RESEARCH ARTICLE Indian Journal of Animal Research, Volume 57 Issue 2: 225-230 (February 2023)

# Canine Parvoviral Enteritis and Its Determinants-An Epidemiological Analysis

M. Geetha[1], G. Selvaraju[1]

10.18805/IJAR.B-4302


## ABSTRACT

**Background:** Canine parvoviral enteritis (CPVE) is a highly contagious disease of dogs of less than two years age group characterized by vomiting, haemorrhagic foul smelling diarrhoea, high grade pyrexia, dehydration and followed by death. The disease is caused by Canine parvovirus type-2 (CPV-2) and its variants, CPV-2a, 2b and 2c. Environmental and host determinants are playing an important role in the occurrence of CPVE in dogs. Limited numbers of research studies have been were conducted on the role of the determinants associated with the disease occurrence. Hence, the present study was aimed to assess the influence of host and environmental determinants associated with the incidence of CPVE in dogs.

**Methods:** Retrospective data on the incidence of CPVE in Namakkal region, Tamil Nadu was collected (2017-2019) from Veterinary Clinical Complex (VCC), Veterinary College and Research Institute (VC and RI), Namakkal, Tamil Nadu and had been subjected to temporal and spatial clustering and regression analysis. One hundred and twenty three faecal samples were collected from dogs with clinical signs of CPVE and subjected to PCR using H primer of CPV. Cross-sectional study was used to investigate the relationship between the disease and hypothesized causal factors. Relative risk, odds ratio were used to determine the causal association. Weather data was collected for the period from 2017-2019 from Animal Feed Analytical and Quality Control Laboratory (AFAQAL), VC and RI, Namakkal to assess the relationship of disease occurrence with the environmental determinants. Multiple linear regression model was developed for prediction of CPVE by correlation of environmental determinants with the occurrence of CPVE.

**Result:** Temporal analysis revealed endemic pattern of CPVE started last week of April, peaks in June and ends in August and second peak was noticed at November month. Higher incidences (>70%) were noticed in males and less than 6 months age group dogs. Polymerase chain reaction for confirmation of CPV infection in dogs revealed the positivity of 70.73%. Analysis of risk factors associated with CPVE revealed that vaccination, roaming of dogs, maternal vaccination and early weaning having positive statistical association with the incidence of CPVE. Multiple linear regression model revealed that relative humidity is positively associated with the occurrence of CPVE in dogs. Vaccination of dogs against CPV and administration of boosters at regular intervals, weaning of dogs after 45 days of age are used as primary strategies for prevention of CPVE.


**Key words:** Canine parvoviral enteritis, Environmental determinants, Risk factors.

## INTRODUCTION

Viral enteritis is one of the most common causes of infectious diarrhoea in younger dogs of less than six months of age. Canine parvoviral enteritis (CPVE) is the most dangerous and contagious disease of dogs and is considered as most life threatening to puppies between weaning and six months of age (Kapil, 1995). Canine parvoviral enteritis is caused by Canine parvovirus (CPV) type 2 and its variants CPV-2a, 2b and 2c. Dogs of any breed, age, or sex are susceptible to this viral infection but puppies between 6 weeks and 6 months of age are appear to be more commonly affected. The virus spreads rapidly among dogs *via* the faeco-oral route (direct transmission) or through oro-nasal exposure to fomites contaminated by faeces (indirect transmission) (Prittie, 2004). The stability of CPV in the kennel environment and excretion of large amounts of CPV by sick puppies can expose susceptible puppies to massive infectious doses of CPV. The window of susceptibility coincides with early weaning of puppies (25-30 days of age) and lack of vaccinal immunity after receipt of primary dose of vaccine. In the kennel environment, availability of large numbers of susceptible puppies, environmental stress and unique properties of CPV combine to form an ideal scenario for rapid spread of this disease among young dogs (Greene and Decaro, 2012). Survival of CPV in the contaminated environment is an important determinant in the occurrence of CPVE in dogs. Climatic factors including temperature, relative humidity, wind speed and rain fall act as secondary determinants and are associated with emerging and re-

[1]Department of Veterinary Public Health and Epidemiology, Veterinary College and Research Institute, Tamil Nadu Veterinary and Animal Sciences University, Namakkal-637 002, Tamil Nadu, India.

**Corresponding Author:** M. Geetha, Department of Veterinary Public Health and Epidemiology, Veterinary College and Research Institute, Tamil Nadu Veterinary and Animal Sciences University, Namakkal-637 002, Tamil Nadu, India.
Email: drmgeetha@gmail.com

**How to cite this article:** Geetha, M. and Selvaraju, G. (2023). Canine Parvoviral Enteritis and Its Determinants-An Epidemiological Analysis. Indian Journal of Animal Research. 57(2): 225-230. doi: 10.18805/IJAR.B-4302.

**Submitted:** 07-09-2020 **Accepted:** 17-05-2021 **Online:** 26-05-2021

emerging of CPVE because these factors alter the survivability of the virus and its transmission. Hence, this study had been carried out focusing on molecular epidemiology of CPVE and climatic determinants and other risk factors associated with the occurrence of CPVE in dogs. Rarely combination of infection of dogs with CPV and canine distemper (Luo *et al*., 2017) or CPV with Canine adenovirus - 1 infection recorded by Chethan *et al*. (2021).

## MATERIALS AND METHODS

Retrospective data on CPVE was collected from the VCC, VC and RI, Namakkal for the period from August, 2017 to July, 2019. Collected data was analysed and graphical representation of gender, age and breed wise prevalence of CPVE was done. Temporal and spatial trends of CPVE were analysed and graphically and cartographically represented, respectively. Weather parameters including maximum and minimum temperature, relative humidity @ 8.00 IST and @ 14.00 IST, rain fall and wind speed (Table 1) were collected from AFAQAL, VC and RI, Namakkal for the study period to develop multiple linear regression model for determining the association of weather components with the occurrence of canine parvoviral enteritis.

Total of one hundred twenty three faecal samples were collected aseptically from the dogs suspected for CPV infection, brought for treatment to Infectious disease unit, VCC Complex, VC&RI, Namakkal from May, 2019 to April, 2020 in phosphate buffered saline (pH-7.0) and stored at 4°C till further processing. Epidemiological data on the age, sex, breed, vaccination status, dam vaccination details, roaming status, colostrum feeding, *etc*. of CPVE suspected dogs were collected using structured proforma. The faecal samples of 123 dogs were subjected to template DNA extraction through hot and cold method as described by Schunck *et al*. (1995). Extracted template DNAs were subjected to polymerase chain reaction (PCR) as per the method described by Buonavoglia *et al*. (2001) using specific primer for large fragment of the capsid protein-encoding gene of CPV encompassing at least six or seven informative amino acids responsible for important biological properties of the virulence. The sequence of H primer used for PCR is given below.

$H_{for}$ - CAG GTG ATG AAT TTG CTA CA

$H_{rev}$ - CAT TTG GAT AAA CTG GTG GT

The PCR cyclical conditions consists of initial denaturation of 95°C for 5 minutes, 30 cycles of denaturation at 95°C, one minute annealing at 55°C for 2 minutes, extension at 72°C for 30 seconds and final extension at 72°C for 10 minutes. Positivity to CPV infection was identified by detection of 630 bp PCR product upon gel electrophoresis of amplified PCR product.

Cross-sectional study was used to investigate the relationship between the disease and hypothesized causal factors. Relative risk and odds ratio were used to determine the causal association as per the formula described by Martin *et al*. (1994).

**Measures of causal association**

| | Disease (+) | Disease (-) |
|---|---|---|
| Factor (+) (Exposed group) | a | b |
| Factor (-) (Un exposed group) | c | d |
| a + b + c + d = N | a + c | b + d |

| | | |
|---|---|---|
| Relative risk (RR) | a/(a+b)/c/(c+d) | If RR and OR >1 - Positive statistical association with the factor and disease |
| Odds ratio (OR) | ad/bc | If RR and OR <1 - Negative statistical association with the factor and disease |
| | | If RR and OR=1 - No statistical association with the factor and disease |

**Multiple linear regression analysis**

It was applied to develop the prediction model as per the protocol followed by Selvaraju (2010) using Vassarstats® open software tool and validated with existing data. Multiple linear regression generalizes this methodology to allow for multiple predictor variables, such as monthly mean maximum

**Table 1:** Weather data (From August 2017 to July 2019).

| Month | Mean maximum temperature (°C) | Mean minimum temperature (°C) | Mean RH (@ 7.30 h IST) (%) | Mean RH (@ 14.30 h IST) (%) | Mean wind speed (km/h) | Mean rainfall (mm) |
|---|---|---|---|---|---|---|
| January | 31.83 | 18.09 | 84.60 | 46.32 | 4.05 | 1.50 |
| February | 32.87 | 19.25 | 78.14 | 36.95 | 4.98 | 3.50 |
| March | 36.61 | 22.75 | 79.52 | 35.05 | 5.58 | 6.50 |
| April | 37.06 | 24.97 | 73.98 | 38.20 | 6.21 | 55.50 |
| May | 37.11 | 24.77 | 81.37 | 50.68 | 6.52 | 75.60 |
| June | 35.24 | 24.53 | 80.17 | 55.55 | 10.34 | 59.10 |
| July | 35.34 | 24.52 | 80.73 | 49.39 | 11.61 | 17.95 |
| August | 34.72 | 24.40 | 82.06 | 49.76 | 7.71 | 109.40 |
| September | 34.15 | 23.74 | 85.42 | 54.50 | 4.68 | 221.60 |
| October | 33.29 | 23.30 | 88.42 | 60.24 | 3.32 | 137.95 |
| November | 31.89 | 21.97 | 87.13 | 60.17 | 3.40 | 66.25 |
| December | 31.10 | 20.19 | 85.55 | 56.26 | 3.63 | 42.60 |

temperature, monthly mean minimum temperature, relative humidity (@ 8.00 h IST), relative humidity (@ 14.00 h IST), monthly total rain fall and wind speed.

Commonly used multiple linear regression model as follows:

$$Y= \beta_0+ \beta_1 w_1+ \beta_2 w_{2+} \beta_3 w_{3+} \beta_4 w_{4+} \beta_5 w_{5+} \beta_6 w_6$$

Where,

Y - Dependent variable.

$\beta_0$ - Constant.

$\beta_{(1-6)}$ - Unstandardised coefficient for each predictor variables.

$w_1$ - Monthly mean maximum temperature (°C).
$w_2$ - Monthly mean minimum temperature (°C).
$w_3$ - Relative humidity at 8.00 h IST (per cent)
$w_4$ - Relative humidity at 14.00 h IST (per cent).
$w_5$ - Monthly total rainfall (mm).
$w_6$ - Monthly mean wind speed (km/h).

} Predictor variables

## RESULTS AND DISCUSSION

Canine parvo virus (CPV) causes most dangerous and life threatening disease to puppies between weaning and six months of age. Parvoviruses are small, enveloped, single stranded DNA viruses that are known to cause disease in a variety of mammalian species (Carr *et al*., 1997). The virus was first identified in 1978 in USA and was designated as CPV type 2 (CPV-2) for differentiating it from CPV-1, a previously recognized parvovirus of dogs known as minute virus of canines (Binn *et al*., 1970). After its emergence, CPV-2 has spread globally and now it is endemic in most populations of domestic and wild canids (Parrish *et al*., 1988). Analysis of CPV isolates by monoclonal antibodies and restriction enzymes have shown that a new antigenic strain, designated CPV type 2a (CPV-2a), became widespread around 1979 and it replaced the original strain during 1980 to 1981 in the USA (Parrish *et al*., 1985). Later, examination of canine isolates identified another antigenic variant, designated CPV type 2b (CPV- 2b) that emerged around 1984 and after 1986 replaced CPV-2a in many parts of the USA (Parrish *et al*., 1991). Currently, the antigenic variants have completely replaced the original type 2, which is still used in most commercial vaccines and are variously distributed in the canine population worldwide. The disease is endemic in India (Behera *et al*., 2015).

### Retrospective analysis of canine parvoviral enteritis

Retrospective data on CPVE was collected from the VCC, VC&RI, Namakkal for the period from August, 2017 to July, 2019. Collected data had been analysed and graphical representation of gender, age and breed wise prevalence of CPVE was done.

### 1) Age-wise representation of canine parvoviral enteritis

Age-wise representation of CPVE revealed that higher incidence (72.66%) was recorded in less than six months age group (Fig 1). This finding is in corresponding with Hoskins, (1997), who reported that puppies between 6 weeks and 6 months of age appear to be more susceptible. For the first few weeks of life, puppies are protected against infection by maternally derived antibody (assuming the bitch has antibodies). However, maternal antibody to parvovirus has a half-life of approximately 10 days and as their maternal antibody titers decline, puppies become susceptible to infection (O'Brien, 1994). Declining of maternal antibody level after 3 months age in dogs might be one of the predisposing factors, which make them more prone to CPV infection (Parrish *et al*., 1988). The higher incidence of CPVE below 6 months might be due to the affinity of the virus for rapidly multiplying intestinal crypt cells in weaning pups with higher mitotic index due to changes in bacterial flora as well as in the diet due to weaning (Prittie, 2004).

### 2) Sex-wise representation of canine parvoviral enteritis

In this study, majority of the dogs represented with clinical signs of CPVE were of males (73.20%) rather than females (26.80%) which is in concurrence with the findings of Gombac *et al*. (2008) and Thomas *et al*. (2014). They reported a higher incidence of CPV in male dogs (78.26%) (Fig 2). The reason for high representation of males might be due to more chance of exposure of them to virus load due to behavioral characteristics mainly roaming and territorial behavior which also well explained by Deka *et al*., (2013). Preference of rearing males than females might be another probable reason for high representation of CPVE.

### 3) Breed-wise representation of canine parvoviral enteritis

Highest representation (55.29%) of CPVE was noticed in non-descript dogs than the pure breed dogs including

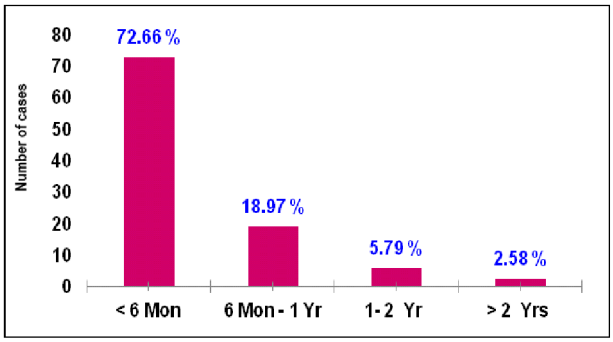



**Fig 1:** Age-wise representation of canine parvoviral enteritis.

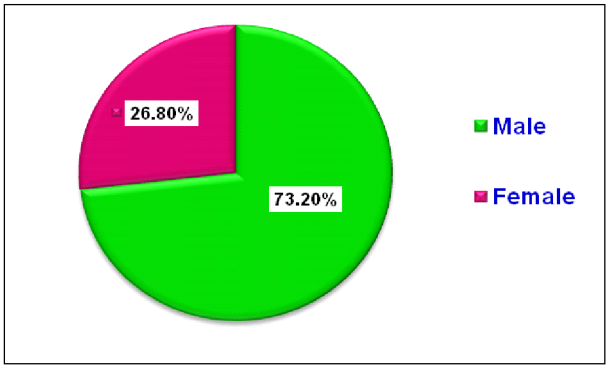



**Fig 2:** Sex-wise representation of canine parvoviral enteritis.

Germen Shepherds, Doberman, Spitz, *etc* (Fig 3). Shukla *et al.* (2009) and Joshi *et al.* (2000) reported higher CPVE incidence of 56.9% and 27.23% in non-descript dogs than pure breeds, respectively. Higher prevalence of CPVE in non-descriptors might be due to population density making their close proximity to spread the infection or following poor vaccination schedule due to lack of awareness in public (Behera *et al.*, 2015).

Incidence of CPVE in Spitz, Germen Shepherd, Labrador, Dobermann were of 9.3%, 7.3%, 6.8% and 4.4% respectively. Spitz is the most common toy breed reared in the reported geographical area next to non-descripts due to its availability and easy maintenance as pet or companion animal compared to other breeds. This might be the reason for high representation of CPVE in Spitz following non-descripts. Behera *et al.* (2015) reported that German Shepherd and Labrador Retriever were found to be more susceptible with the incidences of 17.24% and 10.34%, respectively and same pattern of incidence was also noticed in this study. Houston *et al.* (1996) reported that certain breeds have been shown to be at increased risk for severe CPV enteritis, including the Rottweilers, Doberman Pinscher, Labrador Retriever and German Shepherd and the reasons for breed susceptibility are unclear. There were significant alterations in the haemato-biochemical parameters in diseased vaccinated dogs (Hafid, 2019). Lower incidence of CPVE in pure bred in this region might be due to 1) only few pet owners are fascinated towards the rearing of pure bred dogs, 2) more maintenance cost and 3) less adoptability of pure bred dogs to the stressful tropical climatic conditions and high susceptibility to diseases.

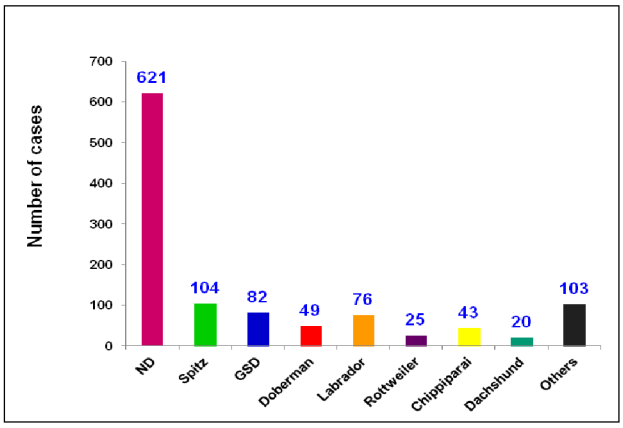



**Fig 3:** Breed-wise representation of canine parvoviral enteritis.

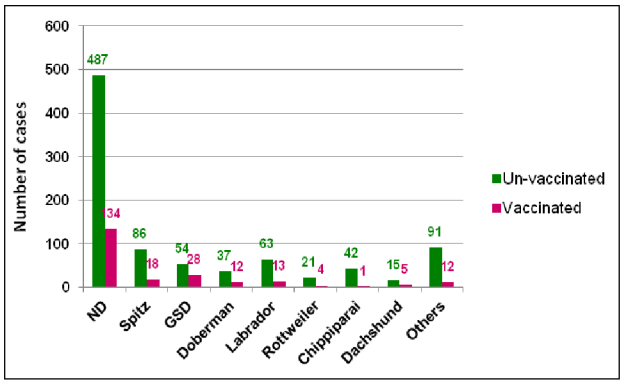



**Fig 4:** Prevalence of CPVE in vaccinated and unvaccinated dogs.

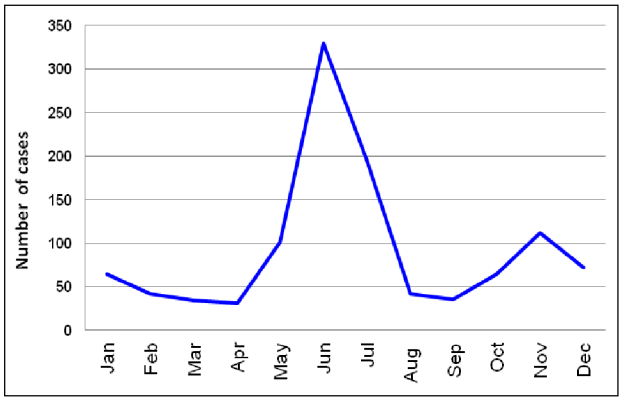



**Fig 5:** Temporal distribution pattern of CPVE.

**Prevalence of CPVE in vaccinated and unvaccinated dogs**

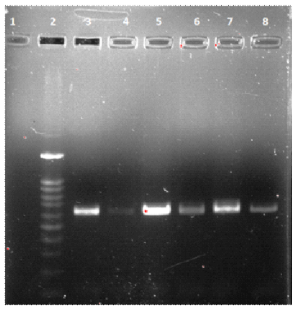
Vaccination of colostrum recipient puppies in early part of life preferably at 42 days of age and colostrum deprived puppies at 28 days of age with first dose of live attenuated canine parvoviral vaccine, boosters at 21 days interval up to 16 weeks of age, regular annual booster up to three years followed by boosters once in three years will protect them against CPVE (Greene and Decaro, 2012). Commercially available vaccines contain live attenuated canine parvovirus, canine distemper, parainfluenza virus and inactivated Leptospira antigens and canine adenovirus. Immunization of puppies usually started at 42 days of age. In this study, more than 95% of dogs did not receive complete recommended vaccination protocol (Fig 4). Probable reasons for the occurrence of CPVE in vaccinated dogs are, 1) administration of primary dose alone, 2) delayed booster vaccination, 3) lack of awareness on vaccination and 4) affordability of the pet owners.

**Temporal distribution pattern of CPVE**

Temporal analysis of CPVE (2017-19) in Namakkal, Tamil Nadu revealed the epidemic started at the last week of April, peaks in June and ends in August and second peak was noticed at November month (Fig 5). Kokilapriya *et al.* (2017) also reported higher prevalence during South-West monsoon (July, 16.3% and August, 12.3%) and North-East monsoon (November, 12.7% and December, 16.3%) and lower during summer season (March, 4.1%, April, 4.7% and May, 4.8%). Dogs were three times more likely to be admitted with CPV enteritis in July, August and September months compared with the rest of the year (Houston *et al.*, 1996).

**Confirmation of CPV infection**

Collected faecal samples (123 numbers) were subjected to PCR for the confirmation using H primer as per the method described by Buonavoglia *et al.* (2001). The “H” primer was




| | |
|---|---|
| Lane 1 | -Negative control |
| Lane 2 | -100 bp DNA ladder |
| Lane 3 | - Positive control |
| Lane 4 to 8 | - Test sample |

**Plate 1:** Confirmation of CPV infection by PCR.

selected to amplify a large fragment of the capsid protein encoding gene of CPV, encompassing at least six or seven informative amino acids responsible for important biological properties of the virus (Parker and Parrish, 1997). Hence, the same primer was used to identify the presence of CPV infection in the selected cases of CPVE. Out of 123, 87 animals (70.73%) were confirmed for CPVE by the detection PCR product at 630 bp on gel electrophoresis of amplified product (Plate 1).

**Identification of risk factors associated with CPVE**

Cross-sectional study was used to investigate the relationship between disease and hypothesized causal factors. Relative Risk (RR) and Odds Ratio (OR) were used to determine the causal association as per the formula described by Martin *et al*. (1994). Vaccination of puppies, maternal vaccination, roaming of dogs and time of weaning are considered as important risk factors and association in the occurrence of disease are calculated follows:

| Risk factor | Disease positive | Disease negative | Risk factor | Disease positive | Disease negative |
|---|---|---|---|---|---|
| Unvaccinated | 73 | 11 | Roaming | 78 | 21 |
| Vaccinated | 14 | 25 | House hold | 9 | 15 |

| Risk factor | Disease positive | Disease negative | Risk factor | Disease positive | Disease negative |
|---|---|---|---|---|---|
| Dam unvaccinated | 83 | 25 | Early weaning | 79 | 12 |
| Dam vaccinated | 4 | 11 | Proper weaning | 8 | 24 |

In this study, vaccination (RR - 2.42, OR - 11.85), roaming of dogs (RR - 2.28, OR -7.02), maternal vaccination (RR - 2.22, OR - 6.27) and early weaning (RR - 3.05, OR - 13.83) having positive statistical association with the occurrence of CPVE in dogs. Houston *et al*. (1996) also reported that lack of vaccination in dogs is considered as an important risk factors associated with CPVE. Lack of maternal vaccination leads to increased susceptibility of puppies born to unimmunized bitches. This fact was also well explained by Carr *et al*. (1997), who reported that the failure of passive transfer of antibodies via colostrum, incomplete or ineffective primary vaccination course, or failure of vaccination to induce immunity are the risk factors associated with CPV infection in puppies.

**Weather based forecast model for prediction of association of environmental determinants with CPVE**

Multiple linear regression developed for detection of association of weather parameters with CPVE:

$$Y = -520.52\ (-0.025)\ X_1 + (-17.019)\ X_2 + (34.998)\ X_3 + (6.473)\ X_4 + (-1.939)\ X_5 + (-10.037)\ X_6$$

In this model, preceding thirty days average of predictor variables on daily basis is used to give early warning. If the value of the dependant variable is less than one (Y<1), there is a remote chance for the occurrence of disease and if greater than one there is more chance of the disease. The model is qualitatively valid only for the Namakkal area within the range of predictor variables. In this model, relative humidity both at 7.30 h IST and 14.30 h IST have strong correlation in the occurrence of CPVE. Kokilapriya *et al*. (2017) also reported that the humidity and rainfall were associated with the increased incidence of CPVE in dogs in Chennai, Tamil Nadu usually occurs in the South - West monsoon season. Kelman *et al*. (2020) reported that climate variables, temperature during hottest month and lower annual rainfall were strongly correlated with CPVE incidence in Australia. Hence, the occurrence of CPVE is depending upon the climatic variables prevailing in the respective geographical area.

## CONCLUSION

Developed model is useful in prediction of CPVE incidence well in advance and accordingly owners are advised to institute the prophylactic measures. Absence or inappropriate vaccination in puppies, roaming of dogs, lack of maternal vaccination and early weaning of puppies are the potential risk factors associated with the occurrence of CPVE in dogs. High relative humidity has positive correlation in the occurrence of CPVE.

## ACKNOWLEDGEMENT

The authors acknowledge Tamil Nadu Veterinary and Animal Sciences University, Chennai for funding and provided the necessary permission for the conduct of the research work.

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