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INFECTIOUS DISEASES IN THE ELDERLY (SF BRADLEY, SECTION EDITOR)

Impact and Management of MRSA in the Long-Term Care Setting

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Abstract Methicillin-resistant *Staphylococcus aureus* (MRSA) is a major cause of morbidity and mortality in healthcare facilities. Residents of nursing homes are commonly colonized with MRSA and acquisition within these facilities is common. While treatment of MRSA infection in the NH is more costly than treatment of infections caused by methicillin-susceptible strains, the frequency of serious infections and attributable mortality remains uncommon. Consequently, controlling the spread of MRSA in NHs is primarily a population health concern and interventions to control intrafacility transmissions should be balanced with a concern for resident quality-of-life.

Keywords Methicillin-resistant Staphylococcus aureus · Nursing homes · Elderly

Introduction

Infections caused by methicillin-resistant *Staphylococcus aureus* (MRSA) are a major cause of morbidity and mortality in the United States [1•, 2•, 3•]. The number of MRSA infections among hospitalized patients increased from 127,000 to 280,000 cases from the years 1999 to 2005 [1•]. Over a similar timeframe, healthcare costs generated by MRSA-related hospitalizations increased ~70 % from $8.7 billion in 1998 to $14.5 billion in 2003 [4]. For incompletely understood reasons, rates of invasive MRSA infections have declined since their peak in 2005 [5]. These encouraging trends notwithstanding, nearly 5 % of patients hospitalized with an MRSA infection die [3•] and MRSA remains one of the leading causes of death in the United States [2•].

Hospitalizations for infection and septicemia disproportionately occur among the elderly [6, 7]. MRSA illness patterns in the elderly largely mirror these population trends. Despite representing only 13 % of the population, 45 % of hospitalizations and 70 % of the deaths associated with an MRSA infection occur in patients over the age of 65 [2•, 3•, 5]. Nursing home residents are a particularly vulnerable elderly subgroup that is at an elevated risk of developing invasive MRSA infections when hospitalized [8]. Nevertheless, it is not clear that asymptomatic MRSA colonization adversely affects resident health outcomes outside acute care settings [9] despite its widespread prevalence in nursing homes [10–13]. The purpose of this review is to examine the epidemiology of MRSA in nursing homes, the impact colonization has on resident outcomes, strategies for managing residents with symptomatic infection, and a pragmatic approach to residents with asymptomatic colonization.

Epidemiologic Patterns of MRSA Colonization in Nursing Homes

MRSA in nursing homes was first reported in 1970, but it was not until the early 1990s that serious attempts to characterize the prevalence of MRSA in nursing homes were reported [14, 15•, 16•]. The reported prevalence of MRSA in these studies, all of which were performed in Veterans Administration extended care facilities, ranged from 16–34 %. Early studies of MRSA in community nursing homes found considerably lower rates of prevalent colonization (~ 10 %) [17, 18]. However, more recent studies suggest that approximately 25 % of nursing home residents are colonized with MRSA, although there is considerable variation observed across facilities [12, 13]. Colonization may be extranasal in approximately 65 % of residents, [19•] and persistent or intermittent colonization has been documented in approximately 85 % of the residents who

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are followed longitudinally [16•, 20]. Persistently colonized residents harbor higher MRSA colony counts on body surfaces than intermittently colonized residents [10], and these individuals have a substantially higher risk of developing infection as compared to residents with intermittent or transient carriage [15•].

It is commonly assumed that a majority of the MRSA observed in NHs is the result of importation from acute care facilities, except in outbreak situations [14, 21, 22]. Indeed, early studies examining the frequency of acquisition of MRSA in NHs failed to identify significant levels of transmission between MRSA-discordant roommates [16•, 17]. However, a number of recent studies have demonstrated that MRSA acquisition in NHs is substantial [23, 24•, 25, 26, 27•]. For example, 26 % of residents in California nursing homes were found to be colonized with MRSA during a recently published point-prevalence study in 26 facilities, however, the MRSA prevalence among new admissions to these facilities was only 15 % [1•, 2•, 26, 28]. Similarly, longitudinal studies have found that 8 to 20 % of subjects free of colonization at baseline subsequently acquire MRSA during follow-up [1•, 23, 24•, 27•]. Despite this level of acquisition, rates of transmission between roommates remain low [4, 24•, 27•] suggesting that other routes of transmission are responsible for the majority of MRSA acquisitions observed in NHs. A higher risk of MRSA acquisition observed among residents receiving rehabilitation services (HR=4.0, 95 % CI 2.2–8.8) and those who are bedbound (aHR 4.3–4.8) suggests that indirect spread through contact with healthcare workers may be significant mechanism of MRSA transmission in NHs [5, 24•]. Nevertheless, our understanding of the sources and modes of MRSA transmission in NHs remains incompletely understood at this time.

Unique strains of MRSA that emerged in community settings independently of healthcare-associated MRSA (HA-MRSA) have become a major problem in recent years [3•, 29]. Community-acquired MRSA (CA-MRSA; also referred to as the USA300 clone) possesses unique genetic characteristics that may confer higher virulence. These strains are now the most common cause of skin and soft tissue infections in many geographic regions and these strains have increasingly been implicated as a cause of invasive infection such as bacteremia, necrotizing fasciitis and necrotizing pneumonia [30, 31]. CA-MRSA strains are now a common cause of healthcare-associated infections in many regions [6, 7, 32] and there is a concern that these strains will eventually become established in NHs [2•, 5, 28, 33]. While USA300 strains account for a minority of MRSA in most NHs [8, 19•, 34], CA-MRSA has become widespread among NHs in some geographic regions [9, 35] and has even become the dominant circulating strain in some long-term care facilities (LTCFs) [10, 12, 24•, 36, 37]. What this means for risk of infection in NHs is unclear. New introductions of HA-MRSA strains did lead to observable increases in the number of infections in some NHs in the 1980s and 1990s [14, 15•, 16•, 21, 22]. Similarly, a large LTCF in California recently reported a significant increase in the incidence of skin and soft tissue infections that ran parallel with an increased prevalence of USA300 in the facility [17, 18, 36]. However, a recently published study performed in two LTCFs in Maryland found no difference in rates of subsequent infection among NH residents colonized with USA300 versus non-USA300 MRSA strains [12, 13, 34].

Impact of MRSA Colonization on Resident Outcomes and Risk of Infection

MRSA carriage is a well-established risk factor for risk of subsequent infection [19•, 38]. A majority of studies examining this risk have been performed in the hospital setting and the impact of colonization on risk of infection among residents of NHs is less well established. Nevertheless, NH residents colonized with MRSA do appear to experience within-NH rates of infection that are twofold to sixfold higher than observed among residents who are MRSA(−) [15•, 16•, 20, 39]. The risk of infection among NH residents who are persistently colonized with MRSA [10, 40, 41] and those who are colonized when hospitalized may be substantially higher [8, 15•].

Despite an elevated risk of infection relative to noncolonized residents, the absolute impact of MRSA colonization on resident outcomes appears to be modest. Approximately 8 % of MRSA(+) residents who remain in a NH for a year will develop an infection caused by MRSA (Table 1). Skin and soft tissue infections are the most common type of infection caused by MRSA in this setting and serious invasive infections requiring hospitalization, such as pneumonia and bacteremia, remain uncommon manifestations of MRSA in the NH. A higher risk of death among residents colonized with MRSA has been reported in several observational studies [14, 21, 22, 42, 43]. Given the low rate of mortality attributable to MRSA in the studies summarized in Table 1 (<1 per resident-year), the higher mortality observed in these studies may represent a spurious association influenced by higher levels of frailty among colonized residents [16•, 17, 18]. Despite a limited impact on mortality, colonized residents who develop an MRSA infection in the NH may require hospitalization for administration of parenteral antibiotic therapy [16•, 23, 24•, 25, 26, 27•, 44] and treatment remains substantially more expensive than treatment of infection caused by methicillin-susceptible *S. aureus* even when managed within the NH [18, 45].

As noted, CA-MRSA may possess enhanced transmissibility and virulence compared to HA-MRSA and there is concern that its introduction into NHs may translate into an increased risk of infection. The number of skin and soft tissue cultures identified as positive for MRSA quadrupled over a 10-year period in a single large California LTCF that experienced significant penetration by USA300 strains of MRSA [36]. Whether this was the

Table 1 Infection due to methicillin-resistant *Staphylococcus aureus* in nursing homes

Study		Facility Bed-Size	Resident-Months	Total	No. of Infections					Attributable Deaths
Author	Year				SSTI	UTI	Pneumonia	Bacteremia / Sepsis	Other	
Bradley [16•]	1991	120	1,228	9	6	–	1	1	3	0
Muder [15•]	1991	432	1,561	20	NR	NR	NR	NR	NR	NR
Spindel [106]	1995	120	6,712	28	9	5	5	2	7	3
Mulhausen [18]	1996	120[a]	2,436	8	1	2	1	3	1	0
Lee [107]	1997	149	1,788	14	4	5	2	NR	3	NR
Manzur [44]	2011	100	6,132	14	NR	NR	NR	NR	NR	0
Shurland [39]	2011	135[b]	11,015	101	NR	NR	NR	NR	NR	NR
Totals			30,872	194	20	12	9	6	14	3
Outcome per Resident-Year[c]				7.5	1.5	0.9	0.6	0.4	1.0	0.2

SSTI skin and soft tissue infection; *UTI* urinary tract infection; *NR* not reported

[a] 4 facilities with bed-sizes=120 (1) and 125 (3) included in this study

[b] 2 facilities with bed-sizes=120 and 150 included in this study

[c] Calculated using reported resident-months observed for eligible outcomes. If a study did not specify specific types of infections or numbers of attributable deaths, then the resident-months observed in study were excluded from the denominator values used to calculate measure

result of changes in culturing practices or a true increase in the number of skin and soft infections in this facility is not clear. In contrast, a retrospective cohort study of residents colonized with USA300 or non-USA300 strains of MRSA did not identify any substantive differences in risk of infection between these two groups although the numbers of MRSA infections in both groups were higher as compared to residents who were MRSA(−) [39].

Treatment of MRSA Infection in Nursing Homes

Guidelines for the treatment of MRSA infections have recently been published [46••] and the management principles of the types of infections most commonly encountered in the NH are summarized in Table 2. While many NHs currently have the capacity to administer parenteral therapy onsite, this review assumes that these services are not commonly available and will instead focus on the management of less severe forms of infection assuming that more severe forms (e.g., pneumonia and bacteremia) will be managed in the acute care setting under the direction of a provider with infectious disease specialty experience.

As noted, skin and soft tissue infections (SSTI) are the most common manifestation of MRSA infection in NHs. These infections are heterogeneous in their presentation but it is useful to consider two subtypes: (1) SSTI associated with previously intact skin integrity (e.g., furuncle, carbuncle and purulent cellulitis) and (2) SSTI associated with compromised skin integrity (e.g., infected pressure ulcers, diabetic foot ulcers, device insertion site or surgical site infection). It is important to note that it is uncommon for MRSA to present as non-purulent cellulitis. β-hemolytic streptococci are the predominant cause of these presentations [47] and empiric treatment for MRSA is not routinely indicated, even in those residents with a prior history of MRSA colonization or infection [46••].

The mainstay of managing MRSA SSTIs associated with previously intact skin is incision and drainage of the purulent fluid collection. Warm compresses may be sufficient for the management of small furuncles (<1 cm) but most cutaneous abscesses of larger size should be incised using a combination of scalpel and blunt dissection followed by packing to facilitate drainage of the involved lesion [48]. Incision and drainage alone may be sufficient for moderately-sized lesions (≤5 cm) [49, 50] but should be combined with antibiotic therapy in residents with larger lesions, systemic signs of infection (e.g., fever), lesions involving difficult to drain anatomical locations (e.g., face or genitalia), or those patients with significant comorbidity or frailty (e.g., extremes of age or diabetes with end-organ complications) [46••]. The oral tetracyclines (doxycycline and minocycline) or trimethoprim-sulfamethoxazole (TMP-SMX) are generally active against HA-MRSA and CA-MRSA while the activity of clindamycin against HA-MRSA strains is less predictable. It is important to note that TMP-SMX can interact with inhibitors of the renin-angiotensin system to cause clinical significant hyperkalemia and residents receiving both of these medications should be monitored closely. Linezolid is another oral treatment option but this medication is quite expensive and carries a significant risk of inducing a serotonin syndrome in those residents receiving selective serotonin reuptake inhibitors as well as serious myelosuppression when administered for more than two weeks.

The management of MRSA SSTIs associated with compromised skin integrity is more complex and the interested reader is referred to excellent reviews and guidelines on the treatment of infected pressure wounds [51•] and diabetic foot ulcers [52•]. Chronic wounds will always grow bacteria and decisions to initiate therapy should be based on the presence of localizing and systemic signs of infection rather than the results of cultures. In residents where infection is suspected, the wound should be sharply debrided to remove necrotic debris before any cultures are performed, as cultures of wound slough are not indicative of the organism(s) causing symptoms and will lead to unnecessarily broad therapy. Tissue biopsy is the gold standard

Table 2 Management of common types of MRSA infection in nursing homes

Condition	Non-Antibiotic Management Issues	Antibiotic Management Issues		Duration of Therapy
		Agent	Comments	
Skin & Soft Tissue Infection (SSTI)				
Involving previously intact skin (purulent cellulitis)	• Incision and drainage	Clindamycin 300–450 mg PO TID	• Higher risk of *Clostridium difficile* infection	7–14 days based on rapidity of clinical response
Involving previously compromised skin integrity (infected pressure ulcers and diabetic foot ulcers)	• Debride necrotic debris	TMP-SMX 1–2 DS tabs PO BID	• Combine with oral beta-lactam (e.g., dicoloxacillin) if concern for superimposed streptococcal infection	
	• Culture wound base by curettage or modified Levine technique		• Watch for hyperkalemia when combined with inhibitors of the renin-angiotensin system	
	• Assess for vascular insufficiency	Doxycycline 100 mg PO BID	• Combine with oral beta-lactam (e.g., dicoloxacillin) if concern for superimposed streptococcal infection	
	• Pressure offload affected area	Minocycline 200 mg x 1, then 100 mg PO BID	• Combine with oral beta-lactam (e.g., dicoloxacillin) if concern for superimposed streptococcal infection	
	• Provide good local wound care	Linezolid 600 mg PO BID	• Very expensive • Risk of serotonin syndrome when combined with selective serotonin reuptake inhibitors (SSRIs) • Risk of myelosuppression when administered for>2 weeks	
Urinary Tract Infection	• Replace indwelling urinary catheters if in place for more than 2 weeks	TMP-SMX 1–2 DS tabs PO BID Doxycycline 100 mg PO BID Minocycline 200 mg x 1, then 100 mg PO BID	• Watch for hyperkalemia when combined with inhibitors of the renin-angiotensin system	7 – 14 days based on rapidity of clinical response. Shorter courses safe in residents with rapid clinical responses.
		Nitrofurantoin 50–100 mg PO BID	• Do not use if there is a suspicion of upper urinary tract infection • Do not use in residents with CrCl <40 mL/min	
Pneumonia	• An uncommon cause of infection that is managed within the nursing home. MRSA should not be a routine part of antibiotic regimens used to treat pneumonia in the nursing home.			
Tracheobronchitis	• The management of residents with recurrent episodes of tracheobronchitis is challenging and may require consultation with a specialist in infectious diseases or pulmonary medicine.			

method for isolating the pathogens primarily responsible for wound infection but is uncommonly performed in the NH setting. Tissue curettage of the wound base (after debridement of necrotic debris) or the modified Levine technique [53] are more accessible options that provide results similar to those achieved by tissue biopsy. Residents with infected wounds should be assessed for the presence of underlying ischemia and treatment should focus on pressure offloading the involved area and good wound care. Oral antibiotic therapy is reasonable in residents with mild presentations. Therapy should empirically target MRSA in residents with a prior history of MRSA or a recent wound culture positive for this organism and should also provide activity against streptococci as most residents will have a polymicrobial infection (Table 2). Oral therapy should be administered for a discrete duration (5–14 days) and residents who fail to respond clinically should be evaluated for a more complicated process (e.g., critical tissue ischemia, unrecognized soft tissue abscess or osteomyelitis).

MRSA is an uncommon cause of urinary tract infection (UTI) and is almost exclusively seen in residents with chronic indwelling catheters [54]. Bacteriuria is nearly universal in these individuals and a decision to initiate treatment should be driven by the presence of symptoms rather than by results of urinalyses and culture [55•]. Treatment of asymptomatic bacteriuria in these individuals should only be performed prior to urological procedures. The management of residents with symptomatic UTI caused by MRSA involves replacement of the indwelling urinary catheter (for devices that have been in place for>2 weeks)[56] and systemic antibiotic therapy. There is limited data on the effectiveness of oral antibiotics for the treatment of UTI caused by MRSA and is not addressed in the Infectious Disease Society of America MRSA guidelines [46]. However, the United Kingdom MRSA guidelines do recommend that residents with infection involving the lower urinary tract can be treated with TMP-SMX, an oral tetracycline-derivative (doxycycline or minocycline) or nitrofurantoin [57]. Nitrofurantoin should not be used in residents with creatinine clearance <40 mL/min and is not effective in infections involving the upper urinary tract infection. In this latter situation, parenteral regimens are generally required. The ultimate length of therapy for UTI caused by MRSA is similarly unclear, but should be continued for at least 7 days and generally not for more than 14 days.

MRSA is a reasonably common cause of pneumonia among NH residents admitted to the hospital, particularly those who are admitted to the intensive care unit [58]. Management of pneumonia in the NH is often done without the benefit of respiratory cultures and a paucity of data on the microbiology of pneumonia managed in this setting make it difficult to determine the extent to which MRSA should be considered when selecting empiric antibiotic regimens in the NH [59]. Nevertheless, a retrospective study of 334 NH residents hospitalized with pneumonia found no significant difference in mortality or time to clinical stability between residents treated with broad-spectrum (anti-MRSA) regimens versus those covered with regimens providing coverage for pathogens typical of community-acquired pneumonia [60]. This study excluded residents who had recently received antibiotic therapy and those who required ICU care, two factors known to be strongly associated with risk of infection with drug-resistant bacteria. It therefore seems reasonable to assume that most residents with pneumonia who are stable enough to remain in the NH do not have an infection caused by MRSA [61].

Residents with severe forms of chronic obstructive lung disease or those with a tracheostomy device may develop recurrent bouts of tracheobronchitis due to MRSA [62•]. These individuals often present with an increase in the purulence of respiratory secretions and more difficulty breathing without significant impairments in gas exchange or evidence of lung infiltrates by exam or chest x-ray. These patients will often quickly respond to short courses (5–10 days) of oral antibiotic therapy (TMP-SMX or an oral tetracycline) but resistance emerges quickly with repeated antimicrobial exposures. Intermittent therapy with inhaled antibiotics (e.g., tobramycin) may reduce the frequency of exacerbations and limit the need for systemic antibiotic therapy although this has not been well studied. As a result, early consultation with a specialist in infectious diseases or pulmonary medicine is recommended in order to delay escalation to parenteral alternatives.

Prevention of Infection in Residents with Known MRSA Colonization

Studies performed in hospitalized patients have shown that ~25 % of long-term MRSA carriers will develop a serious infection in the year after identification of colonization [63]. Similar studies performed in NHs suggest the risk of subsequent infection is significantly lower; in the range of 10 % [39], and many of these infections are mild in severity. Nevertheless, the morbidity and costs of treating these infections makes prevention of infection a worthwhile endeavor. At a conceptual level, avoidance of indwelling medical devices [64] and reducing skin barrier disruptions are two strategies that NH staff can be employ to reduce the risk of infection among residents with MRSA colonization. Elimination of MRSA carriage is another attractive intervention that has been of demonstrated benefit in surgical [65] and dialysis patients [66].

A variety of approaches for eradicating MRSA colonization have been attempted in NHs. An early study examining the impact of systemic antibiotic therapy failed to demonstrate an appreciable impact on MRSA colonization and high levels of resistance emerged as a result of therapy [67]. Based on these data, decolonization of MRSA using systemic antibiotic therapy alone is not recommended. Decolonization of MRSA(+) NH residents using the topical anti-infective mupirocin has been

evaluated in number of studies. An early study using 7 days of intranasal mupirocin eliminated staphylococcal carriage (both MRSA and MSSA) in 91 % of colonized residents in a VA LTCF, however, nearly half re-colonized within 2 months of treatment [68]. A subsequent nonrandomized study performed by the same group redemonstrated that intranasal mupirocin could rapidly eradicate nasal MRSA carriage [69]. However, the intrafacility prevalence of MRSA did not substantially drop until topical treatment of open wounds was combined with intranasal therapy. Despite the observed impact on MRSA prevalence, MRSA infection rates were not appreciably altered and the use of topical therapy was discontinued when significant levels of mupirocin resistance were observed in the study facility [69]. A randomized, placebo-controlled trial examining the impact of mupirocin on carriage of MRSA among residents in 2 LTCFs found that intranasal application eliminated carriage in 93 % of subjects receiving active treatment [70]. Approximately one third of subjects who cleared recolonized within 90 days of therapy. While there was a trend towards a reduced rate of infection among those randomized to mupirocin, this did not reach statistical significance [70].

A number of nonexperimental studies examining the combined impact of topical and systemic therapy on MRSA carriage have been published [71–74]. Three of these studies were initiated in response to an outbreak and are susceptible to a number of methodological biases [75]. The remaining study, performed across 5 NHs in the same geographic region found that a regimen of intranasal mupirocin, oral minocycline and rifampin as well as a daily 5 % tea tree oil shower for 7 days followed a 5-day intranasal mupirocin plus daily showers with tea tree oil continuation phase administered once-monthly for 5 months reduced the prevalence of MRSA in participating NHs by 65 % over a 12-month period [74]. No data on the impact of the intervention on infection rates was provided and there was substantial numbers of residents (~1/3) who were lost to follow-up making it difficult to assess the impact of the intervention on individual resident outcomes.

Taken together, these data suggest that intranasal mupirocin, with or without adjunctive systemic antibiotic therapy, and bathing with anti-infective soap, can effect short-term eradication of MRSA colonization. The impact this intervention has on an individual resident's risk of infection and intra-facility rates of MRSA transmission remains undefined. Given the considerable potential for adverse effects from the agents used and the risk of promoting resistance, particularly to mupirocin, routine decolonization of MRSA(+) residents cannot be routinely recommended at this time [76].

Prevention of MRSA Transmission in Nursing Homes

A number of guidelines on controlling the spread of MRSA in healthcare facilities have been published [77–79]. These guidelines have generally approached control of MRSA from the hospital perspective. Guidelines that address the issue of MRSA in long-term care facilities have also been published by the Association for Professionals in Infection Control and Epidemiology [80•] and the California Department of Public Health [81•] although both are largely modeled after recommendations included in the 2006 Centers for Disease Control and Prevention multi-drug resistant organism (MDRO) guideline [78]. Control methods addressed in these guidelines include the role of hand hygiene, transmission-based precautions (i.e., isolation), room assignment, environmental cleaning, and the role of active surveillance to detect asymptomatic colonization. It is important to note that there is an appalling lack of evidence supporting most of the recommendations included in these guidelines [82] and there is substantial uncertainty about the degree to which any of these measures should be deployed in the NH setting.

While there are few NH-specific studies upon which to draw from [82], there is sufficient biological and indirect evidence to support building an MRSA control program around three basic infection control practices: (1) enhancing staff (and perhaps resident) adherence to hand hygiene; (2) enhancing staff adherence to standard precautions, and (3) enhancing care and maintenance of wounds and indwelling medical devices [64, 83•, 84]. The transmission of drug-resistant bacteria (including MRSA) remained unchanged on a LTCF unit after liberalizing contact isolation of colonized residents when coupled with an intervention to enhance the hand hygiene of staff (routine gloving prior to anticipated resident contact) [23]. Unfortunately, the observed impact of horizontal infection control programs on MRSA and other infectious disease outcomes documented in other published studies have been largely disappointing [85–87]. Education, a notoriously ineffective method for eliciting sustained changes in behavior, was the predominant method used for effecting improved adherence to hygienic practices in these studies. While none of these studies demonstrated a significant impact on the prevalence of MRSA or other types of NH-acquired infections, only one of the studies sought to measure the impact of education on the targeted behavior [87]. Given these methodological weaknesses, it is hard to draw firm conclusions from these studies and, more than anything, suggest a need for more research on ways to more effectively improve staff infection control behaviors in NHs. Achieving advances in this area are particularly important as they would be expected to not only improve facility rates of MRSA but rates of infections caused by other epidemiologically important pathogens (e.g., *C. difficile*) [88, 89].

Contact isolation of individuals colonized with MRSA is a widely used strategy to control the spread of MRSA within hospitals [75]. The effectiveness of this strategy in NHs is more controversial [90, 91]. The mechanisms of MRSA transmission in NHs are largely unknown and an individual resident's risk of

transmitting MRSA to others is likely highly variable. Indeed, it seems reasonable to assume that most MRSA(+) residents pose minimal risk of transmitting MRSA to others based on studies of transmission rates between roommates [16•, 17, 24•, 27•]. Importantly, studies in hospitals have shown that patients under contact isolation experience higher rates of depression and medical errors and have less frequent contact with healthcare workers [92–94]. While similar studies have not been performed in the NH setting, there is reason to believe that the adverse consequences of contact isolation will be augmented in this setting [91]. Consequently, the untargeted isolation of residents colonized with MRSA may have a limited impact on rates of transmission while unnecessarily exposing them to the adverse consequences of this social distancing intervention. In light of these concerns, it seems prudent to approach untargeted application of contact isolation in the NH with some caution. Stratifying transmission-based precautions based on a resident's perceived risk of transmission is a compromise strategy currently employed in VA LTCFs [95] and an approach advocated by the California Department of Public Health [81•] in order to maximize resident opportunities for social interaction while minimizing their risk of transmitting MRSA to others. While individualizing resident social distancing measures based on perceived risk of MRSA transmission faces some practical barriers to implementation, it is a process that is consistent with other care plan activities currently performed in NHs (e.g., falls and pressure sore prevention). An example of how this might be operationalized in a NH is provided in the figure (Fig. 1). Future studies should seek to examine the practicality and effectiveness of this and other approaches [83•].

The limited number of single rooms in most NHs creates challenges for placement of residents colonized with MRSA and colonization status has been identified as a reason for delayed transfers from acute care facilities [96, 97]. While it is reasonable to preferentially place MRSA(+) residents in single rooms when available, a strict policy of avoiding placement with an MRSA(−) individual seems misguided based on the limited number of MRSA transmissions identified in studies of MRSA discordant roommates [16•, 17, 24•, 27•]. Utilizing the approach outlined in the figure, MRSA(+) residents without an active infection and without risk factors for transmission could be placed with an MRSA(−) resident if a single room or vacancy with another MRSA(+) resident is available. In this manner, single rooms in NHs would be reserved primarily for

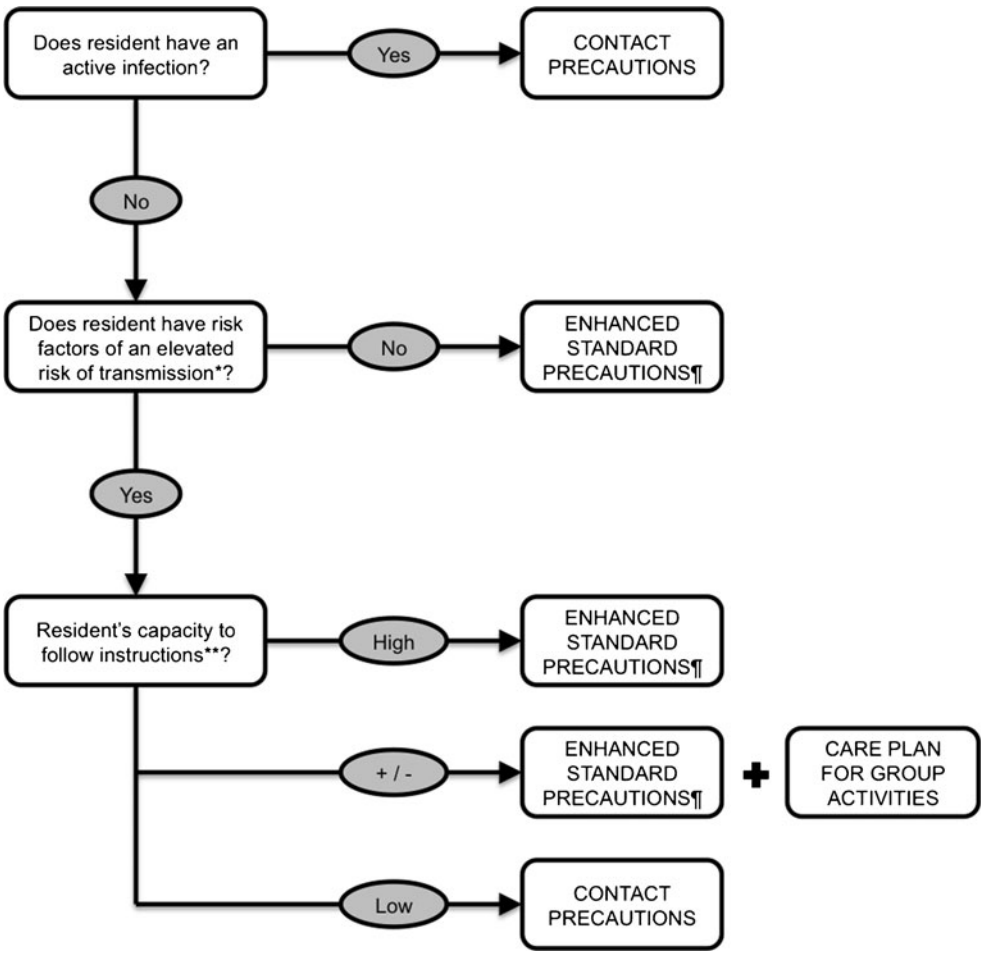

Fig. 1 Proposed strategy for differential application of transmission-based precautions in the nursing home based on a resident's baseline risk of transmitting methicillin-resistant *Staphylococcus aureus* (MRSA). * Transmission risk factors: (1) open wound; (2) exposed indwelling medical device; and (3) impaired cognitive status. ** Instructions to follow: (1) don clean clothes prior to leaving room; (2) performs hand hygiene before contact with other residents; 3) covers cough and sneezes; (4) keeps wounds and devices covered; and (5) ability to clean up after self. ¶ Enhanced standard precautions: identical to standard precautions with the exception that medical equipment is dedicated to the resident's room and residents are preferentially placed in single rooms or with other MRSA(+) residents before placement in a room with an MRSA(−) resident

the small population of MRSA(+) residents who have an elevated risk of transmitting MRSA to others.

Other strategies that may play a role in preventing the transmission of MRSA include active surveillance, enhanced environmental cleaning, and improvements in antibiotic stewardship. Active surveillance to detect asymptomatic MRSA colonization has been advocated as a method to control the transmission of MRSA in healthcare settings [77]. Despite well publicized successes [98–100], active surveillance to detect asymptomatic MRSA colonization remains a controversial topic in hospitals [88]. Given an absence of data clearly demonstrating that existing decolonization strategies can reduce intrafacility transmission of MRSA, active surveillance to detect asymptomatic MRSA colonization would appear to have limited utility in NHs at the current time [83•]. Studies have shown the capacity for MRSA to persist on surfaces for prolonged periods of time and improvements in environmental cleaning have been associated with reduced risk of MRSA transmission in the ICU setting [101]. MRSA contamination of environmental surfaces is common in NHs and higher levels of contamination have been correlated with reduced frequency and duration of cleaning and were associated with a surrogate of MRSA transmission in at least one study [102]. These data suggest that improving environmental cleaning procedures through standardized protocols to target high-touch surfaces in common areas may have a role in the institutional control of MRSA but further studies are needed before NHs devote considerable resources to these activities. Recent antibiotic exposure is associated with acquisition of MRSA in the NH [24•, 27•] and up to 70 % of antibiotic use in in these facilities may be inappropriate [103]. Despite the challenges in changing deeply engrained prescribing behaviors in NHs, improving the use of antibiotics has the potential to influence a number of resident outcomes. Consequently, improving antibiotic stewardship should be a high priority in NHs [103].

Conclusion

MRSA is widespread in NHs and these facilities appear to play an important role in amplifying the regional burden of MRSA [104, 105]. Nevertheless, there is a limited understanding of the mechanisms by which MRSA is spread within the NH and most residents remain asymptomatically colonized. Given an absence of impact on important resident health outcomes, reducing MRSA colonization in a NH primarily benefits the hospitals within its referral network. While this is an important population health goal, it should not come at the expense of resident quality-of-life. Until additional evidence demonstrating the safety and effectiveness of aggressive infection control measures (e.g., strict application of contact isolation, active surveillance, decolonization) emerges, NHs should primarily focus on improving staff adherence to basic hygienic practices (hand hygiene, standard precautions) and individualizing transmission-based precautions in order to minimize their adverse impact on resident quality-of-life. Novel horizontal approaches that reduce microbial contamination of environmental surfaces and minimize inappropriate antibiotic use in NHs have the potential to impact resident outcomes associated with other epidemiologically important pathogens (*C. difficile*) and more research is needed in order to determine how these strategies can be more effectively introduced into these facilities.

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Compliance with Ethics Guidelines

Conflict of Interest Christopher J. Crnich has received compensation from Covance for serving on a data safety monitoring board, and was reimbursed for travel/accommodations expenses by IDWeek (2012).

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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- • Of importance
- •• Of major importance

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