Companion animal disease surveillance: A new solution to an old problem?

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A R T I C L E   I N F O

A B S T R A C T

Infectious disease surveillance in companion animals has a long history. However, it has mostly taken the form of *ad hoc* surveys, or has focused on adverse reactions to pharmaceuticals. In 2006 a Blue Ribbon Panel was convened by the U.S. White House Office of Science and Technology Policy to discuss the potential utility of a national companion animal health surveillance system. Such a system could provide fundamental information about disease occurrence, transmission and risk factors; and could facilitate industry-supported pharmaco-epidemiological studies and post-market surveillance.

Disease WatchDog, a prospective national disease surveillance project, was officially launched in January 2010 to capture data on diseases in dogs and cats throughout Australia. Participation is encouraged by providing registrants real-time disease maps and material for improved communication between veterinarians and clients.

From January to mid-November 2010, an estimated 31% of veterinary clinics Australia-wide joined the project. Over 1300 disease cases – including Canine Parvovirus (CPV), Canine Distemper, Canine Hepatitis, Feline Calicivirus, Feline Herpesvirus, and Tick Paralysis – were reported. In New South Wales alone, 552 CPV cases in dogs were reported from 89 postcode locations. New South Wales data was scanned using the space–time permutation test. Up to 24 clusters ($P < 0.01$) were identified, occurring in all months except March. The greatest number of clusters ($n = 6$) were identified in April. The most likely cluster was identified in western Sydney, where 36 cases of CPV were reported from a postcode in February. Although the project is still in its infancy, already new information on disease distribution has been produced. Disease information generated could facilitate targeted control and prevention programs.

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1. Introduction

Surveillance of infectious diseases in companion animals has a long history. This surveillance has mostly taken the form of *ad hoc* surveys, or has focused on adverse reactions to vaccines and other pharmaceuticals. Most of these activities have not included an ongoing measurement of the population using comparable methods, so strictly do not meet our current understanding of disease surveillance. A notably exception is surveillance for rabies, for which passive surveillance systems exist (for example, see Blanton et al., 2006; Tenzin et al., 2010, 2011).

An example of using secondary data sources for surveillance is research on the recent epidemic of canine leptospirosis in North America (for details, see Ward et al., 2002, 2004a,b; Ward, 2002a,b). This research program was initiated using data from the Veterinary Medical Database (VMDB). The VMDB was established in North America in 1964 by the National Cancer Institute to collect, store, and retrieve veterinary clinical information (Hayes et al., 1997; Priester, 1977). It contains a standardized abstract of every animal examined at participating veterinary teaching hospitals in the United States and Canada. At the time of initiation of this study, 24 veterinary teaching hospitals in

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the United States and Canada had contributed data (Ward et al., 2002). Results showed a clear trend in increasing diagnoses of canine leptospirosis, suggesting this to be a re-emerging zoonosis. However, because the VMDB is a secondary data source, data analysis was limited to those covariates recorded in the VMDB, and results might be subject to diagnostic bias and might not necessarily represent the target population. For spatial analyses (Ward, 2002a), research was limited to the location of the hospitals reporting the cases. Later, data generated within a specific veterinary teaching hospital data management system was integrated (using a geographic information system) with data generated from a state veterinary laboratory accession management system to conduct more focused research on spatial distribution and risk factors (Ward et al., 2004a,b). This allowed recommendations to be made to reduce the impact of this epidemic of leptospirosis. However, integrating databases and data cleaning, error checking and validation consumed a considerable amount of time, and the system could not identify new trends in near-real time. A critical gap identified was database integration and analytical methodologies that could be applied routinely.

Most research in the area of companion animal disease surveillance has focused on systems to detect adverse vaccine and other drug reactions. For example, Moore et al. (2006a) developed a surveillance system that utilized electronic medical records from a large corporate small animal general practice in the United States, in which each of more than 400 hospital locations in this system used the same computerized medical record system. Records of dogs receiving a range of vaccines (including for *Bordetella*, coronavirus, multivalent distemper–adenovirus–parainfluenza–parvovirus–leptospirosis, *Giardia* and rabies) were extracted and searched for adverse reactions. Using the collective data recording of these hospitals, 4678 adverse events were identified during a 2-year period, representing 3,439,576 doses of vaccine administered to 1,226,159 dogs. The use of veterinary practice databases to complement spontaneous reporting systems for vaccine safety is one example of recent advances in companion animal disease surveillance (Moore et al., 2006b). This system has also been used as a research tool to identify space–time clusters of adverse events associated with canine rabies vaccine (Moore et al., 2005).

In September 2006, a Blue Ribbon Panel was convened on behalf of the U.S. White House Office of Science and Technology Policy to discuss the potential utility and possible strategies for design and implementation of a national companion animal health surveillance system (Stone and Hautala, 2008). A goal of such a system is improved veterinary care, and it could be also used to develop evidence-based veterinary practices. Data derived from a surveillance system could provide fundamental information regarding disease incidence, prevalence, transmission, and risk factors. Such an enhanced understanding of disease epidemiology would enable practitioners to evaluate the effectiveness of treatments and intervention programmes. Such a system could also facilitate industry-supported pharmaco-epidemiological studies and post-market surveillance, which would enable the development of safer and more effective veterinary products.

As stated by the Blue Ribbon Panel, a companion animal surveillance system should ideally be a public/private partnership involving representatives from the veterinary community and the veterinary products industry who are involved in the design of the system in order to promote compliance and leverage resources. In January 2010, Virbac Animal Health in Australia launched Disease WatchDog, a prospective national disease surveillance project, to capture data on communicable disease cases and outbreaks, with the ultimate aim of the reduction and control infectious diseases in cats and dogs. This project is unique as it involves a growing number of participants, and as well as gathering data, encourages participation by providing benefits to registrants including real-time maps of disease occurrences and outbreaks, material for improved communication between veterinarians and clients, and empowerment of staff. From January to mid-November, an estimated 31% of veterinary clinics Australia-wide have joined the project, with >1300 cases of disease reported. While the project is still in its infancy, the analysis of initial data is demonstrating some important findings with respect to disease distributions in space and time and risk factors, and there is considerable potential to gather vital information that could lead to targeted vaccination and treatment efforts which could be the key to the control of various diseases. In this paper we report details of this surveillance tool and illustrate its utility with a case study of canine parvovirus (CPV) occurrence and distribution during a 9-month period in the state of New South Wales. The purpose of this paper is to demonstrate the feasibility of surveillance in pet animal populations, and to highlight the value of spatial analysis of such surveillance data.

2. Materials and methods

2.1. Disease WatchDog

Disease WatchDog was created out of the need for better epidemiological data on current and emerging companion animal diseases. Despite significant advances in technology, veterinary science is lacking recent studies on the occurrence and distribution of diseases that affect the lives of millions of animals worldwide. Incidence of common infectious diseases such as Canine Parvovirus (CPV), Canine Distemper Virus (CDV), Feline Calicivirus (FCV), Feline Rhinotracheitis Virus (FVR), Feline Immunodeficiency Virus (FIV), and Feline Leukemia Virus (FeLV) are largely unknown. With comprehensive data and a better understanding of the epidemiology of these diseases, solutions to problems such as how to formulate best practice vaccination protocols during disease outbreaks or how to strategically address endemic disease with preventive and treatment techniques can be proposed.

As a national disease surveillance system, Disease WatchDog was developed to gather epidemiological data and to provide real-time mapping that demonstrates disease occurrences at suburb level. Data needs were based on the following considerations:

(a) Minimal data and ease of reporting mandatory such that the recording of data into the system would not become onerous.
(b) Sufficient patient data to allow assessment of patient factors as risk factors.
(c) Location at which the disease was contracted and/or distributed.
(d) Method of diagnosis (indicator of diagnostic accuracy).
(e) Identification of Veterinary Clinic, Veterinarian and Patient (confidential).
(f) Vaccination or disease preventives administered.
(g) Case outcome.

Fields in which data could be recorded were then assembled into a web-based system and the website interface carefully designed to maximize compliance from users. Estimated time to enter a case of disease is currently 30 s. Features to improve compliance include a "litter" checkbox where multiple affected littermates can be simultaneously entered into the database, reducing repetitive data entry. A chart can be downloaded from the website so that users can record cases on paper as an interim measure, then enter cases in a batch if this is easier for the user.

To maximize accuracy, user access to submit data is limited to registered veterinarians and veterinary nursing staff of veterinary clinics. Veterinary clinics register for access to the Disease WatchDog site at www.diseasewatch-dog.org and once approval is granted, an email provides username and password. There is no charge for using Disease WatchDog.

Once a month, all registered users are sent an email reminder to enter cases for the previous month if they have not already done so. The monthly email also provides an opportunity to communicate with users, updating them on improvements to the system and how best to use the program.

When a user registers, a pack of resources is sent to the clinic to which they belong, to help communicate their involvement to their staff and clients. An emphasis on empowerment of staff to be involved in the program aims at encouraging participation and collegiality. The message behind the program is that together, the veterinary profession has the power to control diseases through participation in the program, data collection, analysis and then strategic disease prevention and treatment.

A benefit for veterinary clinics of participating in Disease WatchDog is the ability to view maps of disease cases and outbreaks in real-time. Data entered via the website is immediately visible on the disease maps that any registered participant can view. Maps can then be used to show clients where at-risk areas for disease exist, highlight the importance of disease prevention, and to monitor disease outbreaks in their local area. Measurement of disease cases and recording of outbreaks also provides strong data that can also be communicated through channels such as the Australian Veterinary Association's media office, to allow alerts to be transmitted to the general public via local and national media. Never before in Australia has accurate recording of disease outbreaks been available on this scale for this number of diseases.

A feature of Disease WatchDog is the role of Disease Surveillance Champions. These are individuals within veterinary practices that are responsible for data entry. These individuals routinely update data within the system, for their practice, on a monthly basis. They act as the primary contact point within each practice, and promote the advantages of the Disease WatchDog surveillance system to colleagues and clients.

Disease WatchDog was upgraded to version 2.0 in September 2010, partly in response to suggestions and ideas for improvements from contributors. This upgrade provided both contributors and analysts with a number of additional features and benefits for better searching and display of disease cases and outbreaks, and improved recording of information. Some of the important news features include:

1. Allowing the graphing feature to be controlled by Disease Surveillance Champions. This feature displays disease cases and outbreaks – enabling the diseases, locations and timeframes that are displayed to be personally selected, for better representation of disease outbreaks relevant to a local community. Disease WatchDog users can adjust the graph that displays on the home page, to suit the needs of their individual clinic. The graph of current outbreaks of disease defaults to the last 3 months.
2. A new facility to search by radius around a suburb, providing more relevant information on the diseases in the user's area and allowing improved mapping. This facility could also be useful for research studies to identify risk factors for disease occurrence.
3. A feature to allow multiple diseases to be displayed by assigning different colors to each disease, so that multiple diseases can be shown simultaneously. More information on diseases in a suburb can be obtained by the user simply by clicking on a colored flag placed at the suburb location. Displaying multiple diseases allows practices and their clients to visualize which diseases are prevalent in their specific area.
4. Tick paralysis data has been added to Disease WatchDog. Tick paralysis is an acute, progressive ascending motor paralysis. It is caused by a salivary neurotoxin produced by some species of ticks. In Australia *Ixodes holocyclus* is the principle cause of cases of tick paralysis in domestic animals. This tick species can be found on native animals along the east coast of Australia. Reported distribution of tick paralysis has previously been mostly anecdotal. Inclusion of tick paralysis in Disease WatchDog allows for the first time the spatial and temporal distribution of this important disease to be monitored in Australia. Recording tick paralysis cases will enable veterinarians to alert clients to the dangers of ticks in specific areas, and also whether tick paralysis is seasonal in their area and the importance of tick prevention and awareness.
5. Two more infectious diseases were added to the Disease WatchDog list; the distribution of FeLV and feline infectious peritonitis (FIP) can now be monitored. These diseases were chosen as the next additions because of their apparent lower prevalence, but higher mortality.

FeLV is caused by a retrovirus that can be transmitted between cats via saliva or nasal secretions, and can be fatal. FIP, caused by a coronavirus, is incurable and generally fatal. Other diseases will be added to Disease WatchDog in the future, based on the perceived health importance and ability of veterinarians to detect and diagnose the health condition.

The development and maintenance of Disease Watch-Dog to date has been funded entirely by Virbac Animal Health. Awareness of the Disease WatchDog initiative is being achieved within the veterinary community via the support of the Australian Veterinary Association (which represents most veterinarians within Australia), IDEXX Laboratories (a company that develops and markets diagnostics within Australia; http://www.idexx.com.au/), Vetnostics (part of a network of pathology laboratories operating throughout Australia; http://www.vetnostics.com.au/), and Gribbles Veterinary (a veterinary pathology organization providing veterinary diagnostic and analytical services throughout Australia and New Zealand; http://www.gribblesvets.com.au/info/general/Home/get/0/0/).

Between 1 January and 17 November 2010, 659 registrants joined Disease WatchDog across Australia (a small number are non-veterinary registrants and do not record disease cases), representing approximately 31% of veterinary clinics Australia-wide. Based on estimates of veterinary clinic numbers across the states of Australia, participation levels range from 20% in Victoria (93) to 40% in New South Wales (263).

2.2. Data

To demonstrate the utility of the Disease WatchDog system, data analysis focused on reports of CPV in the state of New South Wales. CPV is an infectious disease of dogs caused by CPV type 2. It is highly contagious and is spread via direct contact or indirectly via fecal contaminated environments and fomites. This disease is often diagnosed in puppies unprotected by maternal antibodies or vaccination. Although CPV first appeared in the late 1970s as a pandemic (Johnson and Spradbrow, 1979; Walker et al., 1980) and other epidemics have been reported (Sabine et al., 1984), the spatial distribution, seasonality and risk factors for CPV are not well understood. In a questionnaire survey of veterinary practitioners in Australia and New Zealand seeking details of their experience with CPV infections in 1980, Sabine et al. (1982) found that explosive outbreaks of disease had occurred in most parts of Australia in that year. No obvious pattern of spread over the continent could be detected. An overall mortality rate of 16% was estimated. In a serological survey, Smith et al. (1980) found that CPV was generally a disease of dogs less than 6 months of age. The current analysis focuses on the spatial distribution of this disease, as a case study of the application of the Disease WatchDog surveillance system.

Data extracted from Disease WatchDog included date of diagnosis and the residential postcode. For the purposes of demonstration, data selected was restricted to reported cases occurring between 1 January and 30 September, 2010 in the state of New South Wales.

All data was joined to a postcode shapefile (GDA 1994, New South Wales Lambert Conformal Conic projection) in ArcGIS v. 9.3 (ESRI Inc., Redlands CA). The Lambert Conformal Conic projection system is one of the best for 'middle' latitudes. The State of New South Wales lies between latitudes 28 and 37°S. Spatial relationships were measured on the scale of meters.

2.3. Data analysis

Only cases which had valid data entered for location (postcode) and diagnosis date (day, month) were included in spatial analyses. For all postcodes included in the study, the postcode centroid was calculated (ArcTools, ArcGIS 9.3). Most postcode polygons in New South Wales are relatively small: 80% of the postcodes cover a land area of $\leqslant 1260$ km^2.

Data were scanned using the space–time permutation test (SaTScan v. 7. Kulldorff M. and Information Management Services, Inc. SaTScanTM v7.0: Software for the spatial and space–time scan statistics. http://www.satscan.org/, 2006). The permutation test was used because the number of dogs at-risk of CPV per postcode is unknown. However, it was assumed that during the 9-month study period the distribution of the population of dogs would have remained stable across postcodes. Future research using Disease WatchDog will include estimation of the dog and cat population at-risk within suburbs and postcodes. This might be achieved by annual surveys of Disease WatchDog participants, or by estimations based on reported disease cases.

Based on a maximum period of infectiousness for CPV of up to 3–4 weeks (Goddard and Leisewitz, 2010), the temporal scanning window was restricted to $\leqslant 28$ days, with windows of 7, 14, 21 and 28 days used. The spatial scanning window was restricted to $\leqslant 20$ km, with windows of 1, 5, 10 and 20 km used in a series of separate analyses. The analytical approach, recognizing that it was a demonstration of the application of the Disease WatchDog surveillance system, was exploratory and attempted to provide insights into the epidemiology of CPV in the New South Wales dog population – a subject on which no peer-reviewed information has previously been published. The selection of scanning windows was motivated by an assumed level of clustering that might occur within an area covered by up to 3–4 postcodes (in urban and semi-urban areas of New South Wales) within a relatively short timeframe, i.e., potential local outbreaks of CPV.

An additional exploratory analysis was performed using the scan statistic Bernoulli model. For these analyses, cases were reports of CPV in which the affected dogs had been vaccinated and controls were those dogs diagnosed with CPV that reportedly had not been vaccinated. The results of such an analysis might reveal clusters of CPV disease associated with vaccine failure.

In all scan statistic analyses, 999 permutations were performed and significant ($P < 0.05$) clusters were identified and mapped. Clusters were interpreted based on the ratio of observed to expected cases occurring within the

cluster. Data was exported from Disease WatchDog, processed within ArcGIS v. 9.3 (ESRI Inc., Redlands CA) and then exported to SaTScan v. 7 (Kulldorff M. and Information Management Services, Inc. SaTScan™ v7.0: Software for the spatial and space–time scan statistics. http://www.satscan.org/, 2006) for analysis.

3. Results

Between 1 January and 30 September, 2010, there were 1110 reports submitted to Disease Watchdog, representing 1376 disease cases. Only one case of FIP, and two cases each of CDV and CHV, were reported. A total of 65 and 115 cases of FCV and FHV were reported, respectively. Tick paralysis was added to Disease WatchDog in September, and 138 cases were reported during this month.

All reports contained valid data for diagnosis and postcode. During the study period, 1043 cases of CPV were reported from New South Wales (552 cases/407 reports), Queensland (223/183). Victoria (119/90), Western Australia (87/76), the Northern Territory (18/18), South Australia (10/10) and Tasmania (4/1).

In New South Wales, most CPV reports (353; 87%) consisted of only one case. Reports with 2, 3, 4, 5, 6 and 9 cases were made on 18, 18, 4, 6, 3 and 5 occasions. Most of the cases were male (229; 56%). A total of 56 breeds were reported to be affected. The following 7 breeds accounted for >50% of cases: Australian Cattle Dog (60; 15%), Staffordshire Terrier (47; 12%), Jack Russell Terrier (24; 6%), Bull Terrier (22; 5%), Mastiff (20; 5%), Maltese (19; 5%) and Fox Terrier (18; 4%). The mean (95% confidence interval) and median (interquartile range) ages were 29 (24–33) and 16 (8–24) months, respectively. The minimum age of cases was 5 months. The most common methods of diagnosing CPV were the ELISA Snap (260; 64%) and clinical signs (90; 22%). Immunofluorescence and PCR were rarely used (4 and 2, respectively).

Outcome was reported for 355 cases, with treatment ongoing at the time of reporting for a further 51 cases. Of those 355 cases with a final outcome reported, 79 (22%) died, 77 (22%) were euthanized, and 199 (56%) recovered. Vaccination status was reported for 323 cases, of which 87 (27%) cases were vaccinated.

No significant association was found between survival status (recovered versus died or euthanized) and gender (male versus female, odds ratio (OR) 1.22; $P = 0.35$), method of diagnosis (clinical versus test, OR 1.19; $P = 0.53$) or vaccination status (unvaccinated versus vaccinated, OR 1.55; $P = 0.12$ and unknown versus vaccinated, OR 1.39; $P = 0.34$). Dogs that survived were older (34 weeks) than those that died (28 weeks), $P = 0.18$. The greatest number of cases of CPV were reported in the months of February and April (19% each). Half of all cases were reported between 7 March and 18 June.

The data entry screen in Disease WatchDog (www.diseasewatchdog.org) is shown in Fig. 1. Examples of the reports that can be generated and viewed on the Disease Watchdog website are shown in Fig. 2. Reports include histograms showing the frequencies of diseases reported during a given period, and maps of the distribution of cases.

An example of the spatial search capacity of Disease WatchDog is shown in Fig. 3. CPV cases were reported from 89 postcodes. Only one case was reported from 46 postcodes; 10 or more cases were reported from the following 9 postcodes: 2400, 2770, 2810, 2793, 2794, 2340, 2560, 2830, 2390 (Fig. 4). Only 2 of these (2560 and 2770) were in areas of substantial human population.

Regardless of the size of the scanning window used (all combinations of 1, 5, 10 and 20 km and 7, 14, 21 and 28 days), the most likely cluster was identified in western Sydney, in which 2 clinics reported 36 cases of CPV on 16 February (observed ÷ expected 13.4). Depending on the scanning window used, between 18 and 23 significant ($P < 0.01$) additional clusters were detected. At larger spatial scanning windows, fewer clusters were detected. The size of the temporal scanning window had little influence on the number of clusters detected. Clusters were detected in every month except March. The most clusters were identified in April. Twelve of these clusters were only of one day duration; the other 12 clusters lasted from 2 to 16 days (median 7 days). The clusters (Fig. 5) were distributed throughout most of the state, excluding the southeast and the far west. All but two of these clusters were located outside the metropolitan area of Sydney. Using reports of CPV in which the affected dogs had been vaccinated as cases and controls as those dogs diagnosed with CPV that reportedly had not been vaccinated, the same location in western Sydney was identified as the primary cluster, although the observed ÷ expected ratio was less (3.2). In contrast, in this analysis no significant ($P < 0.01$) secondary clusters were detected.

4. Discussion

Surveillance of small animal populations for infectious diseases has been rare. Almost all examples of surveillance systems focus on the detection of rabies cases. For example, in the United States the system for rabies surveillance is well-developed and based on the reporting of cases (usually accompanied by submission of diagnostic samples) to the Centres for Disease Control and Prevention. However, even in this system, the focus is cases in wildlife, rather than companion animals (for example, in 2005 approximately 92% of the cases were in wildlife, and 8% were in domestic animals; Blanton et al., 2006). Other studies have used a surveillance-like design. For example, Biggeri et al. (2006) used a 2-stage sampling design, with first stage transects, to study the risk of dog parasitic infections in the city of Naples, Italy, during 2004–2005. This system focused on zoonotic parasitic diseases, including infections with *Trichuris, Isospora, Toxascaris, Ancylostoma* and *Toxocara*. However, the study apparently was driven by a research goal and not as an ongoing effort, thus, not strictly matching the definition of surveillance. Other initiatives have used existing hospital management systems as a secondary data source for monitoring diseases in companion animal populations. For example, Moore et al. (2005) used databases complied by Banfield, The Pet Hospital corporation in the United States to describe several diseases. Development of a disease surveillance system for

Disease report data collection

* All fields are required

1. Vet's Name: Prof Michael Ward

2. Date of the case presenting to the clinic: 23 ▾ November ▾ 2010 ▾ ▦

3. Animal's name:

4. Suburb that animal lives in:

5. Species:
   ○ Canine
   ○ Feline

6. Breed: Please Select ▾

7. Age: Years: ___   Months: ___   Weeks: ___

8. Animal's Sex:
   ○ Male
   ○ Female
   ○ Unknown

9. Neutered?
   ○ Yes
   ○ No

10. Was a litter infected?
    ○ Yes
    ○ No

11. Infection / Disease: Please Select ▾

12. How was the case diagnosed?

13. Vaccine(s) last administered: ○ Unvaccinated   ○ Vaccination Unknown
    Please select ▾   23 ▾ November ▾ 2010 ▾ ▦

14. What was the outcome of the case?
    ○ Animal recovered
    ○ Animal died
    ○ Animal was euthanased
    ○ Treatment ongoing
    ○ Animal tested positive but not clinically affected

    [Submit data] or Cancel

Fig. 1. Disease report data collection module, Disease Watchdog website (www.diseasewatchdog.org).

companion animal disease as a primary objective apparently has not been successfully undertaken previously.

The Blue Ribbon Panel convened on behalf of the U.S. White House Office of Science and Technology Policy in 2006 to discuss the potential utility and possible strategies for design and implementation of a national companion animal health surveillance system (Stone and Hautala, 2008) stressed the importance of consultation with
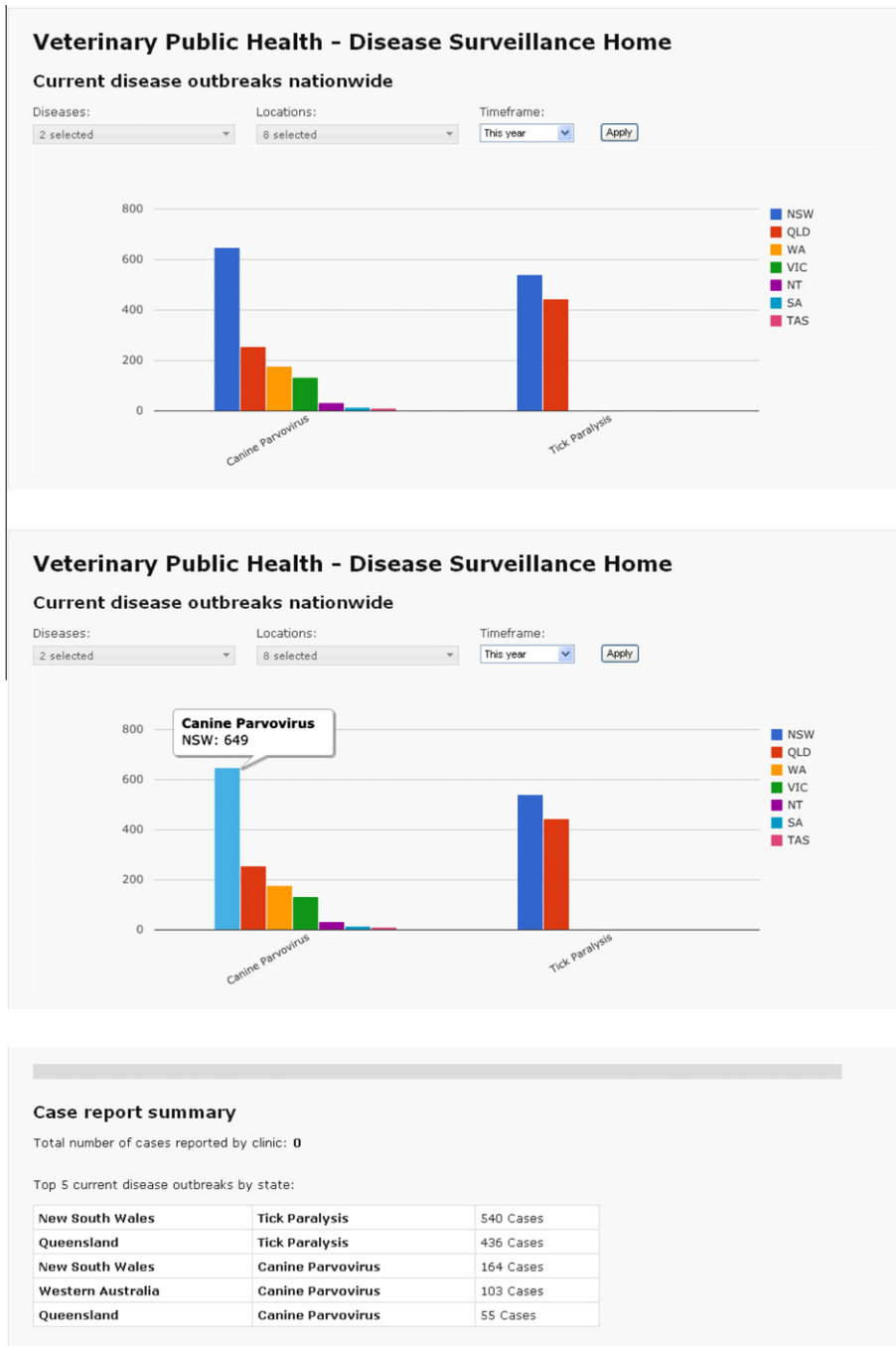
Fig. 2. Examples of the reports that can be generated and viewed on the Disease Watchdog website (www.diseasewatchdog.org).

end-users: "the type of information collected, the frequency with which it is collected, and the format in which it is disseminated should be determined in accordance with user goals". Disease WatchDog is unique in its flexibility and ability to be modified in response to suggestions by those who use the system. For example, the upgrade of the system in September 2010 included several features identified as important by end-users, such as graphing and displays capabilities, and the addition of new diseases such as tick paralysis.

The Blue Ribbon Panel also identified four fundamental principles relevant to the design of a companion animal surveillance system: syndromic versus disease-specific surveillance; the ability to leverage existing systems; predefined response protocols; and integration with other health surveillance systems. Syndromic surveillance involves collection of information on clinical syndromes – two or more characteristic clinical signs. Disease Watchdog is based on the diagnosis and reporting of specific disease, rather than syndromes. Expansion of Disease WatchDog to
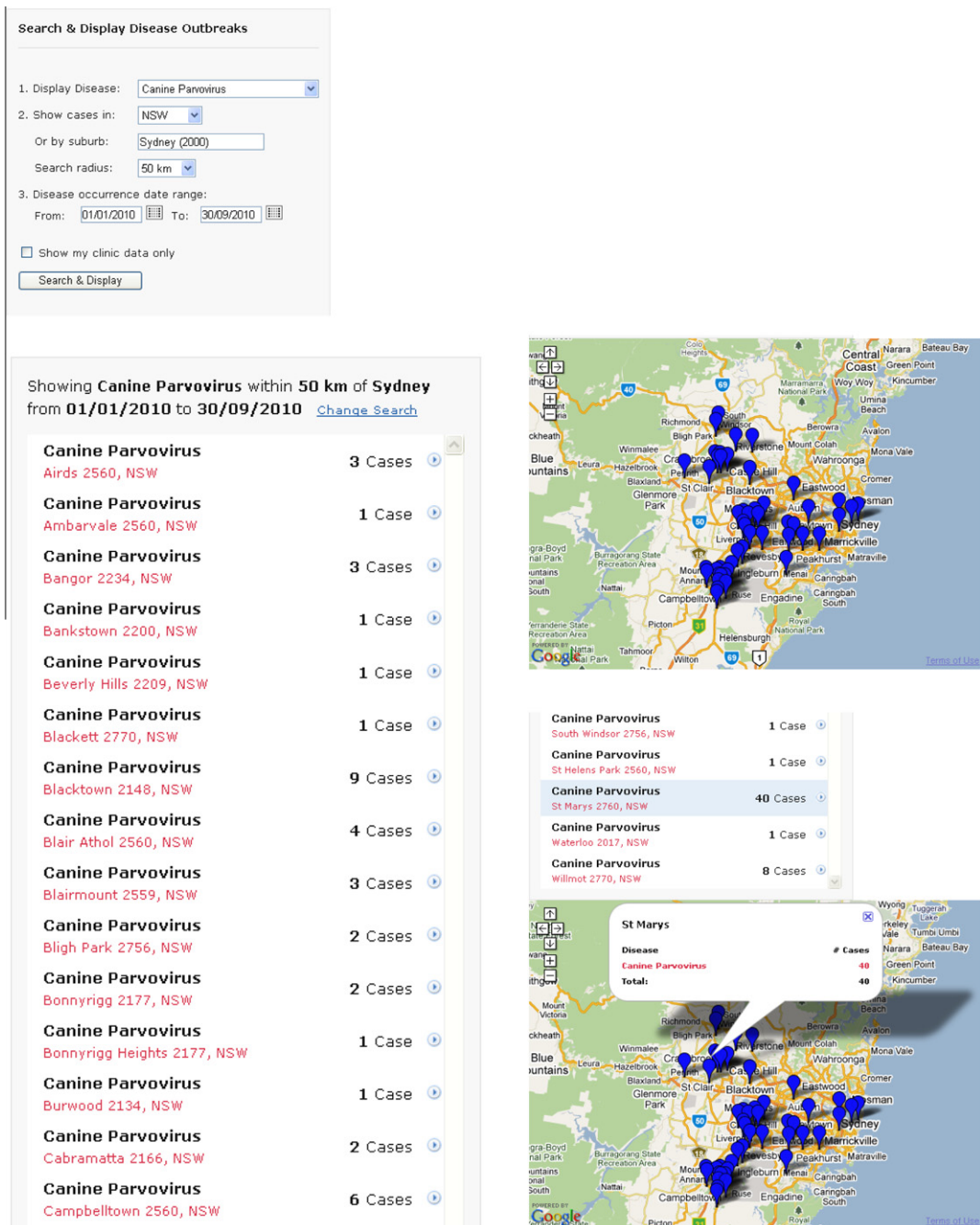
Fig. 3. An example of the spatial search capacity of Disease WatchDog, using canine parvovirus in New South Wales, Australia.

include syndromes (for example, vomiting and diarrhea) could be implemented with comparative ease. However, such a modification would need to be driven by the end-users, which are primarily veterinary practices. In the case of CPV, a substantial proportion (64%) of cases was diagnosed using the Snap ELISA. In this situation, reporting cases based on syndrome might not provide additional benefit to the end-user. In contrast, cases of tick paralysis are generally diagnosed based on clinical signs (for exam-

ple, between 1 and 30 September the 138 reported cases of tick paralysis were diagnosed based on clinical presentation (29%), tick found (70%) or tick crater only found (1%)). Tick paralysis was added to Disease WatchDog in September 2010 in response to requests from end-users of the system. For an applied surveillance system such as Disease WatchDog, the usefulness of syndromic surveillance needs to be assessed in partnership with the end-user.
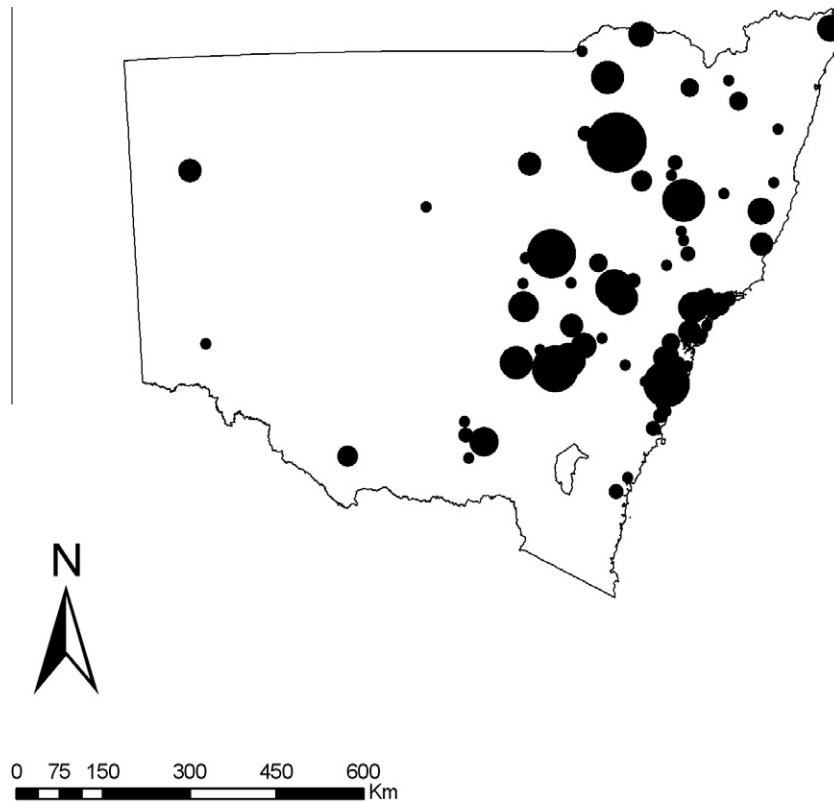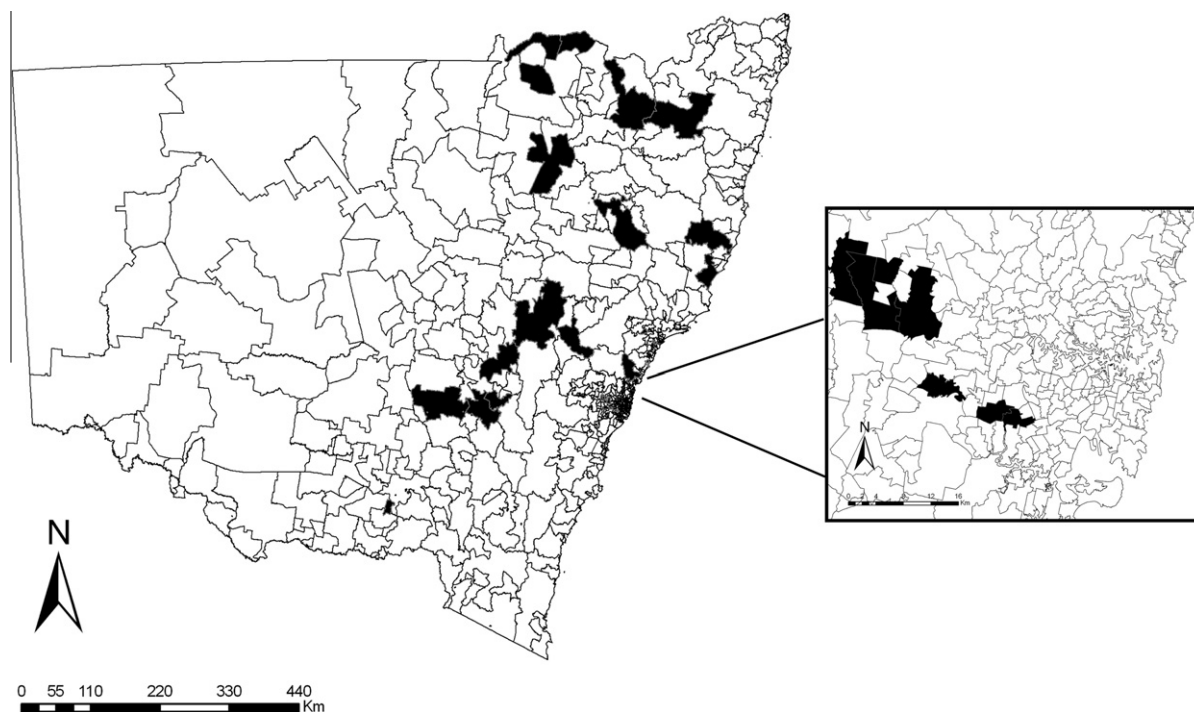
Fig. 4. Cases of canine parvovirus in postcodes in New South Wales, Australia reported within the Disease WatchDog surveillance system, January–September 2010. Symbols are proportional to the number of cases reported, ranging from 1 to 34 cases.

Acute CPV enteritis can reportedly occur in dogs of any breed, age, or sex. However, puppies between 6 weeks and 6 months of age appear to be more susceptible (Goddard and Leisewitz, 2010). In the current study the median (interquartile range) age of reported cases was 16 (8–24) months. This finding was unexpected, based on previous statements regarding the age pre-disposition for CPV. Of those cases with reported vaccination status, only 27% of cases were vaccinated. This might, in part, explain a higher age of cases than expected. However, the common belief amongst veterinarians that CPV is a disease of puppies may need revision, following further research using data generated by Disease WatchDog. Some breeds – mostly large breeds such as Rottweiler, Doberman Pinscher, Labrador retriever and German shepherd dog – have been reported to be more at risk for severe CPV enteritis (Goddard and Leisewitz, 2010). None of these breeds were commonly reported to be cases in the current study. However, the proportion of a breed in a population – and the proportion that are presented at veterinary clinics – needs to be taken into account before breed predisposition can be determined. Goddard and Leisewitz (2010) state that the risk of CPV in sexually intact males is twice that of sexually intact females. In the current study more reported cases were male than female, but the difference was small (56% versus 44%). Half of all cases were reported between 7 March and 18 June, which represents the autumn months. Generally CPV is considered to peak in summer

(Goddard and Leisewitz, 2010). As more data is accumulated in Disease WatchDog, a more accurate description of seasonality can be made. Many clusters of CPV were identified during the short 9-month study period in New South Wales. Such a spatial distribution of cases is likely to indicate that local factors are important, generating local epidemics. Follow-up studies, using larger datasets, might be able to identify some of these factors. Based on preliminary analysis, apparently vaccination practice is unlikely to explain most of these clusters.

There are three specific design elements for a companion animal surveillance system (Stone and Hautala, 2008): target population; data collection, analysis and standards; and mechanisms for dissemination of results. The system must have a clearly defined target population. This is necessary so that the disease frequency estimated can be referred to a defined population. In Disease WatchDog, the target population is comprised of veterinary practices that report disease cases. This is a subset (currently nearly one-third) of all practices in Australia, the reference population. 'All practices in Australia' is a well-defined population, since practices need to be licensed by the relevant state or territory authority where they operate. A current gap in Disease Watchdog is that the population of dogs and cats (and their demographics – such as age, breed and gender distributions) – is unknown. Such data – when available – is for specific locations only (Toribio et al., 2010). This information could potentially be collected

Fig. 5. The distribution of spatio–temporal clusters of cases of canine parvovirus reported in the Disease WatchDog surveillance system between January and September 2010 in New South Wales, Australia. Clusters were detected using the scan statistic permutation test, with spatial scanning windows up to 20 km radius and temporal scanning windows up to 28 days in length.

within the Disease WatchDog system, for example by having contributors annually describe their practice caseload during the previous 12 months, or by estimating the likely population at-risk based on the proportions of cases reported, and potentially informed by known covariates (for example human population size and socioeconomic status) within the practice area. Variable Disease Watch-Dog adoption proportions for different Australian States – currently ranging from 20% in Victoria to 40% in New South Wales – means that inferring the impact of disease in different areas needs to be done with caution.

A companion animal disease surveillance system should collect a comprehensive data set comprising both clinical and epidemiological data (Stone and Hautala, 2008). Disease WatchDog collects spatial information via the postcode of the owner's address. It is assumed that this is the area in which the animal has spent most time during the short period preceding disease diagnosis, and assumed to be the area that other animals are at risk of the same disease. The actual date of diagnosis is reported in Disease Watchdog. Diseases currently reported in this system can be diagnosed on the basis of clinical presentation, diagnostic test (including ELISA Snap, immunofluorescence, PCR) or other. Other information collected includes animal name, suburb, state, postcode, species and breed, age (years/months/weeks), sex, neuter status, whether a litter was affected and if so, the number of animals in the litter and the total number affected, case outcome (recovered, died, euthanized, treatment ongoing) and vaccination status and date. A unique case identification number is

generated by the system, and the case is linked to the clinic name and the veterinarian's name.

Finally, within a surveillance system, each user should define triggers for implementing responses and identify data that will support specific responses (Stone and Hautala, 2008). Within Disease WatchDog, the response to perceived clusters of disease rests with the end-user, the veterinary clinic. A feature of this system is the ability for practices to conduct spatial searches within their local area. This allows veterinarians and veterinary assistants to promote disease control and prevention based on empirical data. This might be one reason why the adoption of Disease WatchDog has been high during its first 9 months of operation.

Two tasks that could facilitate major advances in the surveillance of companion animal populations are standardization of data captured within such systems, and the development of a set of core analytical tools. A current barrier to disease surveillance is an inability to rapidly and validly integrate different surveillance systems. The barrier is usually a lack of consistency in the scale (spatial, temporal) at which data is recorded, a lack of standard case definitions (e.g. method of diagnosis, method of measurement) and differences in which auxiliary data is recorded (e.g. animal data such as age, gender, breed and population demographic data – the 'population at-risk'). Identifying key surveillance systems and key individuals, an agreement on standards that should be used could be reached. An analogy is the recent development of the REFLECT statement: methods and processes of creating reporting

guidelines for randomized control trials for livestock and food safety (O'Connor et al., 2010).

An array of analytical tools are available for detecting trends and clusters in disease surveillance data (for example, see Ward and Carpenter, 2000a,b; Ward, 2007). There is a lack of consistency regarding which tools should be applied routinely, and also a lack of knowledge of the performance of the different tools applied to different types of surveillance data. As above, agreement is needed in order to correctly evaluate the results of analysis of surveillance data. To our knowledge, results of the analysis of the spatial distribution of CPV cases have not been published in the peer-reviewed literature. A likely barrier is the lack of large, good quality surveillance datasets. Disease Watch-Dog fills that gap: in New South Wales alone, 552 cases were reported during just 9 months. Considering the lack of knowledge of spatial distribution of CPV and the lack of knowledge of the population at-risk within each post-code, we used the permutation model. The model does not require any assumptions to be made with respect to how the population at-risk is characterized. The only assumption is that the population at-risk remains relatively stabile during the study period. As more analyses are undertaken of the spatial distribution of diseases in pet populations, analytical approaches are likely to be refined.

5. Conclusion

During a short period of operation, Disease WatchDog has been adopted by nearly one-third of Australian veterinary clinics. Epidemiologic data, including location and date, are providing new insights into the distribution of diseases of dogs and cats in Australia. Ability of end users to produce disease maps is one likely explanation of its success to date.

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