ORIGINAL ARTICLE

Universal Screening and Decolonization for Control of MRSA in Nursing Homes: A Cluster Randomized Controlled Study

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OBJECTIVE. The risk of carrying methicillin-resistant *Staphylococcus aureus* (MRSA) is higher among nursing home (NH) residents than in the general population. However, control strategies are not clearly defined in this setting. In this study, we compared the impact of standard precautions either alone (control) or combined with screening of residents and decolonization of carriers (intervention) to control MRSA in NHs.

DESIGN. Cluster randomized controlled trial

SETTING. NHs of the state of Vaud, Switzerland

PARTICIPANTS. Of 157 total NHs in Vaud, 104 (67%) participated in the study.

INTERVENTION. Standard precautions were enforced in all participating NHs, and residents underwent MRSA screening at baseline and 12 months thereafter. All carriers identified in intervention NHs, either at study entry or among newly admitted residents, underwent topical decolonization combined with environmental disinfection, except in cases of MRSA infection, MRSA bacteriuria, or deep skin ulcers.

RESULTS. NHs were randomly allocated to a control group (51 NHs, 2,412 residents) or an intervention group (53 NHs, 2,338 residents). Characteristics of NHs and residents were similar in both groups. The mean screening rates were 86% (range, 27%–100%) in control NHs and 87% (20%–100%) in intervention NHs. Prevalence of MRSA carriage averaged 8.9% in both control NHs (range, 0%–43%) and intervention NHs (range, 0%–38%) at baseline, and this rate significantly declined to 6.6% in control NHs and to 5.8% in intervention NHs after 12 months. However, the decline did not differ between groups ($P = .66$).

CONCLUSION. Universal screening followed by decolonization of carriers did not significantly reduce the prevalence of the MRSA carriage rate at 1 year compared with standard precautions.

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Methicillin-resistant *Staphylococcus aureus* (MRSA) is an important cause of morbidity and mortality among elderly people. MRSA causes difficult-to-treat, invasive infections in as many as 30%–60% of carriers in the acute care setting and in ~5%–15% of carriers in nursing homes (NHs).[1–3] The risk of carrying MRSA is higher for NH residents than for the general population due to the higher prevalence of comorbidities, chronic skin ulcers, and frequent exposure to antibiotics.[4,5] Furthermore, lifestyle in NHs may favor cross-transmission between residents by promoting social activities. Finally, NHs and acute care settings influence each other; admissions from one site to another are frequent, especially when NHs also provide care for short post-acute stays.[6–9]

The main strategies for MRSA control and prevention are well established in acute care facilities.[3,10] In contrast, these strategies remain largely empirical in NHs due to the lack of good scientific evidence and a paucity of interventional studies.[11] It remains unclear, therefore, whether measures such as MRSA screening, contact precautions, and decolonization of carriers are beneficial enough, from an infection control perspective, to justify their costs, the related burden on NH residents and staff, as well as the negative impact on residents' social activities.[12,13]

Recommendations regarding MRSA in NHs are therefore often based on expert opinions and vary between countries. In the Netherlands and some Canadian provinces, MRSA carriers are placed in single rooms but are not isolated, and contact precautions are advised for nursing activities only.[14,15] Some US states recommend systematic decolonization along with contact precautions,[16,17] whereas in Belgium, decolonization is performed along with standard precautions.[18]

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Prevalence of MRSA carriage in NH residents varies significantly across Western countries: 1%–8% in Germany,[19,20] 5% in Belgium,[1] 13%–35% in the United States,[21,22] 5%–22% in the United Kingdom,[7,23] 21% in France,[24] and 17% in Spain.[25]

From 2003 to 2008, three studies investigated the prevalence of MRSA carriage among residents of the 157 NHs located in Canton Vaud, Switzerland. MRSA prevalence increased from 4.5% in 2003 to 10% in 2006 (range, 0%–39%) and up to 12% in 2008 (range, 0%–60%). Although application of standard precautions is the recommended policy for MRSA control in NHs, heterogeneous strategies are still used across the canton.

To further determine the most appropriate MRSA control strategy in NH settings, we compared the impact of 2 approaches on the 1-year prevalence of MRSA carriage among NH residents in the canton. Specifically, standard precautions, as recommended for all patients in any healthcare setting,[10,26] were compared with a more aggressive strategy that combined the same standard precautions with systematic screening of all residents and decolonization of carriers and disinfection of their environment.

METHODS

Study Design, Setting, and Participants

This prospective cluster randomized controlled study took place from June 2010 to December 2011 in Canton Vaud, a state with 0.8 million inhabitants in western Switzerland. In 2011, the state had 53 NH beds per 1,000 inhabitants aged 65 years and over, distributed among 157 NHs with 7–153 beds (mean, 43 beds per NH).[27]

NHs mostly provide long-term care for older people unable to remain at home because of permanent physical and/or mental disability. Although some NHs specialize in the care of residents with severe dementia or chronic psychiatric conditions (psychogeriatric NHs), most NHs also host residents with mild and moderate dementia. As Canton Vaud encourages home care services, the average length of a resident's stay in an NH was only 2.4 ± 1.1 years in 2011.[27]

All 157 NHs located in Canton Vaud were invited to participate. The study was approved by the research ethics committee of Canton Vaud, Switzerland (Protocol 96/10). It was registered in ClinicalTrials.gov database (NCT01138462).

Randomization and Intervention

NHs were used as unit of randomization. Using a computer-generated code, participating NHs were randomly allocated to either intervention (ie, universal MRSA screening and topical decolonization of carriers and disinfection of their environment along with standard precautions) or control (ie, standard precautions alone) groups.

In each participating NH, oral informed consent for the screening of MRSA carriage was requested from residents or their legal representatives when appropriate. Because most NHs also provide respite care, residents for whom the planned length of stay was <3 weeks were excluded from screening, as were those in a terminal condition (ie, life expectancy <1 week). Residents in intervention NHs were considered ineligible for decolonization if they had hypersensitivity to ≥1 of the substances used for decolonization. In addition, NH residents were considered temporarily ineligible if they were infected with MRSA or if they had an MRSA bacteriuria or a stage 4 chronic ulcer (according to NPUAP staging[28]), until resolution of condition.

MRSA carriage screening. All residents who gave their oral informed consent underwent screening for MRSA carriage at study entry and 12 months thereafter. Baseline and follow-up screening campaigns were each completed over a 6-month period and over a single day in each participating NH. Additionally, all newly admitted or readmitted (usually after an acute-care stay) residents over the 12-month study period underwent MRSA screening.

Screening was performed by study nurses who were not employed by the NH. They used polyester fiber-tipped swabs to collect samples from nostrils, groin, and ulcers (if applicable). In addition, they collected urine for culture from residents equipped with a permanent urinary catheter. All samples were transported to the laboratory on the same day and were processed within 24 hours, as previously described.[29]

Intervention. All healthcare workers from participating NHs (in both control and intervention groups) participated in training sessions on the concept and practice of standard precautions[10] that should be applied to all residents, independent of their MRSA status. Training sessions were delivered by 1 dedicated study nurse in all participating NHs. In addition, teaching material such as DVD and flyers on standard precautions were distributed. Screening results were kept blind in the NHs allocated to the control group to avoid differences in nursing care.

In intervention NHs, MRSA-positive residents identified at study entry or upon admission during the study period underwent a topical decolonization combined with a disinfection of their environment. For this purpose, healthcare workers in intervention NHs received additional specific training and teaching material about the decolonization protocol and environmental disinfection.

Decolonization protocol. The topical decolonization protocol was conducted over 5 consecutive days, in association with environmental disinfection (Table 1).[3,13,30] Decolonization was considered successful if 2 MRSA-negative results were obtained from screenings performed 7 days apart and at least 7 days after the completion of the protocol. Decolonization was repeated once in case of failure.

Data collection and outcome. At baseline, study nurses collected data on the following NH characteristics: mission (psychogeriatric or not), number of beds, proportion of single rooms, number of toilets, number of healthcare workers per resident, and average daily nursing workload.

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TABLE 1. Topical Decolonization Protocol and Environmental Disinfection Used in the Study

	First Choice	Alternative
Topical decolonization		
Nostrils	Mupirocin ointment[a] t.i.d. for 5 d, using a cotton stalk	Bacitracine/neomycin ointment[b]
Pharynx	Chlorhexidine 0.11%[c] oral rinsing for 15 s, b.i.d. for 5 d	Octenidine oral solution[d]
Skin	Daily shower with 4% chlorhexidine[e] soap for 5 d	Octenidine soap[f] If shower not feasible: cetylpridinium chloride[g]–impregnated wipes
Hair	Shampooing with 4% chlorhexidine[e] soap on days 1 and 5	Octenidine soap[f] If shower not feasible: cetylpridinium chloride[g]–impregnated head caps
Dental prosthesis	Chlorhexidine 0.2%[h] during 30 min q.d.	Octenidine oral solution[d]
Stage 2 or 3 ulcers colonized by MRSA	Povidone-iodine[i] q.d. or chlorhexidine[j]	Octenidine[k]
Environment disinfection		
Clothes	Daily change for 5 d	
Linen	Change on days 1 and 5	
Bed	Daily disinfection with 70% alcohol	
Bedside table		
Phone		
Walking aid		
Wheelchair armrests		
Television remote control		

NOTE. MRSA, methicillin-resistant *Staphylococcus aureus*; q.d. = once per day (quaque die); b.i.d = twice per day (bis in die); t.i.d. = three times per day (ter in die).
[a]Bactroban®; GlaxoSmithKline, Münchenbuchsee, Switzerland.
[b]Neotracin®; Omnivision, Neuhausen, Switzerland.
[c]Collunovar®; Thepenier Pharma, St Langis Les Mortagne, France.
[d]Octenidol® oral solution; Schülke, Zurich, Switzerland.
[e]Lifoscrub®; Braun Medical, Sempach, Switzerland; or Hibiscrub®; Streuli Pharma, Uznach, Switzerland.
[f]Octenisan® soap; Schülke, Zurich, Switzerland.
[g]Bedbath Oasis®; Gompels Healthcare, Melksham Wiltshire, UK.
[h]Corsodyl®; GlaxoSmithKline, Münchenbuchsee, Switzerland.
[i]Betadine®; Mundipharma, Basel, Switzerland.
[j]Merfen®; Novartis, Basel, Switzerland; or Hibidil®; Cito Pharma, Uster, Switzerland.
[k]Octeniderm®; Schülke, Zurich, Switzerland.

For each screened resident, data was collected on age, gender, NH admission date and provenance (home, hospital, or another NH), and functional status.[31] Furthermore, the following risk factors for MRSA carriage were collected: previously documented MRSA carriage, hospital admissions during the previous year, chronic pressure ulcers, invasive medical devices, diabetes mellitus, and antibiotic therapy during the previous 30 days. A diagnosis of diabetes mellitus was only considered if the resident was being treated with insulin.

Study outcome was the change in prevalence of MRSA carriage among residents in each NH at the end of the 12-month study period.

Statistical Analysis

Two main approaches have been proposed to analyze data from a cluster randomized design.[32,33] The traditional approach considers the cluster as the unit of analysis and calculates summary statistics in each cluster (in our case in each NH). As recalled in Campbell et al,[32] "because each cluster then provides only one single data point, the data can be considered to be independent, allowing standard statistical tests to be used." This approach has the merit of simplicity[34] as well as consistency with our unit of randomization.[35] Thus, we calculated the 1-year change in MRSA prevalence for each NH, then we compared intervention and control groups using a Mann-Whitney test. The significance of the change in prevalence between baseline and after 12 months was also assessed separately within each NH group using a Wilcoxon signed rank test. Alternatively, we analyzed data at the individual level, considering the individual as the unit of analysis and attempting to adequately model the dependencies induced by the cluster effect using a generalized linear mixed model. We use a post-hoc analysis because we had to restrict our attention to those "permanent" residents who

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remained in their NH throughout the study. $P < .05$ was considered statistically significant. We used STATA 12.0 software (StataCorp, College Station, Texas, USA) and the R free statistical software (version 2.5.1).

The sample size was imposed by the pragmatic design and the public funding of the study, ie, by the existing number of NHs in the state where it took place. Based on results from local previous surveys, this study hypothesized that an initial MRSA carriage prevalence of 12% in the control NHs would increase by 20% (ie, from 12% to 14%) after 12 months. Using the conservative estimate of a 30% decolonization success rate in intervention NHs, followed by the same 20% increase in MRSA prevalence as in controls, the power of the study would be 0.51. This would ensure a statistically significant result in cases where the observed effects were equal to or larger than the hypothetical effects.[36] The power would increase to >0.99 if we assumed a 70% decolonization success rate, as observed in studies involving healthcare workers or healthy volunteers.[37]

RESULTS

Of the 157 NHs in Canton Vaud, 105 (67%) registered to participate in the study. As 1 NH allocated to the control group withdrew its agreement during the course of the study, the final analysis included 51 NHs (corresponding to 2,412 residents) in the control group and 53 NHs (2,338 residents) in the intervention group (Figure 1).

There were no significant differences in baseline characteristics between the 2 NH groups (Table 2). The proportion of residents who accepted and underwent MRSA screening was heterogeneous, ranging from 27% to 100% (mean, 86%) in control NHs and from 20% to 100% (mean, 87%) in intervention NHs. At baseline, the mean prevalence of MRSA carriage was 8.9% in both groups, ranging from 0% to 43% in control NHs and from 0% to 39% in intervention NHs. This baseline prevalence was positively correlated to NH size (Spearman coefficient, 0.31; $P = .001$) and was negatively correlated to the ratio of healthcare workers per resident, and

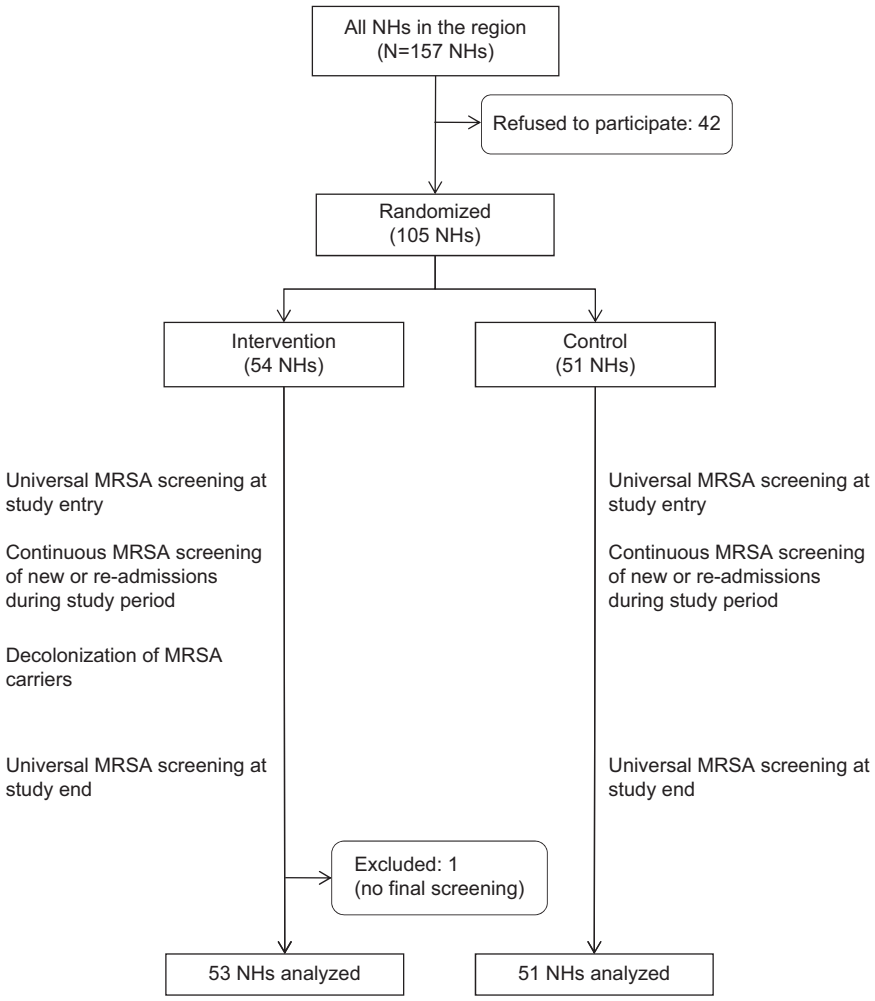

FIGURE 1. Study flow diagram. MRSA, methicillin-resistant *Staphylococcus aureus*; NH: nursing home.

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TABLE 2. Characteristics of Participating Nursing Homes at Baseline[a]

	Control NHs (n = 51; 2,412 residents), ± SD	Intervention NHs (n = 53; 2,338 residents), ± SD
No. of beds	47 ± 30	44 ± 25
Proportion of single rooms (%)	60 ± 23	62 ± 26
No. of toilets per 100 residents	53 ± 32	51 ± 27
No. of shower cabins per 100 residents	31 ± 28	30 ± 21
No. of healthcare workers per resident	0.59 ± 0.13	0.56 ± 0.12
Average daily nursing workload, min	165 ± 22	167 ± 22
Age of residents, years	83.4 ± 5.4	83.7 ± 8.1[b]
Proportion of female residents, %	73 ± 10	72 ± 12
Proportion of residents with at least 1 risk factor for MRSA carriage, %	27 ± 9	29 ± 10
Diabetes, %	5.7 ± 4.3	6.4 ± 5.0
Pressure ulcers, %	8.9 ± 4.8	8.6 ± 5.4
Urinary catheter or other devices, %	7.5 ± 6.6	7.7 ± 5.0
Antibiotics in the previous 30 d, %	11.2 ± 5.6	14.1 ± 8.1
Hospital stay in the previous year, %	42.7 ± 13.5	42.5 ± 11.6
Average functional status score of residents[c]	2.9 ± 0.6	2.9 ± 0.8
Proportion of resident screened, %	86.4 ± 18	87 ± 17
Prevalence of MRSA carriage among screened residents, %	8.9 ± 9.0	8.9 ± 9.3

NOTE. SD, standard deviation; MRSA, methicillin-resistant *Staphylococcus aureus*; NHs, nursing homes
[a]For the 52 non-participating NH (1852 residents), the average number of beds (43 ± 27) and the average daily nursing workload in minutes (159 ± 27) were similar.
[b]$P = .05$ compared to control NHs. No other P values were statistically significant.
[c]Katz score,[31] ranging from 0 to 6, with higher scores indicating better function.

(Spearman coefficient, −0.21; $P = .03$). MRSA strains were all susceptible to mupironcin. No invasive MRSA infections were observed during the entire study period.

Evolution of the Prevalence of MRSA Carriage in NHs

The proportion of residents available for screening at the end of the study was 89% in both control and intervention NHs. The changes in prevalence of MRSA carriage in each NH belonging to the intervention and control groups are represented in Figure 2. The mean prevalence decreased significantly by 3.0% in the intervention NHs (from 8.9% to 5.8%; $P = .003$) and by 2.3% in the control NHs (from 8.9% to 6.6%; $P = .02$). This corresponded to a nonsignificant 0.7% decrease attributable to the intervention ($P = .66$).

Data were then analyzed at the individual level for the 3,790 permanent residents, using a generalized linear mixed model, with NH random effects to predict the MRSA carriage of a resident (positive/negative), given his/her baseline value and his/her group (intervention/control). The odds ratio of being a MRSA carrier was estimated to be 1.38 higher in the control group than in the intervention group. However, this odds ratio was not significant ($P = .17$). Notably, the baseline prevalence of MRSA for permanent residents was 6.7% in the intervention group, whereas it was 9.1% in the control group, which warranted an adjustment for the baseline value.

Several exploratory secondary analyses were performed to investigate whether changes in MRSA prevalence varied according to various subgroups of NHs (Table 3). Results of each exploratory analysis showed a decrease in the mean prevalence over the 12-month study period in both control and intervention NHs, except in those NHs with baseline prevalence below the median value, where there was not much room for improvement. Across the various subgroups, decline in MRSA prevalence was slightly but consistently more important in the intervention group than in the control group. However, none of these differences achieved statistical significance. The largest improvement in the intervention group compared to the control group were observed among NHs with higher baseline prevalence, higher proportion of screened residents, lower number of beds, and lower number of healthcare workers per 100 residents.

DISCUSSION

This pragmatic randomized controlled trial was conducted in 104 NHs with >4,700 residents. To our knowledge, it is the first to investigate the impact of universal screening for MRSA carriage and decolonization of carriers in NHs, combined with a disinfection of their environment.[11] The results of our study show no significant benefit of this strategy on the prevalence of carriage compared with the application of standard precautions. This result is relevant in a field in which there is currently a paucity of evidence.

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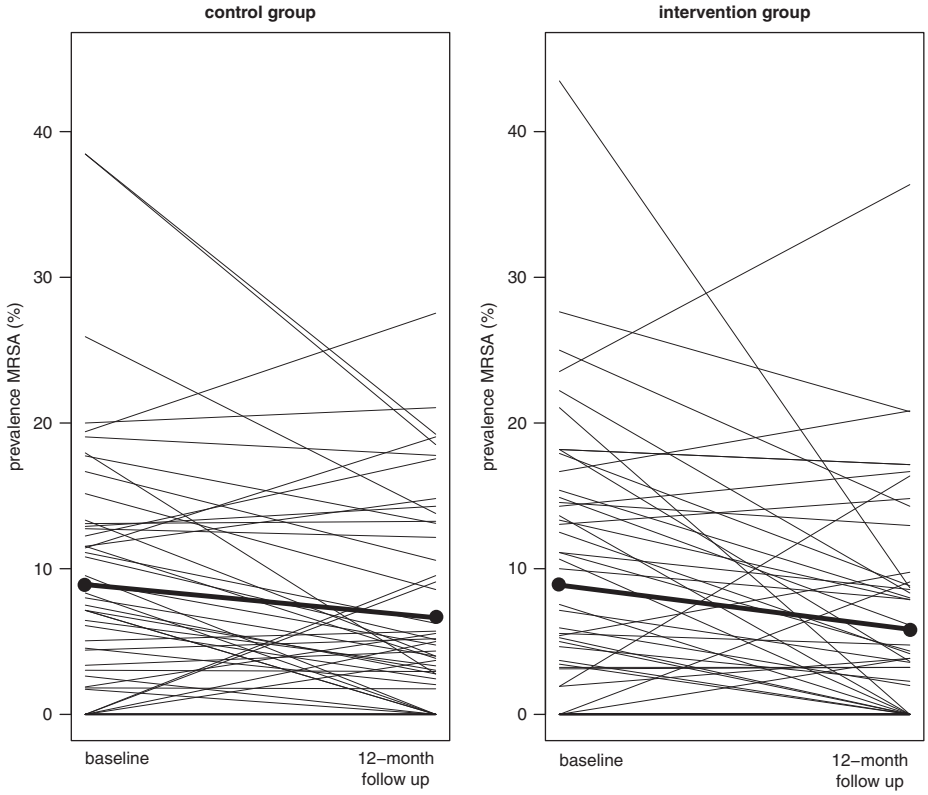

FIGURE 2. Evolution of the prevalence of MRSA carriage in nursing homes. Each thin line represents the evolution from baseline to 12-month follow-up of MRSA carriage prevalence in NHs from the control group (left panel) and the intervention group (right panel). The thick line represents the evolution of the mean prevalence of MRSA carriage in NHs from the control group (left panel) and the intervention group (right panel). MRSA, methicillin-resistant *Staphylococcus aureus*. NH, nursing home.

TABLE 3. Comparison of the Mean Changes in MRSA Prevalence Between Control and Intervention Among All Nursing Homes (NHs) and Among Various Subgroups[a]

	Mean Change in Prevalence, %		
	Control NHs	Intervention NHs	*P* Value[b]
All NHs	−2.3 (n = 51)	−3.0 (n = 53)	.66
Baseline prevalence <7%	+0.9 (n = 23)	+0.3 (n = 28)	.56
Baseline prevalence ≥7%	−4.8 (n = 28)	−6.8 (n = 25)	.38
Proportion of residents screened <92%	−1.4 (n = 28)	−1.9 (n = 24)	.52
Proportion of residents screened ≥92%	−3.3 (n = 23)	−4.0 (n = 29)	.96
No. of beds <38	−3.1 (n = 26)	−4.3 (n = 25)	.83
No. of beds ≥38	−1.6 (n = 25)	−1.9 (n = 28)	.54
No. of healthcare workers per 100 residents <0.57	−3.4 (n = 24)	−4.7 (n = 28)	.38
No. of healthcare workers per 100 residents ≥0.57	−1.2 (n = 27)	−1.2 (n = 25)	.38
Proportion of single room <57%	−2.5 (n = 27)	−3.7 (n = 24)	.70
Proportion of single room ≥57%	−2.0 (n = 24)	−2.5 (n = 29)	.79

NOTE. MRSA, methicillin-resistant *Staphylococcus aureus*; NH, nursing home.
[a]Subgroups of NHs were obtained by dichotomizing each factor (baseline prevalence, proportion of screened residents, number of beds, number of healthcare workers per 100 residents, proportion of single rooms) according to its median value in the 104 participating NHs.
[b]*P* values from Mann-Whitney test.

Another randomized controlled trial conducted in 32 NHs in Northern Ireland showed that an infection control program based solely on a staff education intervention had no effect on MRSA prevalence.[38]

The lack of efficacy of universal screening and decolonization of carriers in the present study may be largely attributable to the decrease in prevalence of MRSA carriage measured in control NHs as well. This unexpected finding contradicts the

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upward trend observed in 3 consecutive prevalence surveys performed prior to this study in 2003, 2006, and 2008. This result could not be due to an out-of-protocol use of a decolonization regimen because screening results were kept blinded in this study group. At least 2 hypotheses could be proposed to explain this downward trend. First, it may result from a spontaneous evolution of the predominant MRSA clones, as the evolution of these clones often has a wave-like shape.[39] This hypothesis is strengthened by a baseline prevalence that was lower than expected. This finding decreased the statistical power of the study to show an impact of the intervention because it left less room for improvement, as illustrated by the null prevalence observed at baseline in several NHs. Interestingly, we found that the baseline prevalence of MRSA carriage was positively correlated with the size of the NH and negatively correlated with the healthcare-worker-to-resident ratio, a finding that may be relevant to public health authorities involved in the organization of NHs. Second, an alternative or complementary hypothesis to explain the decrease in MRSA prevalence in control NHs may be an enhanced quality of care, as prior prevalence surveys were likely to have stimulated efforts toward a better observation of standard precautions. This trend was further reinforced by the training program developed in the context of the present study itself.

The study might have shown a more encouraging impact of screening and decolonization had this strategy been tested in selected NHs. Indeed, exploratory subgroup analyses suggest a possible, although not significant, benefit in those NHs with the lowest number of beds, the highest proportion of residents screened, the highest baseline prevalence of MRSA carriage, and the lowest number of healthcare workers per 100 residents.

This study suffered from several limitations that may have contributed to its negative results. One limitation was the relatively modest power of the study (calculated at 51%). Still, the intervention's impact would actually have been statistically significant had the prevalence of MRSA carriage not decreased in the control NHs. Further limitations stemmed from the fact that the study was conducted in real-life conditions. Indeed, screening was less than optimal, ranging from 20% to 100% of the residents from participating NHs. However, an average participation rate of 87% left most NHs with some unidentified MRSA carriers who may have compromised the intervention's effects. This limitation, in addition to a subpopulation of MRSA carriers who were not eligible for decolonization, may have prevented MRSA transmission from achieving a level low enough to permit a reduction in the prevalence of carriage.

However, these limitations induced by the study's real-life conditions also allowed us to obtain the most realistic results possible, and these results will be useful in helping public health authorities to choose preventive strategies in NH settings. Another strength of this study was its almost complete reliance on everyday NH resources and staff.

In conclusion, this study found no benefit from universal screening and decolonization of carriers along with standard precautions compared with standard precautions alone in reducing the prevalence of MRSA carriage in NHs. Additional investigations are needed to determine whether a similar intervention strategy could be effective under specific epidemiological conditions, such as very high prevalence of MRSA carriage or in case of an outbreak.

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