

An investigation of methicillin-resistant *Staphylococcus aureus* colonization in people and pets in the same household with an infected person or infected pet

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Objective—To investigate the prevalence of concurrent methicillin-resistant *Staphylococcus aureus* (MRSA) colonization in people and pets in the same household with a person or pet with an MRSA infection and to compare MRSA isolates by use of molecular techniques.

Design—2 cross-sectional evaluations conducted concurrently.

Sample Population—24 dogs, 10 cats, and 56 humans in part 1 and 21 dogs, 4 cats, and 16 humans in part 2 of the study.

Procedures—In both parts of the study, nasal swab specimens were collected from humans and nasal and rectal swab specimens were collected from household pets. Selective culture for MRSA was performed, and isolates were typed via pulsed-field gel electrophoresis (PFGE) and *spa* typing. Households were defined as positive when MRSA was isolated from at least 1 person (part 1) or 1 pet (part 2).

Results—In part 1, 6 of 22 (27.3%) households were identified with MRSA colonization in a person. In these households, 10 of 56 (17.9%) humans, 2 of 24 (8.3%) dogs, and 1 of 10 (10%) cats were colonized with MRSA. In part 2, only 1 of 8 households was identified with MRSA colonization in a pet. Most MRSA isolates obtained from humans and pets in the same household were indistinguishable by use of PFGE.

Conclusions and Clinical Relevance—The high prevalence of concurrent MRSA colonization as well as identification of indistinguishable strains in humans and pet dogs and cats in the same household suggested that interspecies transmission of MRSA is possible. Longitudinal studies are required to identify factors associated with interspecies transmission. (*J Am Vet Med Assoc* 2009;235:540–543)

Methicillin-resistant *Staphylococcus aureus* is an important pathogen that has gained global attention. Originally found almost exclusively in humans, MRSA is increasingly being identified in dogs and cats with infections as well as healthy dogs and cats (ie, inapparent carriers). Currently, household pets frequently are considered and treated as family members.¹ This allows for close physical contact between humans and pets that may result in the transmission of bacteria,¹ including MRSA. This is a potential public health concern because MRSA from humans may be causing infections in pets, and pets may be sources of MRSA for human infection. Suspected transmission of MRSA between people and pets in households has been described,^{2–4} but the incidence of this phenomenon is unclear because these have typically been case reports or case series. Little information is available regarding the prevalence of concurrent MRSA colonization in humans and pets in the same household. Currently, the population prevalence of MRSA in humans (< 3%)^{5–9} and dogs (< 1%)^{10–12} in a community is relatively low. However, MRSA-

ABBREVIATIONS

| | |
|------|--|
| MRSA | Methicillin-resistant <i>Staphylococcus aureus</i> |
| PFGE | Pulsed-field gel electrophoresis |
| PVL | Panton-Valentine leukocidin |

colonized humans are at a higher risk of developing an MRSA infection^{13,14} and may be a potential source for transmission to others. Therefore, investigation of MRSA colonization is important to understanding and determining the epidemiologic characteristics of MRSA.

Because MRSA transmission between humans and pets has been reported, some physicians have instructed their patients to restrict contacts with pets or to even remove pets from certain households, despite a lack of evidence to suggest that this is a reasonable measure. An understanding of the dynamic of pet-human transmission of MRSA is required to provide objective information so that appropriate recommendations can be made to lessen the risk of transmission of MRSA between humans and pets.

To provide information on the potential role of household pets in MRSA colonization, 2 evaluations were conducted concurrently. The objective of part 1 of the study reported here was to determine the prevalence of MRSA colonization in humans and pet dogs and cats in households in which a pet was known to be infected with MRSA. The objective of part 2 was to determine the prevalence of MRSA coloniza-

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tion in humans and pets in households in which there were recurrent MRSA infections in humans. We hypothesized that MRSA strains from humans and pets in the same household would be indistinguishable at the molecular level.

Materials and Methods

Sample population—A convenience sample of households from Canada and the United States was enrolled in 2 concurrent parts of the study. The inclusion criterion for part 1 was the presence of a household pet in which an MRSA infection had been diagnosed during the past 30 days. For part 2, the inclusion criterion was a household that had ≥ 2 MRSA infections in 1 or more persons within the past year. In these studies, pet referred to a dog or cat.

Households in Canada were recruited on the basis of identification of MRSA at private diagnostic laboratories, whereas US households were recruited by participating veterinarians in California and Massachusetts. In addition, households were recruited from those who made telephone calls to the investigators to obtain advice regarding management of pets with MRSA. Households were defined as positive when MRSA was isolated from at least 1 person (in part 1) or 1 pet (in part 2). All participants were required to complete consent forms. The study was approved by the University of Guelph Research Ethics Board and Animal Care Committee.

Procedures—For both parts of the study, nasal swab specimens were collected from consenting humans and nasal and rectal swab specimens were collected from all household pets. Selective enrichment culture was used. Swab specimens were inoculated into 2 mL of enrichment broth containing tryptone (10 g/L), sodium chloride (75 g/L), mannitol (10 g/L), and yeast extract (2.5 g/L) and incubated at 35°C for 24 hours. Following incubation, a 5- μ L aliquot of broth was inoculated onto selective MRSA culture agar^a and incubated aerobically at 35°C for 24 to 48 hours. Isolates were identified as *S aureus* on the basis of results for a Gram stain, catalase test, tube coagulase test, and *S aureus* latex agglutination assay.^b Methicillin resistance was confirmed by testing for the penicillin-bind-

ing protein 2a.^c Isolates were tested for genes encoding the production of the PVL toxin by use of real-time PCR assay, as described elsewhere.¹⁵

All isolates identified as MRSA were typed via PFGE¹⁶ and *spa* typing.¹⁷ For PFGE, large DNA fragments were separated on agarose gels and resulting band profiles were compared among isolates.¹⁸ Interpretation of the relatedness of the band profiles was based on the Tenover criteria.¹⁸ The *spa* typing, which is based on variation in the tandem repeat region of the gene encoding protein A, results in a profile derived from the sequence of the repeats.¹⁹ Sequences were assigned *spa* types by use of Web-based software.^{20,d}

Results

Part 1—Twenty-two households (19 in the United States and 3 in Canada) in which an MRSA infection was identified in a pet were enrolled. The majority (19/22 [86.4%]) of pets identified with the MRSA infection were dogs. In these 19 dogs, MRSA was isolated from the skin (n = 7 dogs), a surgical site (5), wounds (4), a nasal sinus (2), and a tracheotomy tube (1). For the 3 cats identified with an MRSA infection, MRSA was isolated from the urine in 2 cats and from the skin of the other cat. Seven dogs and 1 cat had a history of recurring infections. In this subset of dogs, recurring infections involved the skin (n = 4 dogs), a wound (1), a surgical site (1), and a nasal sinus (1), whereas the cat had a recurring urinary tract infection attributable to MRSA. Only 1 dog was identified with an invasive MRSA infection that resulted in amputation of a hind limb.

One or more humans living with a pet with an MRSA infection were identified as colonized with MRSA in 6 of 22 (27.3%) households. Overall, in these households, 10 of 56 (17.9%) humans, 2 of 24 (8.3%) dogs, and 1 of 10 (10%) cats were colonized with MRSA (not including the pet with the clinical infection).

Part 2—Eight households (7 in the United States and 1 in Canada) in which humans had recurrent MRSA infections were enrolled. In these households, the index-case humans had MRSA isolated from dermal abscesses.

Table 1—The *spa* and PFGE types for MRSA isolates obtained from humans and pets in the same household.

| Part of the study* | Household | Source of MRSA isolate | <i>spa</i> sequence | <i>spa</i> type† | PFGE type |
|--------------------|-----------|------------------------|----------------------------------|------------------|-----------|
| 1 | 1 | Human | Y1-H1-G1-F1-M1-B1-Q1-B1-L1-O1 | 1/t008 | USA300 |
| | | Human | Y1-H1-G1-F1-M1-B1-Q1-B1-L1-O1 | 1/t008 | USA300 |
| | | Human | Y1-H1-G1-F1-M1-B1-Q1-B1-L1-O1 | 1/t008 | USA300 |
| | | Dog‡ | Y1-H1-G1-F1-M1-B1-Q1-B1-L1-O1 | 1/t008 | USA300 |
| 1 | 2 | Human | T1-J1-M1-B1-M1-D1-M1-G1-K1 | 23/t548 | USA100 |
| | | Human | T1-J1-M1-B1-M1-D1-M1-G1-K1 | 23/t548 | USA100 |
| | | Cat‡ | T1-J1-M1-B1-M1-D1-M1-G1-K1 | 23/t548 | USA100 |
| 1 | 3 | Human | T1-J1-M1-B1-M1-D1-M1-G1-K1 | 23/t548 | USA100 |
| | | Cat‡ | T1-J1-M1-B1-M1-D1-M1-G1-K1 | 23/t548 | USA100 |
| | | Cat | T1-J1-M1-B1-M1-D1-M1-G1-K1 | 23/t548 | USA100 |
| 1 | 4 | Human | T1-J1-M1-B1-M1-D1-M1-G1-M1-K1-K1 | 14/t214 | USA100 |
| | | Human | T1-M1-B1-M1-D1-M1-G1-M1-K1 | 230/t010 | USA100 |
| | | Dog‡ | T1-J1-M1-B1-M1-D1-M1-G1-M1-K1 | 2/t002 | USA100 |
| | | Dog | T1-J1-M1-B1-M1-D1-M1-G1-M1-K1-K1 | 14/t214 | USA100 |
| 2 | 5 | Human | Y1-H1-G1-F1-M1-B1-Q1-B1-L1-O1 | 1/t008 | USA300 |
| | | Dog | Y1-H1-G1-F1-M1-B1-Q1-B1-L1-O1 | 1/t008 | USA300 |
| | | Dog | Y1-H1-G1-F1-M1-B1-Q1-B1-L1-O1 | 1/t008 | USA300 |

*For 2 households in part 1, the MRSA isolate was not obtained from the pet with the clinical MRSA infection. †Two different *spa* types were assigned by use of Web-based software packages. ‡Pet with the clinical MRSA infection.

Colonization with MRSA was identified in animals from only 1 household. In that household, 1 of 3 humans and 2 of 2 dogs were colonized with MRSA. In 1 other household, a person colonized with MRSA was identified, but no pets were colonized with MRSA. Overall, the prevalence of colonization in households with recurrent MRSA infections (not including the person with recurrent MRSA infections) was 1 of 16 (6.3%) humans, 2 of 21 (9.5%) dogs, and 0 of 4 (0%) cats.

PFGE—For both parts of the study, in households in which MRSA was isolated concurrently from humans and pets, all MRSA isolates from humans and animals were identified by use of PFGE as belonging to the same strain (Table 1). On the basis of results of PFGE, only 2 MRSA strains were identified: human epidemic clones USA100 (a PVL-negative strain) and USA300 (a PVL-positive strain). In 4 households, isolates from humans and animals were indistinguishable by use of PFGE. In those households, *spa* types were identical. Two households had the PVL-negative USA100 clone, whereas 2 had the PVL-positive USA300 clone. In the fifth household, 3 different but related PFGE types (as determined on the basis of banding profiles) belonging to the USA100 clone were identified. These profiles were considered closely related by use of the Tenover criteria.¹⁸ In addition, 3 *spa* types were identified in that household.

Discussion

To our knowledge, the study reported here was the first in which investigators have attempted to determine the prevalence of MRSA colonization in people and pets in the same household with a person or pet with an MRSA infection. Although we intended to use control groups, difficulties were encountered obtaining geographically matched control households.

The high prevalence of MRSA in people and pets in known infected households as well as the identification of indistinguishable strains in humans and domestic animals suggested that there was interspecies transmission of MRSA, although the direction of transmission is unknown. However, it is likely that humans were the ultimate source of MRSA in most households because most pets have limited contact with other animals. It is also possible that some people with infected pets were colonized before the pet developed the infection and could have been the source of infection for the animal. Therefore, although the high rate of MRSA colonization in humans could have reflected transmission from infected pets, it also could have indicated that identification of an MRSA infection in a pet was associated with the owner being previously colonized and was essentially a proxy for previous human colonization in the household.

For parts 1 and 2 of the study, households were eligible for inclusion on the basis of the specific time frame during which MRSA infection was diagnosed (30 days and 1 year, respectively). These time frames were selected on the basis of reports of the duration of MRSA colonization. In dogs and cats, little information is available regarding the duration of MRSA colonization; however, < 30 days has been reported.²¹ In humans, persistent (up to 4 years) MRSA colonization has been described.²² It may be possible that the difference in the diagnosis pe-

riod for MRSA plays a part in concurrent colonization in humans and pets in the same household; therefore, this factor should be considered for future studies.

In the study reported here, the 2 MRSA strains identified in humans and animals are common strains in humans, with the USA100 strain being the most predominant strain in humans in Canada and the United States.^{23,24} This strain has classically been designated as a hospital-associated strain in humans and the most common cause of hospital-associated MRSA infections in North America.^{23,25} However, USA100 is also a common cause of community-associated infections and is the strain most commonly found in colonized people in the United States.²⁴ Furthermore, this strain has also been frequently identified in dogs and cats in North America.^{21,26}

The USA300 strain is typically, but not exclusively, a community-associated strain in humans and is a leading cause of skin and soft tissue infections in humans in the United States.²⁷ However, despite its role in community-associated infections, USA300 is less frequently found in colonized humans in the general population than USA100. The USA300 strain has been identified in animals,^{2,28} and identification of this strain in the study reported here was not surprising. The results of our study (namely, finding common human epidemic clones in dogs and cats) and the isolation of indistinguishable or closely related strains from humans and their pets provided further support to the hypothesis that MRSA in dogs and cats is closely related to MRSA in humans and that there can be interspecies transmission.

Pulsed-field gel electrophoresis and *spa* typing are 2 widely used methods that provide complementary information. Pulsed-field gel electrophoresis allows for classification of isolates into epidemic clones, which are designated USA clones in the United States. The *spa* typing is a more objective sequence-based method that can be more discriminatory. The identification of 3 strains in 1 household on the basis of *spa* typing indicated this increase in discriminatory power. Evaluation of the *spa* repeat patterns of the 3 strains in this household indicated that they were closely related strains that differed by only 1 or 2 repeats. This is a relatively minor genetic modification that can develop over time. Further investigation of this household revealed that the dog with the clinical MRSA infection had several intermittent MRSA infections at a surgical site during the preceding 13 months. Therefore, it is possible that the original MRSA strain was circulating among humans and pets in this household and over time had undergone a mutation or recombination event that subsequently resulted in changes in *spa* type.

This study indicated that owners of pets with MRSA infections may be at a higher risk for MRSA colonization and perhaps subsequent infection. On the basis of the study design, information regarding household contact, pet management, and household hygiene practices was not obtained, so an evaluation of risk factors for concurrent colonization of animals and humans was not performed. This is an important area that requires further study because household management and infection control practices may be a means of reducing the risk of transmission of MRSA between pets and humans. Although recommendations pertaining to pets have been made for management of community-associated MRSA in humans,²⁹ evidence-based

guidelines are currently lacking. Furthermore, considering there are increasing calls to screen or isolate high-risk individuals at the time of admission to hospitals, owners of pets with MRSA infections could certainly be considered a potentially high-risk group. If screening of these individuals was ever desired, it would require querying patients about pet ownership and pet health, which makes sense given the one-medicine concept.

In contrast, the low prevalence of colonization of people and pets in households with recurrent infections in humans of the present study was surprising, considering the attention that has been paid to pets as a possible source of recurrent infection in humans.^{2,3} Although the small sample size must be considered, the rarity of MRSA colonization in pets in these households may suggest that pets do not play a major role in recurrent MRSA infections in households.

Concerns regarding the role of pets in MRSA transmission can also have a major effect on the human-animal bond, and the authors have dealt with many situations in which it has been recommended that pets be removed from the household or euthanatized, even without verification of concurrent colonization, let alone identification of pets as the source of infection. Although the potential role of pets in MRSA infections in humans should not be dismissed, it is important that an evidence-based approach be taken and that further studies be performed in this area. Longitudinal studies are needed to follow up on studies such as the one reported here to clearly identify the role of pets in MRSA colonization and infection in humans as well as to identify risk factors associated with interspecies transmission so that infection control measures can be objectively designed and evaluated. In addition, appropriate recommendations can be made to lessen the risk of transmission of MRSA between humans and domestic animals, reduce the risk of MRSA infection in owners whose pets are infected, and ensure that pets are not inappropriately removed or euthanatized.

- a. BBL CHROMagar MRSA, Becton-Dickinson Co, Sparks, Md.
- b. MRSA latex agglutination, Oxoid Ltd, Basingstoke, Hants, England.
- c. Pastorex Staph Plus kit, Bio-Rad Laboratories Ltd, Mississauga, ON, Canada.
- d. eGenomics, eGenomics Inc, New York, NY. Available at: tools.egenomics.com. Accessed Jan, 8, 2009.

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