Canine parvovirus in Australia: the role of socio-economic factors in disease clusters

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Abstract

Objective: Identify clusters of canine paroviral related disease occurring in Australia during 2010 and investigate the role of socio-economic factors contributing to these clusters.

Methods: Reported cases of canine parovirus were extracted from the Disease WatchDog database. Reported residence postcode was used to locate cases and was analysed using scan statistics to detect significant disease clusters in space and time. Maps of reported disease locations and clusters were created to visualise these distributions. Cases included in clusters were compared to those not included in such clusters with respect to human socioeconomic factors (postcode area relative socioeconomic disadvantage, economic resources, education and occupation) and dog factors (breed, age, gender, vaccination status).

Results: During 2010, a total of 622 Australian veterinary practices in all states and territories became registered users of Disease WatchDog. There were 1187 cases of canine parovirus reported. Nineteen significant (P<0.05) disease clusters were identified. Nine clusters were located in NSW, with the remainder in Victoria, Queensland, Western Australia, and South Australia. Eleven (58%) clusters occurred between April and July. The average cluster length was 5.7 days. All clusters occurred in postcodes with a significantly (P<0.05) greater level of relative socioeconomic disadvantage and a lower rank in education and occupation. No significant difference (P>0.05) was found between cases reported from cluster postcodes and those not within clusters for dog age, gender, breed or vaccination status.
Conclusion: Canine parvovirus occurs more frequently in areas of greater relative socioeconomic disadvantage and lower levels of education and occupation status. The occurrence of significant spatio-temporal disease clusters in this study could not be attributed to differences in dog breed, age, gender, or vaccination status. Further research is required to investigate the apparent association between indicators of poor socioeconomic status and clusters of reported canine parvovirus diseases; however these initial findings may be useful for developing geographically- and temporally-targeted prevention and disease control programs.

Keywords: canine parvovirus; spatio-temporal analysis; socio-economic factors; cluster; epidemiology; surveillance; Australia
1. Introduction

Canine parvovirus (CPV) is widely distributed in the global canine population and remains an important cause of morbidity and mortality in this species, despite extensive vaccination. The clinical presentation of this disease is most commonly acute enteritis, with severe leucopaenia in young dogs up to 6 months of age; however in recent years a number of cases have been reported in older dogs. Survival rates have been reported to be as high as 80–95% when cases are treated early and aggressively, but as low as 9.1% without treatment. The persistence of this virus in dog populations is attributed to its environmental resilience, virulence in susceptible populations, and the ability to mutate and avoid recognition by the immune system even in vaccinated individuals. There are currently three widely recognised strains of Canine Parvovirus: CPV-2a, CPV-2b and the recently characterised CPV-2c, though other strains have also been documented. The most recent study of Australian strains suggests that CPV-2a remains the most prevalent strain; CPV-2b was found uncommonly, and there was no evidence of CPV-2c infection.

Predisposing factors associated with the development of clinical parvovirus disease include stressors (such as weaning, overcrowding and parasite load), insufficient passive or active immunity, geographical region and the presence of co-pathogens (including canine coronavirus and intestinal parasites). Some of these factors are thought to increase the likelihood of developing clinical canine parvoviral disease by increasing the mitotic activity of mucosal cells. The role of season and breed in the development of CPV is debatable with discrepancies in findings between studies; however, it is possible that the importance of these factors may vary geographically due to local factors such as extremes in weather,
environmental viral loads, population density, and breed popularity.\textsuperscript{1,8-11} Warmer months have been associated with increased reporting of cases.\textsuperscript{1,10} Studies in companion animal epidemiology have been limited thus far by a lack of reliable and suitable data. Companion animal disease surveillance has mainly focused on zoonotic diseases such as rabies, for which case reporting is mandatory in most jurisdictions. Some specific research projects have been conducted, using data collected within the veterinary medical database (source data contributed by veterinary teaching hospitals across the United States).\textsuperscript{12-15} More recently, the Purdue University-Banfield National Companion Animal Surveillance program for emerging and exotic diseases was established for the purpose of recognising temporal and spatial patterns of disease in the companion animal population. This project allowed identification of clustered disease events in geographical areas, with Banfield hospitals’ patients accounting for 2% of the entire dog and cat population of the United States.\textsuperscript{16,17} Unfortunately, funding for this project was discontinued after only a few years.\textsuperscript{12} Until very recently, epidemiological data on diseases of companion animals in Australia could only be obtained by questionnaires and surveys used for a specific research objective.\textsuperscript{18,19} The introduction of Disease WatchDog (www.diseasewatchdog.org) by Virbac Australia presents opportunities for the veterinary community to accumulate data – both temporally and spatially – on important diseases of dogs and cats relevant to their patients.\textsuperscript{20} Evidence of spatio-temporal disease clustering indicates that some common factor(s) are contributing to disease propagation in specific areas and that targeted prevention programs will likely be effective in reducing disease occurrence.\textsuperscript{21} Analysis of
data from the Disease Watchdog database will ideally fill some of the current deficits in companion animal disease epidemiology.\textsuperscript{20}

The objective of this study was to identify clusters of canine parvoviral related disease that occurred in Australia during 2010 and to investigate potential factors contributing to these clusters. Specific aims were to analyse data from Disease Watchdog and describe the role that human socioeconomic indicators (relative socioeconomic disadvantage, access to economic resources, level of education, and occupation status) and dog factors (breed, age, gender, vaccination status) might have played in the development of canine parvoviral related disease clusters; and to assess the role of geographical distribution of registered clinics in the formation of these clusters. This study endeavoured to further characterise canine parvoviral disease occurrence in Australia and provide insights into potential target areas for disease prevention.

\textbf{2. Materials and Method}

\textbf{2.1. Data source}

All case data for the study was acquired via the Disease Watchdog database (www.diseasewatchdog.org). The Disease Watchdog national disease surveillance program was launched by Virbac Australia in January 2010 to log cases of diseases of dogs (including parvovirus) and cats occurring in Australia.\textsuperscript{20} The database relies on veterinary practitioners and nurses entering case details; in exchange, practices gain access to real-time maps and data specific to their practice area. Access to up-to-date epidemiological data enables practitioners to make informed decisions regarding appropriate vaccination schedules and
health prevention protocols relevant to their patients. A complete description of the database is provided by Ward & Kelman (2011).

Records of all cases reported during 2010 were extracted from the Disease WatchDog database. All cases of parvovirus related disease reported were screened for duplicate entries to ensure that case reports were only included once in analyses. Each record entered was counted as one case report, even though there may have been more than one disease case when a litter was involved in the report. Each report (record) was allocated a case identification number and contained the following generic data fields: clinic name, veterinarian name, case occurrence date, animal name, suburb, postcode, state, species, breed, age (years, months, weeks), gender (male, female or unknown), neuter status (neutered, entire or unknown), disease (including canine parvovirus), case diagnosis (clinical presentation, ELISA snap test, PCR, immunofluorescence or other), case outcome (died, recovered, euthanased, tested positive but not clinically affected or treatment ongoing), vaccination status (vaccinated, unvaccinated or unknown), vaccine given and vaccine date. In addition, there is an optional field to record litters infected (number of animals in litter, number of animals in litter infected); however, this additional data was not analysed in the current study.

Socio-economic data was sourced from the 2006 Australian census, made available by the Australian Bureau of Statistics (www.abs.gov.au). Census data for each Australian postcode was obtained in summarised format from the Socio-economic Indexes for Areas (SEIFA) data cube. Indices recorded in the data set included education and occupation, economic resources, relative socio-economic disadvantage, and relative socio-economic advantage and disadvantage. The usual human population of each postal area code was also recorded.
The index of socio-economic disadvantage is measured using financial and overall liveability factors, and can only be used as an indication of disadvantage, i.e. while a low score indicates greater relative disadvantage, a higher score does not necessarily indicate advantage. The economic resources index is a ranking of postcodes based on indicators of high and low income and variables that correlate with high or low wealth, with higher scores indicating greater access to economic resources. Low education and occupation index scores represent postal areas with a high proportion of the population without tertiary qualifications, without jobs or with low skilled jobs; in contrast, a high score for this index suggests that a greater proportion of postcode residents are qualified and employed in skilled jobs. In addition, the relative socio-economic disadvantage index was used. A lower score for a postal area indicated greater relative disadvantage, with deciles also recorded for each postal area in relation to these scores i.e. the lowest 10% of all postcode scores were allocated a decile of 1, while the highest 10% of all postcode scores were allocated a decile of 10.

2.2. Data management

Dog factors extracted from the recorded data in Disease Watchdog and analysed were breed, age, gender, and vaccination status. Breeds were allocated to one of seven categories based on the Australian National Kennel Council (ANKC) breed standards. Any cases recorded as crossbreeds or mixed breed were coded as mixed; the remainder of the dogs were classified by breed as toy, terrier, gundog, hound, working, utility or non-sporting. Three breeds reported in the extracted data are not
recognised by the ANKC; these were subsequently classified as working (Bull Arab, Koolie) and non-sporting (Pitbull).

Vaccination status was reported as vaccinated, unvaccinated or unknown. Vaccinated dogs were those that were recorded as having received at least one vaccination in their life.

Based on reported information regarding date of vaccination, dogs classified as vaccinated were further categorised as vaccination incomplete (i.e. last recorded vaccination before 16 weeks of age), vaccinated within the previous 12 months, or non recent vaccination (last recorded vaccination greater than 3 years prior to infection). Eleven cases classified initially as vaccinated were excluded from analysis of vaccination category due to errors (inconsistencies) in the reported dates of vaccine given.

The age of dogs was transformed from a years−months−weeks format to weeks only. For this transformation, it was assumed that one month consisted of four weeks and that one year consisted of fifty two weeks. Gender was categorised as male, female or unknown.

All clinic data was sorted according to postcode and month of registration in the database. Duplicate clinic entries (based on clinic name, postcode and state) were excluded, as were registrants identified as businesses other than Australian veterinary practices, and non-practising veterinarians.

Once disease clusters were identified at a postcode level, all recorded parvovirus cases were divided (based on postcode) into two data sets: cases within a cluster, and those not within a cluster. Although clusters were identified using a scanning window of 25% of the population and 2 week time period (see below), all cases recorded for these postcodes during the year 2010 were included in the ‘within cluster’ data set.
2.3. Data analysis

Maps displaying disease clusters, canine parvovirus case locations, and registered clinic locations were generated using ArcGIS v. 10 (ESRI Inc., Redlands CA).

A retrospective space-time analysis scanning for clusters with high rates of disease was performed using the Space-Time Permutation model (SaTScan v9.1.1 Kulldorf M. and Information Management Services Inc. 2009). Space-time canine parvovirus case clusters were identified using a maximum spatial cluster size of 25% of the population at risk i.e. 297 cases, and a maximum temporal cluster size of 4% of study period (1 January to 31 December 2010) i.e. 2 weeks. Clusters identified were postal code areas where a significantly (P<0.05) greater number of cases were reported within the spatio-temporal window than would be expected based on the total number of canine parvovirus cases reported in Disease WatchDog during the study period (1 January to 31 December, 2010).

A Wilcoxin Rank Sum Test by cluster (outside versus within cluster) was performed for age of reported cases; and also for both decile and score of postcode education and occupation, economic resources, and relative socio-economic disadvantage indices. Significance was reported using a two-tailed P-value for normal approximation. In addition, a chi-squared test for independence was performed by cluster (outside versus within cluster) for reported dog breed, gender and vaccination status. An overall chi-squared statistic and P-value were reported (Statistix v 8.0. Analytical Software, Tallahassee FL).

3. Results
Extraction of reported cases of canine parvovirus in Disease WatchDog between 1st January and 31st December 2010 yielded 1,187 cases (individual dogs and litters) from 169 clinics across Australia. Of these cases 916 (77%) were reported to be diagnosed by an ELISA antigen test, 233 (20%) by clinical presentation, and 38 (3%) by other methods (including PCR, immunofluorescence, and other unspecified CPV test). Overall, cases were reported from 357 (14.2%) Australian postal codes (Figure 1).

3.1. Clinic results

During 2010, 622 Australian veterinary practices across all states and territories became registered users of Disease WatchDog (approximately 30% of all registered practices in Australia). Of these clinics 27% (n=168) of all registrations occurred during February (Figure 2). Registrations during the remainder of 2010 ranged from 13 to 72 per month. In addition, 37.8% of all registered clinics were located in NSW, accounting for 37.2% of all registered veterinary practices in this state (n=632). Overall, registered clinics were located in 481 Australian postal codes (Figure 3) and distributed throughout most of the populated regions of Australia.

3.2. Cluster results

Nineteen significant (P<0.05) space-time disease clusters were identified with a mean radius of 42.3km (range 0–223 km). Clusters with a radius of 0 km represent clusters of disease reports within a single post code. The median number of cases within these clusters was 7 (range 4–22). Clusters were identified in both rural and urban areas of New South Wales (9), Victoria (3), Queensland (3), South Australia (1), and Western Australia (3)(Figure 4). Eleven
(58%) clusters occurred between April and July. The average cluster lasted for 5.7 days. A complete list of identified clusters is presented in Table 1.

3.3. Dog factors

No significant difference ($P = 0.5216$) was observed between the age distributions of those cases reported from within clusters (median age 140 days) versus those cases reported from areas not included within a cluster (median age 133 days). No significant difference ($\chi^2 = 13.55; P = 0.0599$) was observed in the number of reported cases in dog breed categories between those CPV cases reported from within clusters versus those cases reported from areas not included within a cluster (Figure 6). The gender of cases reported from within clusters versus those cases reported from areas not included within a cluster was not significantly different ($\chi^2 = 2.88; P$-value $= 0.2369$) (Table 2).

No significant difference ($\chi^2 = 2.77; P = 0.2505$) was observed in the vaccination status (ever vaccinated versus never vaccinated) reported from within clusters versus those cases reported from areas not included within a cluster (Table 3). Comparison of vaccination category (unknown/never vaccinated, incomplete vaccination, vaccinated within previous 12 months) between the two groups was also non-significant ($\chi^2 = 1.11; P = 0.5745$). Both groups reported 18% of dogs with an incomplete vaccination status, and 78% and 79% unknown/unvaccinated dogs outside and within clusters, respectively. Only 0.04% of cases reported outside clusters, and 0.02% within clusters were vaccinated within the twelve months prior to infection.

3.4. Socio-economic indices
All socioeconomic indices were significantly (P<0.05) lower for postcodes included in identified parvovirus clusters compared to postcodes from which parvovirus was reported but which were not included in identified clusters (Tables 4 and 5).

3.5. Population of postcodes

No significant difference (P>0.05) was observed between the median human population size of postcodes within clusters (11,587) and postcodes outside clusters (14,199) of canine parvovirus reports.

4. Discussion

Contagious diseases such as those caused by canine parvovirus are often clustered in time or space, and the presence of clusters usually indicates the contribution of common factor(s) to disease occurrence in these patients.21 The recognition of such clusters allows targeted disease prevention and control practices to be implemented. In the current study, nineteen significant space-time disease clusters were identified: these disease clusters occurred in both rural and urban communities and in five states of Australia.

Postal code areas that were included within these clusters on average had a significantly greater level of relative socio-economic disadvantage than postal areas that also reported cases of canine parvovirus in 2010 but which were not included in the identified clusters. In addition, postcodes within clusters on average had significantly lower economic resources scores and level of education and occupation. A lower level of ‘occupation’ refers to a greater proportion of unskilled workers and unemployed, versus a greater proportion of qualified professionals within higher score areas. The Australian Bureau of Statistics has
summarised socioeconomic data and reported that areas of high or low disadvantage tend to be clustered, and that people in areas with a low economic resources score (i.e. limited access to economic resources) are more likely to report fair or poor health status than those living in the highest decile. In addition, those with lower education levels and those living in greater relative socio-economic disadvantage are more likely to be obese. Studies reporting similar findings in companion animals are limited. However, previous research has indicated that owners with a higher education level (especially those with a professional qualification) generally provide a better standard of housing, feeding, and veterinary care for dogs than other owners and have greater knowledge of basic animal care based on survey responses from both pet owners and households that did not own a pet. In addition, as the socio-economic status of an area increases, so too does the proportion of dogs that receive preventive veterinary care such as desexing, intestinal parasite prophylaxis and vaccination. For example, in a study of parasite burden in Argentina, the percentage of owned dogs that had never received anthelmintic treatment was 53% in the low income neighbourhood group versus 22% in the medium income group. Although Australian data in this area is inadequate, it is feasible that attention to pet health follows a similar trend as has been reported elsewhere, that is, animals from households with a higher income or level of education generally receive a greater level of veterinary pet care. To help prevent infectious diseases in these susceptible pet populations, a greater level of herd immunity is required in the general canine population. Targeted preventive health programs should be carried out in those areas adjacent to, and within, cluster postcodes to reduce disease propagation in these populations.
Dog factors examined in this study included vaccination status, gender, age and breed. No significant difference was detected between cases within clusters and those outside clusters for any of these variables. Kalli et al. (2010) found that in some geographical areas certain breeds, especially purebreds, may be at increased risk of developing canine parvovirus. This finding may be biased by dog breed distribution and seasonal conditions, because it has also been argued that breed does not play a significant role in predisposition to canine parvovirus. Houston et al. (1996) determined that in dogs older than 6 months of age, males were more likely to develop CPV related disease than females, and intact dogs were at a greater risk of disease than neutered dogs. The association with neuter status probably relates to factors influencing the decision to neuter (e.g. financial limitations and social attitudes) rather than a direct correlation between disease and presence/absence of reproductive organs. Several studies have also found vaccination to be protective against development of clinical disease; however vaccination in these studies refers to compliance with a vaccination protocol capable of inducing protective antibody titres. Less than one percent of dogs in the current study were reported as having received adequate vaccination against canine parvovirus as determined by the WSAVA vaccination guidelines. To date, all studies on factors influencing the development of canine parvovirus related disease have used normal (clinically healthy) dogs as a control group. Therefore, whilst these studies offer insight into potential contributing factors to disease clusters their results are not immediately comparable to our study because all dogs included in the dataset were demonstrating clinical signs of disease. As there was no control data with which to compare, it is difficult to draw conclusions regarding the significance of these factors in the development of CPV. Although the findings in this study suggest that vaccination status (as
well as gender, age and breed) did not play a significant role in the formation of disease clusters, information on vaccination status was limited. The logging of all vaccinations administered – especially the number of vaccines received in the primary course – would be a beneficial addition to Disease WatchDog and would allow more accurate conclusions regarding the significance of vaccination in cluster populations.

There were a number of limitations to this study, many of which are being overcome as Disease WatchDog evolves as a disease surveillance system. The main constraint to this study was that the baseline population demographics for dogs in Australia is largely unknown, and the small amount of data that is available is usually specific to a local area. The absence of a control population makes it difficult to draw conclusions regarding analysis of diseased populations because there is no baseline data against which to make comparisons. Thus, all comparisons in this study were made between clinical cases within cluster areas and cases not within a cluster. Clusters (cases reported to occur within 2 weeks within relatively small areas) were assumed to represent potential epidemics of disease transmission. Thus, this study examined factors that might promote local epidemics of canine parvovirus. In addition to extra input fields in Disease WatchDog relating to practice demographics, a pet ownership component to the national census would undoubtedly be beneficial in the assessment of both animal and human health.

Another major limitation to the study was the use of data collected within a passive surveillance system. Moore & Lund (2009) comment that passive surveillance systems have a number of drawbacks, including a high rate of underreporting, incomplete reporting, increased chance of reporting bias, and commonly the lack of a population at risk. The Disease WatchDog database includes these limitations at present and so results of analysis
of the dataset in this study need to be interpreted with caution. Underreporting is a concern in any surveillance system; Godsall et al. (2010) observed that reporting compliance (5.9%) of staff was significantly lower than expected in a study in which data came from one group of hospitals under the same management in the UK. Reporting bias is difficult to assess in this situation because reporting of canine parvovirus is not mandatory and some clinics may be more diligent with reporting than others. Twenty percent of cases in this study were reported using a sole diagnosis of clinical presentation; this further limits the accuracy of the results reported. These cases were not excluded from the study due to the risk of eliminating cases in lower socioeconomic households where funds for diagnostics may have been limited.

Another challenge with passive surveillance systems is determining the reliability of the data that has been entered by the registered practice. The data in this study was edited and any duplicates or incomplete entries removed. However, it is possible that the final data was not 100% accurate in every case due to human error. Finally, our data may not be completely representative of the canine parvovirus situation in Australia because a substantial number of veterinary practices are not registered users of Disease WatchDog. The mapped data shows a broad distribution of registered clinics across Australia, and although some states have a higher registration rate than others the cases registered are likely to be reasonably representative of disease across these areas.

There is great scope for more research to be conducted using the Disease WatchDog database. As a greater number of clinics become registered users the data will become more representative, with larger case numbers available for analysis. Collection of population at risk information would be advantageous for further analysis and could
potentially be incorporated into Disease WatchDog at the time when clinics are entering
disease cases on a monthly basis. Specific information fields and prompts specific to each
disease would also increase validity of results from the database. Further research required
to augment this initial study would include additional analysis of cluster areas to determine
the cause of increased parvovirus in these areas; acquisition of more detailed vaccination
records, analysis of data examining vaccination to disease interval to determine the
importance of this factor in cluster formation; and comparison of these areas with areas
that do not regularly report parvovirus cases.

5. Conclusion

Canine parvovirus occurs in disease clusters where a greater number of cases are reported
than expected. These clusters tend to occur in areas of greater relative socioeconomic
disadvantage, lower levels of education and skilled occupations, and reduced access to
economic resources. Dog age, gender, breed and vaccination status do not appear to play a
significant role in the formation of these clusters. Additional research is needed to further
classify these disease clusters and potential factors contributing to their formation.

6. Acknowledgements

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senior author.
7. References
27. Ramón ME, Slater MR, Ward MP. Companion animal knowledge, attachment and pet cat care and their associations with household demographics for residents of a rural texas town Preventative Veterinary Medicine 2010 94 251-263.

Figures & Tables

Figure 1. Distribution of Australian postcodes that reported one or more cases of canine parvovirus within the Disease WatchDog database (www.diseasewatchdog.org) in 2010.
Figure 2. Distribution of new veterinary clinic registration, by month, within the Disease WatchDog database (www.diseasewatchdog.org).
Figure 3. Distribution of all Australian veterinary clinics registered within the Disease WatchDog database (www.diseasewatchdog.org), 2010.
Figure 4. Postcodes from which canine parvovirus was reported within the Disease WatchDog database (www.diseasewatchdog.org) in 2010 (dark blue) and the centres of clusters (black dots) identified using a space-time permutation test.
Figure 5. Distribution of new parvovirus cases reported in Australia within Disease WatchDog (www.diseasewatchdog.org) by month within clusters identified using a space-time permutation scan test and in areas outside identified clusters.
Figure 6. Canine parvovirus cases reported in the Disease WatchDog database (www.diseasewatchdog.org) by breed category within identified clusters compared to those reported from areas not within a cluster.
Table 1. Clusters of parvovirus disease in Australia reported in Disease WatchDog (www.diseasewatchdog.org) during 2010 and identified using the space-time permutation model

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Time Period</th>
<th>Number of cases</th>
<th>Expected cases</th>
<th>Radius (km)</th>
<th>Location</th>
<th>Epicentre</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>04/02/10 – 04/02/10</td>
<td>9</td>
<td>0.13</td>
<td>0</td>
<td>Regional QLD (north east)</td>
<td>Bowen</td>
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<tr>
<td>2</td>
<td>21/04/10 – 30/04/10</td>
<td>22</td>
<td>2.61</td>
<td>51.91</td>
<td>Regional NSW (central)</td>
<td>Cowra</td>
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<tr>
<td>3</td>
<td>13/11/10 – 13/11/10</td>
<td>7</td>
<td>0.077</td>
<td>0</td>
<td>North – west Sydney</td>
<td>Blacktown</td>
</tr>
<tr>
<td>4</td>
<td>02/12/10 – 03/12/10</td>
<td>6</td>
<td>0.053</td>
<td>0</td>
<td>Regional SA (south east)</td>
<td>Morgan</td>
</tr>
<tr>
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<td>03/01/10 – 14/01/10</td>
<td>12</td>
<td>0.92</td>
<td>17.98</td>
<td>Regional WA (south west)</td>
<td>Bunbury</td>
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<td>0.18</td>
<td>68.27</td>
<td>Regional NSW (central)</td>
<td>Mudgee</td>
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<td>15</td>
<td>1.79</td>
<td>173.23</td>
<td>Regional NSW (north east)</td>
<td>Taree, Tamworth, Coffs Harbour</td>
</tr>
<tr>
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<td>03/05/11 – 03/05/11</td>
<td>5</td>
<td>0.044</td>
<td>0</td>
<td>South-west Melbourne</td>
<td>Altona</td>
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<td>0.044</td>
<td>222.99</td>
<td>Regional WA (southern coast)</td>
<td>Albany</td>
</tr>
<tr>
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<td>0</td>
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<td>06/04/10 – 18/04/10</td>
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<td>1.96</td>
<td>21.16</td>
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<td>Collingwood Park, Ipswich, Marsden</td>
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<td></td>
<td>Date Range</td>
<td>Count</td>
<td>Cost</td>
<td>Location</td>
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<td>Regional NSW (central north) Moree</td>
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<td>Regional NSW (west) Broken Hill</td>
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</tr>
<tr>
<td>16</td>
<td>26/06/10 – 09/07/10</td>
<td>8</td>
<td>0</td>
<td>Regional WA (central east coast) Geraldton</td>
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<td></td>
</tr>
<tr>
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<td>10/05/10 – 10/05/10</td>
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<td>0.035</td>
<td>South-east Melbourne Cheltenham</td>
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<td>28/07/10 – 29/07/10</td>
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<td>Regional NSW (central coast) Gosford</td>
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<td>06/07/10 – 10/07/10</td>
<td>4</td>
<td>0</td>
<td>South-east Melbourne Chadstone</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 2. Gender of cases reported within clusters versus those reported outside clusters. No significant difference was observed between groups.*

<table>
<thead>
<tr>
<th>Gender</th>
<th>Outside clusters</th>
<th>Within clusters</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>486</td>
<td>161</td>
<td>654</td>
</tr>
<tr>
<td>Female</td>
<td>390</td>
<td>119</td>
<td>509</td>
</tr>
<tr>
<td>Unknown</td>
<td>15</td>
<td>9</td>
<td>24</td>
</tr>
</tbody>
</table>

*p = 0.2369
Table 3. Vaccination status of parvovirus cases reported in Australia in Disease WatchDog (www.diseasewatchdog.org), within identified clusters compared to those reported from areas not within a cluster. A status of ‘vaccinated’ indicates that the dog had received at least one vaccination.

<table>
<thead>
<tr>
<th>Vaccination status</th>
<th>Outside cluster</th>
<th>Within cluster</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vaccinated</td>
<td>210</td>
<td>64</td>
<td>274</td>
</tr>
<tr>
<td>Unvaccinated</td>
<td>460</td>
<td>169</td>
<td>629</td>
</tr>
<tr>
<td>Unknown</td>
<td>221</td>
<td>63</td>
<td>284</td>
</tr>
</tbody>
</table>
Table 4. Median score of socio-economic indices of postcodes included within identified clusters of parvovirus cases reported in Disease WatchDog (www.diseasewatchdog.org) in Australia during 2010 and postcodes from which reported cases were not within clusters.

<table>
<thead>
<tr>
<th>Socio-economic index</th>
<th>Median score within clusters</th>
<th>Median score outside clusters</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Index of Relative Socioeconomic Disadvantage</td>
<td>955 (741–1055)</td>
<td>987 (639–1132)</td>
<td>0.0001</td>
</tr>
<tr>
<td>Index of Economic Resources</td>
<td>966 (831–1086)</td>
<td>991 (659–1199)</td>
<td>0.0004</td>
</tr>
<tr>
<td>Index of Education &amp; Occupation</td>
<td>927 (774–1059)</td>
<td>954 (772–1206)</td>
<td>0.0002</td>
</tr>
</tbody>
</table>
Table 5. Median decile ranking of socio-economic indices of postcodes included within identified clusters of parvovirus cases reported in Disease WatchDog ([www.diseasewatchdog.org](http://www.diseasewatchdog.org)) in Australia during 2010 and postcodes from which reported cases were not within clusters.

<table>
<thead>
<tr>
<th>Socio-economic Index</th>
<th>Median decile within clusters</th>
<th>Median decile outside clusters</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Index of Relative Socioeconomic Disadvantage</td>
<td>3 (1–9)</td>
<td>5 (1–10)</td>
<td>0.0001</td>
</tr>
<tr>
<td>Index of Economic Resources</td>
<td>3 (1–10)</td>
<td>5 (1–10)</td>
<td>0.0004</td>
</tr>
<tr>
<td>Index of Education &amp; Occupation</td>
<td>3 (1–9)</td>
<td>5 (1–10)</td>
<td>0.0001</td>
</tr>
</tbody>
</table>