Importance

*Staphylococcus aureus* is an opportunistic pathogen often carried asymptomatically on the human body. Methicillin-resistant *S. aureus* (MRSA) strains have acquired a gene that makes them resistant to all beta-lactam antibiotics. Hospital-associated strains of this organism are serious nosocomial pathogens that have become resistant to most common antibiotics, and treatment can be challenging. Community-associated MRSA strains occur in people who have not been hospitalized or recently had invasive procedures. They first appeared in high-risk populations (e.g., intravenous drug users, people with chronic illnesses), but are now found even in healthy children. Until recently, community-associated strains were susceptible to many antibiotics other than beta-lactams; however, resistance seems to be increasing, and multiple antibiotic resistant strains have started to emerge. Human-adapted MRSA can be transmitted to animals in close contact, which can sometimes act as carriers and re-infect people.

Animal-adapted MRSA strains also exist. The pig-associated lineage MRSA CC398 is a particular concern. This lineage, which apparently emerged between 2003 and 2005, has spread widely among swine in some locations. Colonization with CC398 has also been reported in other species, including veal calves and poultry. Asymptomatic carriage is common among people who work with colonized swine or other livestock, and these organisms can cause opportunistic infections. Other MRSA strains can also affect animals. Outbreaks in horses suggest that MRSA might be an emerging problem in this species. Dogs and cats seem to be infected infrequently, and mainly by human-adapted strains; however, carriage rates can be higher during outbreaks in veterinary hospitals and other facilities. While colonization of pets is often transient, it might contribute to maintaining MRSA within a household or facility.

Etiology

*Staphylococcus aureus* is a Gram positive, coagulase positive coccus in the family *Staphylococcaceae*. Methicillin-resistant *S. aureus* strains have acquired the mecA gene, which is carried on a large mobile genetic element called the staphylococcal chromosomal cassette mec (SCCmec). This gene codes for a penicillin binding protein, PBP2a, which interferes with the effects of beta lactam antibiotics (e.g., penicillins and cephalosporins) on cell walls. It confers virtually complete resistance to all beta-lactam antibiotics including the semi-synthetic penicillins.

Acquisition of mecA seems to have occurred independently in a number of *S. aureus* strains. Some clonal lineages of *S. aureus* have a tendency to colonize specific species, and may be adapted to either humans or animals. Other lineages (“extended host spectrum genotypes”) are less host-specific, and can infect a wide variety of species. Some MRSA strains, called epidemic strains, are more prevalent and tend to spread within or between hospitals and countries. Other “sporadic” strains are isolated less frequently and do not usually spread widely. There are also MRSA strains that produce various exotoxins (e.g., toxic shock syndrome toxin 1, exfoliative toxins A or B, and enterotoxins) associated with specific syndromes, such as toxic shock syndrome. Community-associated MRSA strains that express a toxin called Panton-Valentine leucocidin (PVL) have been linked to skin and soft tissue infections and severe necrotizing pneumonia. It is possible that PVL are associated with increased virulence in general, although this remains to be proven.

Phenotypic methicillin resistance and/or the mecA gene has been reported occasionally in various animal-adapted *Staphylococcus* species. Some of these organisms can cause zoonotic infections or colonize people asymptomatically. There are also concerns that they may transfer mecA to human-adapted staphylococci.

Naming conventions for *S. aureus* strains

There are at least three different genetic techniques currently used for the classification of *S. aureus* strains, including pulsed-field gel electrophoresis (PFGE), multilocus sequence typing (MLST), and DNA sequencing of the X region of the protein A gene (spa typing). Additional methods were used in the past. Consequently,
a single *S. aureus* isolate can have more than one valid name, depending on the test used for typing. Examples of strain names are USA100, CMRSA1 or EMRSA1, based on PFGE typing, ST followed by a number (e.g., ST398) based on MLST typing, or “t” followed by a number (e.g., t011) in spa typing. MRSA are also grouped, by MLST, into clonal complexes (e.g., CC398), which contain genetically related ST types. Naming conventions are complex, and strains given a single name in one system are sometimes separated into more than one strain in another system. Although names such as ST9 or CC398 are used for both methicillin-resistant and methicillin-susceptible *S. aureus* of that genetic type, the isolates referred to in this factsheet are all MRSA unless otherwise noted.

**Species Affected**

Colonization or infection with MRSA has been reported in many species including domesticated ruminants, pigs, horses, dogs, cats, rabbits, rodents, captive marine mammals, a captive elephant, a bat, birds (including poultry, pigeons and psittacine birds) and turtles.

Pigs seem to be true reservoir hosts for MRSA CC398, which is also called “non-typeable MRSA” (NT-MRSA) because most isolates cannot be typed by PFGE (although they can be typed by other methods), or livestock-associated MRSA (LA-MRSA). CC398 does not seem to be particularly host specific, and it has been detected in other species including horses, cattle, poultry and dogs, as well as rats living on pig farms. Other strains may be common among pigs in some areas (e.g., CMRSA2 [EMRSA3] in Canada, or ST9 in parts of Asia). In cattle, many MRSA strains that cause mastitis seem to be of human origin, although bovine-associated strains have been identified. Poultry infected with either CC398 or ST9 have been found in Europe. MRSA strains in horses are varied and their origin is largely unknown. Many of the common strains in this species (e.g., CMRSA5 [USA500; MRSA ST8 SCCmecIV]) belong to older human lineages that were common in the past, but have been superceded by other strains, or to less common groups. Equine-adapted strains may exist, and may be spreading in horse populations. Cats and dogs seem to be colonized only sporadically, mainly by human hospital-associated or community-associated strains. Most infections in these species are thought to be acquired from people, and carriage is often transient. There is little information about MRSA in exotic animals. In case reports, humans seemed to be the source of the organism for an elephant calf with skin disease, and for captive dolphins and walruses at a marine park.

**Zoonotic potential**

A number of MRSA strains predominantly colonize people and circulate in human populations. They include the common hospital-associated clones CC5, CC8, CC22, CC30 and CC45, and additional community-associated strains. There is evidence that these organisms can be transferred to animals, and most likely re-transmitted from this source to humans. People can also be infected or colonized with MRSA clonal complexes maintained in animals, such as CC398. How long such colonization persists, in the absence of continued contact with the animal, is still uncertain.

**Geographic Distribution**

MRSA can be found worldwide, although the prevalence varies between regions. CC398 is the predominant MRSA among pigs in Europe, but it has also been recognized in North America and Singapore. ST9 appears to be the prevalent MRSA strain among pigs in China, Hong Kong and Malaysia, and CC398 may be uncommon or absent in these regions. The most common strains in dogs and cats are those found in humans, which differ between geographic regions. Equine MRSA isolates also appear to vary with the location.

**Transmission**

**Humans**

In humans, *S. aureus* is an opportunistic pathogen. Both methicillin-sensitive and methicillin-resistant strains can be found as normal commensals on the skin (especially the axillae and perineum), the nasopharynx and anterior nares of some of the population. Most people who develop symptomatic infections with hospital-associated MRSA carry the organism in the nares, but community-associated MRSA can colonize sites other than the nares, and clinical cases often occur in patients who are not colonized. Colonization with *S. aureus* can occur any time after birth, and carriage may be transient or persistent.

MRSA are usually transmitted by direct contact, often via the hands, with colonized or infected people. Humans remain infectious as long as the carrier state persists or the clinical lesions remain active. MRSA can also be disseminated on fomites (including food that has been contaminated by human carriers) and in aerosols. *S. aureus* (and presumably MRSA) can be transmitted from the mother to her infant during delivery.

Person-to-person spread of the pig-adapted MRSA strain CC398 seems to be infrequent and limited, and to occur mainly within families or in hospitals and institutions. However, a recent outbreak in a hospital in the Netherlands suggests that more extensive person-to-person transmission can be seen under some conditions. People can also transmit CC398 to animals such as dogs.

**Animals**

Asymptomatic colonization with MRSA, including both nasal and rectal carriage, has been reported in animals. The organisms can colonize more than one site. Carrier animals may serve as reservoirs for disease in themselves, and they may transmit MRSA to other animals or people. Infection or colonization has been observed in people after as little as 4 hours of close contact with a sick, MRSA colonized foal.
Methicillin Resistant Staphylococcus aureus

Some MRSA strains, such as CC398, are readily transmitted within the host species to which they are adapted. The transmission of human-adapted MRSA lineages between animals is poorly understood. One study conducted at a canine rescue facility suggested that these strains might not be transmitted readily between healthy dogs. In a few case reports, family pets seem to have acted as one reservoir for the bacteria, and decolonization of humans was unsuccessful when carriage in these animals was not addressed. The frequency with which this occurs is still poorly understood.

Environmental sources and food products

*S. aureus* are reported to remain viable for 46 hours on glass, 17 hours in sunlight, and less than 7 days on floors under laboratory conditions. Environmental contamination with MRSA has been reported in some veterinary practices, even at times when MRSA patients were not detected. On pig farms, these organisms have been found in various samples, such as dust, and possibly even in air. In abattoirs that slaughter CC398 carrier pigs, MRSA could be detected in a number of areas by the end of the day, but only limited locations were still contaminated by the next morning.

Both animal-associated and human-associated MRSA strains have been found in meat. MRSA can also occur in raw milk and cheese. *S. aureus* is not ordinarily invasive when eaten, except under rare and unusual circumstances, and these organisms are mainly of concern in contributing to carriage or infection by direct contact.

Disinfection

*S. aureus* is susceptible to various disinfectants including sodium hypochlorite, alcohols, quaternary ammonium compounds, iodophors, phenolics, glutaraldehyde, formaldehyde, and a combination of iodine and alcohol. This organism can also be destroyed by moist heat (121°C for a minimum of 15 minutes) or dry heat (160-170°C for at least 1 hour).

Infections in Animals

Incubation Period

The incubation period varies with the syndrome. Animals can be colonized for prolonged periods without developing clinical signs.

Clinical Signs

Infection with MRSA results in the same syndromes as *S. aureus*, which can cause a wide variety of suppurative infections. MRSA has been specifically isolated from various skin and wound infections including abscesses, dermatitis including severe pyoderma, exudative dermatitis in pigs, postoperative wound infections, fistulas, and intravenous catheter or surgical implant infections. The presence of suture material or orthopedic implants seems to be linked to persistent infections in dogs and cats. MRSA has also been found in other conditions including pneumonia, rhinitis, sinusitis, otitis, bacteremia, septic arthritis, osteomyelitis, omphalophlebitis, metritis, mastitis (including gangrenous mastitis) and urinary tract infections. Both *Bordetella bronchiseptica* and MRSA were isolated from the nasal and oropharyngeal tract of puppies after an outbreak of fatal respiratory disease; the role of MRSA in the outbreak was uncertain.

Post Mortem Lesions

The post-mortem lesions of MRSA infections are those seen with any purulent bacterial infection, and vary with the organ system or tissue involved.

Diagnostic Tests

Infection with MRSA, including colonization, can be diagnosed by culture and identification of the organism. MRSA can colonize more than one site, and in many species including dogs and cats, the best sampling site to detect carriers is uncertain. Nasal and rectal sampling should both be done whenever possible. One study reported that nasal swabs detected most colonized pigs, but some animals carried MRSA in both locations, and a few carrier pigs (all weanlings) could only be found using rectal swabs. *S. aureus* grows on a number of media. On blood agar, colonies are usually beta-hemolytic. Enrichment media, as well as selective plates for MRSA, are available. On microscopic examination, *S. aureus* is a Gram positive, non-spore forming coccus, which may be found singly, in pairs, in short chains or in irregular clusters. Biochemical tests such as the coagulase test are used to differentiate it from other staphylococci. *S. aureus* can also be identified with the API Staph Ident system.

If *S. aureus* is isolated from an infection, genetic testing or antibiotic susceptibility testing can identify methicillin resistant strains. The presence of the mecA gene defines MRSA, and tests to detect this gene, such as PCR, are the gold standard for identification. A latex agglutination test can detect PBP2a, the product of mecA. Phenotypic antibiotic susceptibility tests (e.g., disk diffusion or MIC determination) can also be used to identify MRSA, but have some drawbacks compared to detecting mecA or PBP2a. Methicillin-susceptible and resistant subpopulations can coexist in vitro; although the entire colony carries the resistance genes, only a small number of bacteria may express resistance in culture. The expression of resistance in phenotypic tests can also vary with growth conditions such as temperature. In addition, some susceptibility tests can overestimate methicillin resistance; isolates that do not carry mecA (and thus, are not MRSA) can appear to be phenotypically resistant to methicillin.

MRSA clones or strains can be identified with molecular tests such as PFGE, MLST, SCCmec typing, spa typing and other assays. This is usually done mainly for epidemiological purposes, such as tracing outbreaks. A combination of methods may be needed to identify a strain.
Methicillin Resistant *Staphylococcus aureus*

**Treatment**

Antibiotics, topical treatments and other measures have been used successfully to treat clinical cases. In some cases, surgical implants were also removed. Antibiotic therapy should be based on susceptibility testing; however, all MRSA strains are considered to be resistant to penicillins, cephalosporins, cephems and other β-lactam antibiotics, regardless of susceptibility testing results. Most CC398 MRSA are resistant to tetracyclines, and many are also resistant to trimethoprim. Susceptibility to fluoroquinolones and resistance to tetracycline seems to be typical of the epidemic MRSA strain CMRSA5 (CC8 lineage; USA500), found among horses especially in Canada. Some MRSA can appear sensitive to clindamycin during routine sensitivity testing, but carry a gene that allows them to become resistant during treatment. In one study, inducible clindamycin resistance was very common among erythromycin-resistant, clindamycin-susceptible MRSA isolates from dogs and cats in Canada. Local treatment with antiseptic compounds such as chlorhexidine or povidone iodine may be helpful in some types of infections. Meticulous wound management without antimicrobials was successful in one dog. Animals treated with topical therapy alone must be monitored closely for signs of localized progression or systemic spread.

Certain antimicrobials, such as vancomycin and tigecycline, are critically important for treating human illnesses caused by MRSA. In some cases, they may be the only drugs of last resort. The use of these drugs in animals may place selection pressure on isolates that can infect humans. Thus, they are controversial for treating MRSA-infected animals, and should be avoided if at all possible. Recent publications should be consulted for the current list of critically important drugs.

**Prevention**

Veterinary hospitals should establish guidelines to minimize cross-contamination by MRSA and other methicillin-resistant *staphylococci*. In addition to hand hygiene, infection control measures (with particular attention to invasive devices such as intravenous catheters and urinary catheters), and environmental disinfection, barrier precautions should be used when there is a risk of contact with body fluids or when an animal has a recognized MRSA infection. These animals should be isolated. MRSA-infected wounds should be covered whenever possible. Although colonized people can transmit MRSA to animals, one study suggests that there may be only a small risk of transmission from colonized surgical personnel if infection control protocols are followed.

Researchers have recommended that veterinary hospitals initiate surveillance programs for MRSA, particularly in horses. Screening at admission allows isolation of carriers, the establishment of barrier precautions to prevent transmission to other animals, and prompt recognition of opportunistic infections caused by these organisms. However, screening all animals can be costly and may not be practical in some practices. An alternative is to screen targeted populations, such as animals with non-antibiotic responsive, non-healing or nosocomial infections, and animals belonging to healthcare workers or known MRSA-positive households. Animals that have been in contact with either MRSA cases or infected/colonized staff should be tested.

On farms, MRSA may sometimes be introduced when buying new stock, and spread during livestock movements. Biosecurity measures, including dedicated clothing and showering in, may decrease the risk of MRSA introduction to a farm by human visitors, or reduce transmission between units. Because CC398 has been detected in rats living on pig farms, rats should be considered in control programs. Whether MRSA in manure poses a risk when used as fertilizer, and the effectiveness of measures such as composting or heat treatment, are unknown. Avoiding routine antimicrobial use in food animals might reduce selection pressures, and lower the prevalence of these organisms in livestock.

The best method to eliminate MRSA carriage in animals in poorly understood, and may vary with the species. Dogs, cats and some other animals have been known to spontaneously eliminate MRSA when the environment is regularly cleaned and disinfected, and re-infection is prevented. Kenneling a colonized pet, preferably in isolation, might be considered in some situations. The efficacy of decolonization with antimicrobials is uncertain. It is not recommended for routine use in pets, but may be considered in individual cases to control transmission, e.g., when an animal remains a persistent carrier or infection control measures are impossible. Successful treatments used in three colonized dogs were oral doxycycline and rifampin, rifampin and ciprofloxacin, and fusidic acid and chlorhexidine. Topical treatment with mupirocin or other drugs to eliminate nasal carriage has been considered impractical in pets. On two colonized horse farms, MRSA was eliminated with infection control measures, screening and segregation of animal carriers, and decolonization of human personnel, together with antibiotics in two horses that remained long-term carriers.

**Morbidity and Mortality**

Outbreaks or clusters of clinical cases have been reported occasionally among horses at veterinary hospitals, and some studies suggest that MRSA may be an emerging pathogen in this species. Reports of infections in companion animals, mainly as postoperative complications and wound infections, also appear to be increasing. In addition to MRSA carriage or contact with carriers, risk factors include repeated courses of antibiotics, hospitalizations, intravenous catheterization and surgery. The mortality rate is expected to vary with the syndrome, e.g., lower mortality in superficial infections and higher case fatality rates in septicemia and other serious invasive
Methicillin Resistant Staphylococcus aureus

diseases. At several veterinary referral hospitals, 92% of dogs with infections mainly affecting the skin and ears were discharged, with no significant differences in the survival rate compared to methicillin-sensitive S. aureus. In another study, 84% of horses with MRSA infections at 6 veterinary hospitals in Canada survived to discharge. The mortality rate was 20% in an outbreak of exudative dermatitis caused by CC398 in young pigs.

Prevalence of MRSA carriage in animals

Colonization with MRSA seems to be uncommon in healthy dogs and cats not linked to a source of MRSA. Studies from North America, Europe, Hong Kong and Brazil reported carriage rates of 0-2% among healthy dogs and cats in the community, although one U.S. study found that up to 4% were colonized. Elevated rates of MRSA carriage have been reported in some animal facilities such as veterinary clinics or kennels, especially during outbreaks. In a household or institution (e.g., assisted living facility) where humans are MRSA carriers, individual animals may be persistent carriers, sporadically colonized, or unaffected. The colonization status can differ for each animal in a multi-pet household or institution.

Overall MRSA carriage may also be low among healthy horses in the community, and colonization seems to be transient in many animals. Some North American and European surveys reported that MRSA was isolated from 0% to less than 2% of horses surveyed. Carryage rates varying from less than 0.5% to 11% were found on presentation at equine clinics and veterinary hospitals. One Canadian study reported that infections were clustered, with 13% or 5% of the horses colonized on two farms, and no MRSA detected on eight other farms.

Colonization with CC398 is very common among pigs in some parts of Europe. The reported prevalence ranges from approximately 1% to 40% in different countries, and up to 81% of the farms in some countries may be affected. One study also found MRSA (mainly CC398) in 88% of the veal calf rearing units and 28% of the veal calves tested in the Netherlands. In Belgium, MRSA was detected on almost 10% of farms with mastitis problems, and in 4-7% of the cattle on infected farms. Information on livestock-associated MRSA strains in other parts of the world is limited. In Canada, a study found that 25% of swine, and 45% of farms were colonized with MRSA, mainly CC398 but also CMRSA2 (US100; EMRSA3; in CC5). In Iowa and Illinois, 11% of tested swine carried MRSA. Approximately 11% of pigs on Chinese farms and 16% of pigs from Hong Kong markets were colonized with MRSA ST9, with apparently lower ST9 colonization rates in surveys from Malaysia. In South Korea, where MRSA is common among people, the quarter-level prevalence of MRSA in milk was reported to be less than 0.5%. Some studies found that colonization in pigs varies with their age, while others detected no significant difference.

MRSA has also been detected in poultry in several countries, but its prevalence and importance are still poorly understood. In Belgium, CC398 was isolated from healthy poultry on 13% of the farms sampled. Another Belgian study detected MRSA in 20% to 100% of broiler chickens but not in laying hens. All of these isolates were CC398, but of a spa type not usually detected in other livestock. In the Netherlands, 0% to 24% of each broiler group entering abattoirs carried MRSA, and 23% of their flocks of origin were colonized.

Infections in Humans

Incubation Period

The incubation period for S. aureus infections in humans is highly variable. In susceptible patients, clinical cases may become apparent 4 to 10 days after exposure; however, opportunistic infections can also occur after an indefinite period of asymptomatic carriage.

Clinical Signs

MRSA is an opportunistic, like other S. aureus, and can cause the same types of infections. It may be involved in various skin and soft tissue infections, as well as invasive conditions such as pneumonia, endocarditis, septic arthritis, osteomyelitis, meningitis and septicemia. Hospital-acquired MRSA strains are major causes of nosocomial infections associated with indwelling medical devices and surgical sites. Human community-acquired-MRSA strains are mainly associated with superficial skin or soft tissue disease, although they have also caused sepsis, necrotizing fasciitis, necrotizing pneumonia and other conditions. MRSA strains that carry the exotoxin TSST-1 have been found in cases of toxic shock syndrome, especially in Japan. Other toxin-expressing MRSA strains (exfoliative toxins A or B) can cause staphylococcal scalded skin syndrome, a disease characterized by widespread blistering and loss of the outer layers of the epidermis.

MRSA strains that produce enterotoxins while growing in food can cause acute staphylococcal gastroenteritis (food poisoning). However, antibiotic resistance is generally irrelevant in this condition, because the preformed toxin is eaten in food and the organism is not present in the body. Invasive disease after ingesting S. aureus is very unusual, although it was reported in a severely immunocompromised patient who had received antacids, as well as antibiotics to which the (methicillin-sensitive) strain was resistant.

Zoonotic MRSA can presumably cause the same types of infections as human-associated MRSA strains. CC398 has mainly been found in superficial skin and soft tissue infections, but some case reports have described aggressive wound infection, destructive otomastoiditis, sinusitis, endocarditis, nosocomial bacteremia, pneumonia, and severe invasive infection with multiorgan failure.
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**Diagnostic Tests**

*S. aureus* infections in humans are diagnosed by culture and identification of the organism, as in animals. (Staphylococcal food poisoning is diagnosed by examination of the food for the organisms and/or toxins.).

**Treatment**

Factors such as the location, severity and progression of the infection, as well as the age and health of the patient, can affect the type of treatment chosen. Skin infections are sometimes treated by management techniques that do not require systemic antibiotics (e.g., incision and drainage for abscesses). Treatment may also require adjunct measures such as the removal of catheters.

Antibiotics must be selected based on susceptibility testing. It can be difficult to find an effective choice for hospital-acquired MRSA, which are often resistant to most common antibiotics. Agents used to treat serious infections caused by multiple drug resistant MRSA strains include vancomycin linezolid, tigecycline, quinupristin/dalfopristin and daptomycin. Resistance has been reported to some of these antibiotics. In particular, vancomycin resistance seems to be increasing. Community-acquired MRSA strains have often been resistant only to β-lactam agents, macrolides and azalides. However, resistance to other antibiotics may be increasing, multiple antibiotic resistant strains have started to emerge, and vancomycin-resistant strains have been reported.

**Prevention**

Hand washing, avoidance of direct contact with nasal secretions and wounds, barrier precautions when handling animals with illnesses caused by MRSA, environmental cleaning and other infection control measures are expected to reduce the risk of acquiring MRSA from infected or colonized animals. The best procedure to follow when a resident animal becomes colonized in a healthcare facility is still uncertain. In one recent outbreak, options presented to the facility included removing the animal until it cleared the bacterium, or allowing it to remain, with or without antibiotic treatment, and with continued monitoring (culture) and the encouragement of good hand hygiene among human contacts.

Infection control measures, particularly hand washing, are also important in preventing MRSA transmission from humans. Outpatients with MRSA skin lesions should keep them covered with clean, dry bandages. In some circumstances, such as the inability to adequately cover a MRSA-infected wound, close contact with other people (or susceptible animals) should be avoided. The Netherlands and Scandinavian counties have greatly reduced the incidence of hospital-associated human MRSA by screening and decolonization of hospital staff, and screening of patients on admission. High risk patients, including people who work with pigs or veal calves, are isolated until the screening test demonstrates that they are MRSA-free. MRSA outbreaks are investigated aggressively, and antibiotic use is restricted. Opinions in other countries remain divided on the benefits of screening on admission, compared to universal infection control procedures alone.

Decolonization of humans can be controversial, and may be recommended in some situations or groups of patients, but not others. A variety of agents, including various combinations of intranasal agents (e.g., mupirocin and fusidic acid) and systemic antimicrobials have been used in people. Other family members may need to be decolonized concurrently, and in some cases, carriage in pets may need to be considered. Decolonization is not always successful; the organism may be reintroduced by carriage in other parts of the body, and resistance to drugs, including mupirocin, can occur. People who work with pigs carrying CC398 often become recolonized from this source.

**Morbidity and Mortality**

Hospital-associated MRSA is one of the most prevalent nosocomial pathogens worldwide. Most infections occur in high risk patients, including the elderly and people with open wounds. Infections caused by community-acquired MRSA are also becoming more common. As with many bacterial infections, the case fatality rate differs with the syndrome. Mortality also depends on success in finding an effective antibiotic for the strain.

Some evidence suggests that CC398 might be less virulent in people than traditional human-adapted strains, although severe infections can occur. In one hospital in the Netherlands, approximately 13% of the patients who carried CC398 had symptomatic infections, while 42% of patients colonized with other isolates were affected. In Belgium, where 28% of humans who lived on swine farms were colonized with CC398, skin infections occurred in 0.8%.

**MRSA carriage**

Carriage rates for human MRSA strains in the general population range from less than 1% to 5%, but only some people are persistently colonized. Human healthcare workers are expected to be at an increased risk for colonization, due to occupational exposure. A number of studies have also reported elevated MRSA carriage among veterinary personnel (including livestock, equine and small animal veterinarians), even in people with no known link to a MRSA case. Reported colonization rates among staff at veterinary hospitals and referral clinics in Europe and North America vary from 0% to 10%, and have occasionally been reported to be as high as 27%. MRSA carriage is also elevated in farm and abattoir workers who handle live swine, veal calves or poultry infected with CC398, or pigs infected with ST9. In the Netherlands, Germany and Belgium, reported colonization with CC398 can be as high as 86% in some populations. Some studies have suggested that human colonization with animal-adapted MRSA strains might be transient.
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