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EDITORIAL

Methicillin-resistant *Staphylococcus aureus*—the new zoonosis

The etiologic agents of many emerging infectious diseases are thought to originate in animal reservoirs¹ and, after becoming established in the human population, to spread by direct human-to-human contact. The crossing of species barriers is historically credited with some of the most devastating and unconventional outbreaks, and pandemic influenza, Creutzfeldt–Jacob disease, West Nile virus, severe acute respiratory syndrome (SARS), and HIV represent some of the notable examples still vivid in public memory.^{1–4}

One of the major public health crises we are currently witnessing is the one linked to methicillin-resistant *Staphylococcus aureus* (MRSA). While MRSA is easily transmitted among humans by direct skin-to-skin contact, by contact with infected biological material or contaminated personal objects, or through the airborne route, food-initiated outbreaks are increasingly implicated in human infections.⁵ Several reports reveal that this pathogen can be isolated from cattle, pig, and chicken samples in slaughterhouses⁶ and from food samples randomly tested in supermarkets.^{7,8}

At the same time, a thought-provoking phenomenon is currently unraveling. Although MRSA has historically been associated with healthcare and has become known as hospital-associated MRSA, it increasingly emerges without relationship to healthcare, in patients without apparent risk factors, as a distinct epidemiological, microbiological, and clinical entity known as community-associated MRSA.^{9,10} The prevalence of community-associated MRSA, as revealed by a recent study conducted on 2636 patients with skin and skin structure *S. aureus* infections, increased from 9% in 2004 to 16% in 2005 and 21% in 2006.¹¹ At the same time, growing epidemiological and genetic evidence points towards MRSA transmission across species, and unveils a previously unknown face that this microorganism is assuming, as an emerging zoonotic pathogen. The surge in community-associated MRSA, at a time when reports of animal-to-human transmission are increasing, might not be merely coincidental,^{12,13} and according to a recent study conducted in the Netherlands, MRSA that entered from an animal reservoir into the human population is now responsible for over 20% of the strains isolated.¹⁴

Findings that have accumulated in recent years make it necessary to define three additional patient groups at high

risk for zoonotic MRSA: individuals in contact with farm animals, contacts of household pets, and veterinarian staff.

In 2003, a new non-typeable MRSA strain was identified in the Netherlands and linked to animal farming; subsequent studies supported the possibility of farm workers becoming infected from farm animals.^{14–19} Non-typeability with Sma I by pulsed field gel electrophoresis has emerged over the years as a shared characteristic of MRSA strains originating in pigs,²⁰ and currently over 39% of slaughterhouse pigs in the Netherlands are estimated to be positive for non-typeable MRSA isolates.²¹ In the Netherlands, 23% of pig farmers¹⁹ and 32% of farm workers exposed to pigs and veal calves¹⁷ were found to be colonized with MRSA, rates that exceed 760 and 1000 times, respectively, those seen in the general population, and that outweigh those reported for any other population described so far. A similar study conducted among pig farmers in North America found colonization rates of 20%,²² supporting the possibility that pigs represent reservoirs for human MRSA infections irrespective of the geographic area. Moreover, it is important to note that MRSA strains of animal origin have been isolated from people lacking previous documented direct animal contacts, supporting the possibility that direct human-to-human transmission occurs subsequent to one person's colonization/infection. After a female patient was diagnosed with MRSA mastitis,¹⁸ her farmer husband, their baby girl, and three co-workers from the same farm were found to be colonized, as were eight out of 10 randomly chosen pigs. The strain isolated from the baby was genetically identical to the one isolated from her parents,¹⁸ despite her lack of direct contact with farm animals. In another example, MRSA was found in the screening cultures of a 6-month-old girl before thoracic surgery, and subsequently her parents were found to be colonized as well, presumably from a pig that the family raised on the farm.¹⁹

MRSA transmission also occurs, in both directions, between humans and household animals. Owners have been shown to infect pets, and these pets may subsequently act as reservoirs to infect and/or re-infect susceptible hosts.¹³ Several studies underscore the possibility of pet dogs colonizing household contacts.^{13,23–25} A diabetic patient and his wife exhibited recurrent MRSA leg infections and cellulitis, respectively, and both were cured only after their dog was

treated as well.²⁵ Remarkably, MRSA was isolated from a kitten for up to 9 months after the initial diagnosis, an alarming finding that points towards the possibility of prolonged colonization of pets and the subsequent increased risk of transmission to household members.¹³

Veterinary clinic personnel represent the third group at risk for MRSA colonization and/or infection. Very similar MRSA strains have been isolated from animals and animal care staff.²⁶ As recently pointed out,²⁷ MRSA carriage is significantly higher (3.9% vs. 0.7%) among veterinary practitioners than among individuals without professional exposure to animals. The screening of 80 veterinary students and 99 veterinarians in the Netherlands²⁸ revealed a 4.6% prevalence of MRSA carriage in this group, while other surveys performed on international veterinary conference attendees have reported MRSA colonization rates of 6.5%,²⁹ 10.1%,³⁰ and 12.5%,³¹ values that exceed, by far, MRSA prevalence in the general population, estimated to range between 0.03% and 3%.^{32–34} Professionals with frequent animal contact (daily or 5 hours/week) were found to have the highest risk for colonization. However, as revealed by a recent study on personnel working with neonatal horses, contacts as short as 4 hours are sufficient for the infection of veterinary personnel.¹² These findings have prompted the suggestion that veterinary personnel, when managing skin and skin-related soft tissue MRSA infections, should always consider previous contacts with animals.¹²

In the context of these findings, the defining of additional groups at high risk for MRSA colonization and infection emerges as an urgent task. Recent hospitalizations, outpatient visits, nursing home admissions, antibiotic exposure, chronic illness, and injection drug use are some of the most important MRSA risk factors.^{34,35} However, maintaining a high index of suspicion in animal farmers and their families, pet owners, and professionals involved in animal care is essential, particularly when no apparent risk factors can be identified or when infections recur despite initial successful treatment. Moreover, besides the medical aspect, it is important to reflect on the broader public health perspective. Zoonotic colonization of these high-risk groups can provide the initial MRSA port of entry into the human population, facilitating subsequent direct human-to-human transmission—an alarming scenario, especially if we recall the H5N1 influenza virus, for which human-to-human transmission was proposed to represent the last barrier needed to unleash a pandemic.³⁶

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