronavirus *Leptospira* (L. *interrogans serovars Canicola, Icterohaemorrhagiae, Pomona, Grippotyphosa)*	Modified live viruses combined with inactivated canine coronavirus and leptospira bacteria	MULTI-DOG® HERTAPE/ CEVA	Parenteral SC
		RECOMBITEK® MAX 5-CVK/4L - BOEHRINGER INGELHEIM	Parenteral SC
Canine Distemper Virus Canine Parvovirus Canine Adenovirus Type-2 Canine Parainfluenza Canine Coronavirus *Leptospira* (L. *interrogans serovars Canicola, Icterohaemorrhagiae, Pomona, Grippotyphosa)*	Modified live viruses combined with inactivated canine coronavirus and leptospira bacterins	PROVIDEAN® VIRATEC - AGENER UNIÃO	Parenteral SC/IM
Bordetella bronchiseptica	Modified active immunogen	BRONCHIGUARD® – ZOETIS	Parenteral SC
Canine Parainfluenza	Modified active immunogen	NOBIVAC® KC – MSD SAÚDE ANIMAL	Intranasal
Bordetella bronchiseptica	Inactivated	PNEUMODOG® – BOEHRINGER INGELHEIM	Parenteral SC/IM

SC = subcutaneous; IM = Intramuscular.

Table 4 – Continued...

Vaccine	Type of Vaccine	Commercial Name - Company	Route of Administration
Canine Adenovirus Type-2 Canine Parainfluenza *Bordetella bronchiseptica*	Modified live viruses and non-virulent live culture	BRONCHI-SHIELD® III – ZOETIS	Intranasal
Giardia	Inactivated	GIARDIAVAX® – ZOETIS	Parenteral SC
Leptospira (L. *interrogans serovars Canicola, Icterohaemorrhagiae, Pomona, Grippotyphosa)*	Inactivated leptospira bacterin	GUARD-VAC® LCI/GP – ZOETIS	Parenteral SC
Leishmania	Recombinant	LEISH-TEC ®– HERTAPE/ CEVA	Parenteral SC/IM
Rabies	Inactivated	DEFENSOR® – ZOETIS	Parenteral SC
		RABMUNE® – HERTAPE	Parenteral SC
		NOBIVAC® RAIVA – MSD SAUDE ANIMAL	Parenteral SC/IM
		CANIGEN® R – VIRBAC	Parenteral SC/IM
		RABISIN I® – BOEHRINGER INGELHEIM	Parenteral SC/IM
		HERTALIQ® - CEVA	Parenteral SC/IM
		VACINA ANTIRRÁBICA INATIVADA LABOVET®	Parenteral SC

SC = subcutaneous; IM = Intramuscular.

is extremely high in most shelters (Larson et al., 2009; Newbury et al., 2010; Scherk et al., 2013; Spindel, 2013; Day et al., 2016; Ford et al., 2017; Stone et al., 2020). To reduce costs or financial limitations, many shelters delay the vaccination of the animal during its stay at the shelter or until it is available for adoption. Consequently, the delay or non-performance of the animal at entry or before will significantly compromise the ability of the vaccine in providing protection.

For pregnant animals, the risks must be balanced with the benefits, with the small risk of adverse effects of vaccination being outweighed by the high risk of exposure to possible infectious diseases in the shelter (Larson et al., 2009). Vaccination in pregnant animals will be advised in shelter settings especially if the pregnant animal has never been vaccinated and/or if there is an outbreak of an infectious disease for which the vaccine is intended to protect. If pregnant females are not vaccinated, every effort should be made to physically protect them from exposure, either by isolation or good hygiene measures (Spindel, 2013; Day et al., 2016). For immunocompromised animals, the same logic is followed. That is unless it is possible to perform the serological test to avoid unnecessary vaccination, it is recommended to vaccinate those animals with at least an essential vaccine on admission, as the benefit in these cases is greater than the risks.

In animal shelters, non-infectious vaccines (killed or inactivated vaccines, including subunit vaccines) against canine distemper virus (CDV), canine parvovirus (CPV-2), and against feline panleukopenia virus (FPV), for example, are not recommended because, in addition to requiring two doses with at least 2 weeks apart to induce a proper immune response, they take a significantly longer period to develop protective immunity and are less able to overcome MDA interference when compared to infectious vaccines (modified live virus vaccines [MLV] or attenuated) (Newbury et al., 2010; Spindel, 2013; Day et al., 2016; Decaro et al., 2020). Thus, due to this longer induction of immunity, in many shelters, exposure to the disease will likely occur before protection is achieved.

Although a mentioned counterpoint in literature is that some MLV vaccines can revert their virulence or produce significant disease in severely immunosuppressed animals, this is an extremely rare event (University of Wisconsin Madison, 2015; Day et al., 2016). Studies have shown that factors such as stress, malnutrition, and surgery, for example, have not been shown to potentiate the severity of vaccine-induced disease and have not caused the inapparent infection

Table 5 – Commercial vaccines available in Brazil for cats

Vaccine	Type of Vaccine	Commercial Name – Company	Route of Administration
Feline Parvovirus Feline Calicivirus Feline Herpesvirus	Modified live virus	FELOCELL CVR® (TRIPLE FELINE) – ZOETIS	Parenteral SC/IM
		FELIGEN CR/P® – VIRBAC	Parenteral SC/IM
	Inactivated	RONVAC® – DECHRA (VENCO)	Parenteral SC
Feline Parvovirus Feline Calicivirus Feline Herpesvirus *Chlamydia felis*	Modified live immunogens	FELOCELL CVR-C® (QUADRUPLE FELINE) – ZOESTIS	Parenteral SC/IM
		NOBIVAC FELINE 1+HCPCH® – MSD SAUDE ANIMAL	Parenteral SC/IM
		FELINE 4® – BOEHRINGER INGELHEIM	Parenteral SC/IM
Feline Parvovirus Feline Calicivirus Feline Herpesvirus *Chlamydia felis*	Inactivated	FEL-O-VAX LVK IV CALICIVAX® (QUINTUPLE FELINE) – ZOETIS	Parenteral SC
Feline Leukemia Virus	Modified live virus and inactivated FeLV fraction	NOBIVAC FELINE 1+HCPCH+FELV® – MSD SAUDE ANIMAL	Parenteral SC/IM
Rabies	Inactivated	DEFENSOR® – ZOETIS	Parenteral SC
		RABISIN I® – BOEHRINGER INGELHEIM	Parenteral SC/IM
		NOBIVAC® RAIVA – MSD SAUDE ANIMAL	Parenteral SC/IM
		CANIGEN R® – VIRBAC	Parenteral SC/IM
		ANTI-RABIES VACCINE FOR DOGS AND CATS - LABOVET®	Parenteral SC/IM

SC = subcutaneous; IM = Intramuscular.

to become clinically apparent. Genetic immunodeficiency, chemotherapy, or parvovirus infection are more significant risk factors (Miyamoto et al., 1995; Greene, 1998; University of Wisconsin Madison, 2015). Thus, animals that are severely immunosuppressed to the point that vaccination poses a significant risk should not remain in a shelter except under strict isolation, as they are unlikely to survive to exposure to the various pathogens present in the shelter (University of Wisconsin Madison 2015).

Other types of vaccines containing genetically modified antigens have been developed. Among them, some recombinant vectored vaccines are characterized by the inducement of early onset of immunity, long duration of immunity, and appear to be able to generate immunity in the presence of MDA (Newbury et al., 2010; Spindel, 2013; Day et al., 2016; Decaro et al., 2020). In the study carried out by Larson & Schultz (2006), dogs were experimentally challenged with the distemper virus, hours after a single dose of a recombinant vaccine for canine distemper (rCDV) or MLV. The findings proved that the rCDV vaccine has an immunity time similar to the MLV-CDV vaccines and can protect dogs in high-risk environments after a single dose.

Principles for vaccine storage and handling

Vaccines must be stored and handled correctly to preserve their effectiveness, as they are extremely sensitive to temperature fluctuations. Following the manufacturer's instructions regarding the proper storage and handling of the products is one of the factors to ensure successful vaccination, in addition to guaranteeing the veterinarian's support from

the manufacturers in cases of suspected vaccine failure or adverse reactions (DiGangi et al., 2012; University of Wisconsin Madison, 2015). In the medical record, complete data on the date of vaccination, type of vaccine, manufacturer, serial number for each animal must be recorded, preferably with the original product label that is detachable and adhesive for this purpose (University of Wisconsin Madison, 2015).

Below is the main information on how to store and handle vaccines (DiGangi et al., 2012; University of Wisconsin Madison, 2015; Squires, 2018; Day et al., 2020):

- Upon arrival at the shelter, vaccines must be unloaded as soon as possible, undergo an inspection to ensure that the integrity of the shipment is intact, and the ice packs are adequately chilled. If there is any irregularity, the vaccines must not be used, and the distributor must be called immediately.
- The ideal storage temperature for vaccines is usually around 2 to 8 °C. They should be placed away from the freezer to prevent them from being frozen. According to current legislation, Decree no. 5.053 of April 22, 2004, and CFMV Resolution no. 1.275 of June 25, 2019, biological products must be stored in refrigerators with temperature controlled by a refrigerator thermometer. Some available systems record refrigerator temperatures throughout the day, allowing for greater control of fluctuations and readjustments in the device settings for proper maintenance of this factor (Brasil, 2004, 2019).
- Transportation of vaccines must also be subject to continuation of the "cold chain" with the use of ice packs in a thermal compartment, but they must not be placed in direct contact with this material, establishing the exchange of these bags every 1 h. Modified live vaccines that are not refrigerated for more than 2 h may be ineffective and should be discarded.
- Vaccines must be kept in a refrigerator designated only for storing medicines and vaccines, and must not have drinks and/or food, with a guarantee of sufficient space for air circulation and maintenance of a constant temperature around the products.
- Vaccines must be stored inside the manufacturer's packaging.
- It is recommended that some shelves be designated for specific vaccines and the location listed outside the refrigerator, minimizing the time the door is kept open while accessing vaccines.
- The supply of electricity to a vaccine refrigerator must be protected from inadvertent interruptions by using a non-switched electrical outlet or a plug marked "do not turn off".
- Lyophilized vaccines should only be reconstituted immediately before use with the appropriate diluent and following the manufacturer's instructions, and under no circumstances should they be prepared hours before application.
- Mixing of vaccines should only take place in the same syringe if specified as acceptable in the manufacturer's instructions.
- Syringes and needles must not be reused.
- Vaccine injection sites should not be sterilized with alcohol or another disinfectant, as this may result in the inactivation of infectious vaccines.
- Vaccines must be within the expiration date.

Serological tests

Currently, the use of serological testing has gained notoriety to assess and monitor the duration of immunity to vaccines, and its availability has an important impact on outbreak management in animal shelters (Day et al., 2016). Serological tests can be used to help diagnose infection, assess pathogen exposure in animals with unknown vaccination history, in assessing risk versus benefit for animals with a history of adverse reactions after vaccination, and assessing immunity before and/or after vaccination (Day et al., 2016; Ford et al., 2017; Stone et al., 2020).

In the context of the shelter, in particular, antibody titers against species-specific diseases can be used to assess whether animals are protected against infection, especially for CDV, CPV, or FPV, as antibody levels are closely related to protection for these three diseases and help in a more effective approach to controlling disease outbreaks. Its use can avoid high future financial expenses and the euthanasia of animals (Greene & Schultz, 2006; Larson & Schultz, 2006; McCaw & Hoskins, 2006; Larson et al., 2009; Day et al., 2016).

A systematic risk assessment, based on the assessment of serological immunity, can also be used to assess the individual risk of the animal after possible exposure. Even if the assessment of the level and assignment of risk groups never gives a guarantee that a particular animal will become infected, it will allow us to guide and help in decisions (Larson et al., 2009). In cases of disease outbreaks with a long incubation period, such as canine distemper,

for example, or when the clinical signs of the animals are not a reliable indicator of infection, the use of serological tests is the best option for evaluating animals exposed and at-risk (Hurley, 2009).

Based on the serological risk assessment of the animals, we can classify them as low risk or high-risk group of exposure to infectious diseases, which will help plan actions against an outbreak and in decision-making, such as minimizing the amount of euthanasia or establishing for which area these animals will be allocated, whether for quarantine, isolation or areas outside the shelter. Serology for risk assessment should be performed on animals that are completely free of clinical signs of disease at the time of testing. In the face of an outbreak, all those who show clinical signs should be considered at high risk and should be immediately removed from the general population and placed in isolation or their area to prevent further disease spread (Hurley, 2009; Larson et al, 2009).

In general, in the face of an outbreak, dogs and cats that are in the shelter without clinical signs, with a known history of vaccination, over 16 weeks of age and that in their serological condition are seropositive, can be assigned to a low-risk category and can remain in the general population, as long as they are separated from unresponsive or poorly responsive animals, and can be adopted with relative safety. In this second case, it is extremely important to report to adopters about the risk and the possibility of exposing the animal to the pathogen, since low risk does not mean being absent from risk. In the case of dogs and cats that are in the same serological condition, seropositive for the disease in question, but that is outside the shelter and need to enter, they can enter the shelter safely because they are protected against the disease (Hurley, 2009; Larson et al., 2009; Day et al., 2016).

In contrast, dogs and cats that in their serological condition are seronegative, have no clinical signs, and are exposed without a known history of vaccination should be considered at high risk of infection, as they are susceptible to exposure and should not be taken outside the shelter even after the period of incubation of the disease, even if they have been newly vaccinated on admission or before. It is recommended that these animals be removed from the general population of the shelter immediately. It is also suggested that these animals be vaccinated and tested again to confirm their seropositivity after the infection incubation periods. Dogs and cats outside the shelter that need to be admitted, but have negative serological status, must be vaccinated and sent to temporary or foster homes until seroconversion occurs, and admission to the shelter is contraindicated until they are seropositive (Hurley, 2009; Larson et al., 2009; Day et al., 2016).

Vaccine failures

Despite immunization through vaccines being one of the key points in ensuring protection, health, and quality of life for sheltered animals (Hurley & Miller, 2009; Larson et al., 2009; Newbury et al., 2010; Spindel, 2013; Day et al., 2016), vaccination does not always guarantee the success of immunization, since, as mentioned above, the immunization process is biological and depends on several factors. First, it is important to emphasize that the concepts of vaccination and immunization are different. While vaccination consists of administering a product containing the antigen capable of inducing the organism to produce immunity against it, immunity is established only when the organism's immune response is effective in facing that challenge (Greene & Levy, 2014). Furthermore, vaccines do not work instantly and are not available for every possible disease in a shelter environment.

No vaccine is capable of providing 100% protection in 100% of a vaccinated population. Thus, vaccine failures can happen and can be related to both the vaccine and the individual (Wiedermann et al., 2016). Causes of vaccine-related failures include errors in vaccine storage or administration, non-compliance with vaccine protocols, and failures in vaccine immunogenicity (Decaro et al., 2008; Wiedermann et al., 2016; Altman et al., 2017). Low immunogenicity may reflect several factors ranging from the stage of vaccine design and manufacturing to administration to the animal (Day et al., 2016).

However, the most common cause of vaccine failures is the neutralization of vaccine antigens by maternal antibodies during the puppies'/kittens' immunization process (Day et al., 2016; Ford et al., 2017). A study of vaccination protocols used by Australian veterinarians in 2017 showed that nearly half of respondents did not meet the recommended guideline for ending primary vaccination at 16 weeks of age or older (Kelman et al., 2020). Such guidelines are an essential measure for the correct immunization of animals, in particular, in animal shelters for the prevention of infectious disease outbreaks. In this context, research by Altman et al. (2017) found that 80% of vaccine failures occurred when the last CPV vaccination was given to puppies/kittens before 16-18 weeks of age, portraying MDA interference with the vaccine as a possible cause of lack of response to vaccination. Therefore, they concluded that all puppies/kittens should receive a final dose of vaccination after 16

weeks of age or older, and they should not be exposed to risk areas until at least two weeks after the final vaccination.

As for individual factors, it is worth remembering that a vaccinated population follows an expected distribution pattern, in which most individuals can mount a protective immune response, a small part can respond excellently, and another small part is not able to mount a protective immune response. Therefore, causes of vaccine failures are also related to the individual, including genetic factors, factors related to health and age, the individual's immune status, and nutritional status at the time of the challenge (Wiedermann et al., 2016).

Vaccine reactions

The administration of vaccines, although safe, is not without risks and has the potential to generate unwanted reactions (Larson et al., 2009). An adverse vaccine reaction is defined as any unwanted or unplanned side effect associated with the administration of a licensed biological product (Day et al., 2016). Although post-vaccination reactions are considered rare, no vaccine is completely risk-free (Stone et al., 2020) and a reliable prevalence is probably underestimated due to lack of reports by tutors and veterinarians (Gaskell et al., 2002; Waner et al., 2006; Bobadilla et al., 2017; Cossio et al. 2017).

The most frequently reported reactions are mild and short-lived, such as malaise, lethargy, fever, loss of appetite, itching, pain, and swelling at the application site, and generally do not require treatment (Day, 2006; Moore & Hogenesch, 2010; Bobadilla et al., 2017; Cossio et al., 2017). On the other hand, situations involving type I hypersensitivity or acute anaphylaxis are the most worrisome from the standpoint of risk to the patient, as they can manifest either in a milder way, such as angioedema or urticaria, or progress to shock and death of the animal, hence the procedure. The vaccination course must be followed by a follow-up of the vaccinated animal to identify possible more serious adverse effects. Other vaccine-related reactions described include type II or cytotoxic reactions, which lead to immune-mediated events such as immune-mediated hemolytic anemia or immune-mediated thrombocytopenia, and whose correlation with vaccination in dogs and cats is still quite controversial; type III hypersensitivity or immune-complex reactions, such as cutaneous ischemic vasculopathy, well described in dogs and commonly related to rabies vaccination, and finally; type IV or delayed hypersensitivity reactions, little described in dogs and cats, and may be associated with the formation of post-vaccinal granulomas (Moore et al., 2007; Moore & Hogenesch, 2010; Greene & Levy, 2014).

The veterinarian and shelter staff must always be trained and able to identify and, when possible, minimize the occurrence of adverse reactions. In addition, an adverse reaction must be registered in the animal's medical record if it occurs and it must be communicated to the adopters in the future (Larson et al., 2009). It is extremely important to portray that under no circumstances the risk of an adverse reaction to the vaccine outweighs or negate the benefit of vaccination in animals in a shelter situation.

Concluding Remarks

Vaccination in animal shelters is one of the essential and most reliable points to guarantee protection against the main infectious diseases. It is extremely important that vaccination schedules are based on strategies and principles of shelter medicine and must be customized for each facility, recognizing that no universal protocol will apply to the circumstances of all shelters, especially in Latin American shelters, where published data on the occurrence of infectious and contagious diseases are lacking.

Thus, it is necessary to not only conduct more studies on the real prevalence of infectious diseases in Latin American shelters but also to recommend and institute more convenient practices and policies to reduce the transmission of pathogens and reduce the possibility of infectious disease outbreaks in shelters. From this, it is possible to promote a healthy environment and actions to reduce risks. This integration can contribute to improving the health and well-being of dogs and cats in shelters.

Conflict of Interest

The authors declare no conflict of interest.

Ethics Statement

The study did not require ethical approval.

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