

***Staphylococcus aureus* carriage in care homes: identification of risk factors, including the role of dementia**

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SUMMARY

The aim of this study was to investigate the prevalence and associated risk factors of methicillin-susceptible and methicillin-resistant *Staphylococcus aureus* (MSSA and MRSA) carriage in care homes, with particular focus on dementia. A point-prevalence survey of 748 residents in 51 care homes in Gloucestershire and Greater Bristol was undertaken. Dementia was assessed by the clock test or abbreviated mini-mental test. Nasal swabs were cultured for *S. aureus* on selective agar media. Multivariable analysis indicated that dementia was not a significant risk factor for MSSA (16.2%) or MRSA (7.8%); and that residents able to move around the home unassisted were at a lower risk of MRSA ($P=0.04$). MSSA carriage increased with increasing age ($P=0.03$) but MRSA carriage decreased with increasing age ($P=0.05$). Hospitalization in the last 6 months increased the risk of MSSA ($P=0.04$) and MRSA ($P=0.10$). We concluded that cross-infection through staff caring for more dependent residents may spread MRSA within care homes and from the recently hospitalized. Control of MSSA and MRSA in care homes requires focused infection control interventions.

Key words: Dementia, epidemiology, hand hygiene, methicillin-resistant *S. aureus* (MRSA), *Staphylococcus aureus*.

INTRODUCTION

Staphylococcus aureus is carried on the skin or mucosa of healthy individuals without causing harm, but it can cause severe infections and bacteraemia with high mortality [1]. Infection with methicillin-resistant

S. aureus (MRSA) is associated with increased morbidity, mortality and length of hospitalization compared to methicillin-susceptible *S. aureus* (MSSA) [2, 3] and patients colonized with MRSA are at a greater risk of MRSA infection compared with non-colonized patients [4].

In 2008, about 16% of the UK population was aged >65 years [5], with the fastest population increase in England associated with those aged >85 years, with numbers doubling to 1.3 million [6]. By 2033 it is

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predicted that the number of people aged >85 years in England will double again to 3.2 million, accounting for 5% of the population. Notably, the proportion of older people in care homes increases rapidly with age, with 12% of men and 23% of women aged ≥ 85 years in residential care in England. Being a closed community, care-home residents may be at a higher risk of *S. aureus* carriage and infections and are a source of potential transmission of MRSA both inside and outside the home [7–9].

Only four previous studies have investigated the prevalence and risk factors associated with MRSA in UK care homes – estimating the prevalence of MRSA to range from 0.14% to 22% [10–13]. Univariable analysis from these studies shows that MRSA carriage is associated with: male gender, age >80 years, previous antibiotic treatment, skin condition, invasive devices, vascular disease, ≥ 6 beds per registered nurse, hospital admission and length of stay [10–14]. However, after multivariable analysis, only male gender, age, invasive devices, hospital stay and number of beds per registered nurse remained significant.

The burden of dementia in care homes is high. Current estimates for the prevalence of dementia in individuals aged ≥ 65 years living in Elderly Mentally Infirm (EMI) homes are 79.9%, nursing homes 66.9% and residential care homes 52.2% [15]. People with dementia are at risk of the same illnesses and risk of hospitalization as those without dementia. It is clear that residents with dementia have many characteristics which make infection control difficult, such as non-compliance with hand-washing, behavioural traits, frequent physical contact with care staff or other people. Yet residents with dementia are usually excluded from studies investigating MRSA in care homes because of the difficulties associated with enrolling vulnerable adults under the 2005 Mental Capacity Act for England and Wales [11, 13]. A large questionnaire study undertaken in Ireland 10 years ago, found that dementia was predictive of MRSA carriage in nursing homes, although dementia did not remain significant during multivariate analysis [14]. More recently, a study in 2006 demonstrated a statistically significant association between MRSA colonization and mortality of care-home residents with impaired cognitive function [16].

It is important to know whether dementia is an independent risk factor for the carriage of *S. aureus*, both for the management of residents and for the validity of future studies investigating healthcare-associated infections. In this point-prevalence study

we aimed to ascertain whether residents with dementia in nursing homes and residential care homes in Gloucestershire and Greater Bristol (UK) have an increased prevalence of MSSA and MRSA nasal carriage compared to residents without dementia. We also aimed to investigate other care-home and resident risk factors associated with the carriage of these organisms.

METHOD

Study population

The study was undertaken in Greater Bristol and Gloucestershire areas (mid-2007 population estimates 416 400 and 582 600, respectively) [17]; with care homes located in the inner city, urban and rural settings. Bristol has a higher 2007 Index of Multiple Deprivation score at 27.76 (ranked 49/152 where a ranking of 1 is the most deprived) compared with Gloucestershire, 14.65 (ranked 124/152) [18].

Homes providing old age and/or dementia services were identified in Greater Bristol and Gloucestershire via the Quality Care Commission (previously Commission for Social Care Inspection). Following stratification by the type of care provided, homes with at least 20 residents were randomly selected and invited to participate by telephone and letter from January 2008 until the end of the study in August 2009. All residents at participating homes were eligible for inclusion.

Sample size

A total of 750 residents were estimated, based on previously reported MRSA prevalence rates of 20% [19]. This gave the power to detect an increase of MRSA prevalence of 15% in patients with dementia (expected prevalence 30%) [19], 15% in patients hospitalized in the previous year (expected prevalence 26%) [13], 20% in urinary catheterized patients (expected prevalence 8%) [19] and 15% in male patients (expected prevalence 20%) [13].

Screening residents for dementia

Presence of dementia was determined with the clock-drawing test and was administered in accordance with previously published methods [20]. The test is easy to administer, appears to be well tolerated by patients and is not influenced by language, culture, ethnicity or education [21]. The test requires a mix of cognitive skills, including visuo-spatial abilities and executive

control functions [20]. We graded the test results using the scoring system of Shulman [20], which has been shown to have good sensitivity and specificity compared with other validated methods of cognitive function, especially the Mini-Mental State Examination [22–24]. Furthermore, inter-rater and non-expert agreement has been shown to be good [22–24]. For residents who were unable to participate in the clock-drawing test, due to poor eyesight or physical disabilities, we used the 10-question Abbreviated Mental Test (AMT) score. A score of >6 in the AMT reliably rules out dementia [25].

Ethics and consent

Approval was gained from the local research ethics committee (LREC no: 06/Q2005/99). A senior member of staff gave written informed consent for the care home to participate.

At the first visit to a participating home, researchers approached only residents who were considered by care-home staff to have the capacity to consent. These residents were asked to complete a dementia assessment exercise and for informed oral consent to a nasal swab. Individuals who did not have the capacity to consent or those initially considered by home staff to have the capacity to consent but later failed the clock-drawing exercise were not excluded from the study. Residents who were considered too ill or frail to participate were excluded. Assent was sought from a resident's nominated or personal consultee in accordance with the Mental Capacity Act 2005. Letters requesting assent were sent to the appropriate person and non-respondents were followed up after 2 weeks with an additional letter. Any residents without an appropriate consultee acting on their behalf or without assent were excluded from the study.

Residents for whom consent or assent had been obtained, but were later found unwilling to cooperate when approached by researchers wishing to take a nasal swab, were given a second opportunity on a different day to be involved with the study. This was considered important due to the nature of dementia and the daily variation in understanding. Refusal on both occasions was considered a refusal of consent and therefore the resident was excluded from the study.

Microbiological survey

On a separate care-home visit, swabs were taken from the anterior nares of residents for whom consent or

assent had been given. A researcher or carer asked residents to blow their nose, then the inside rim of the nostril was carefully wiped for about 5 s with a sterile cotton-tipped swab, which was then inserted in Amies charcoal transport medium (TCS plc, UK) and sent to Gloucestershire Royal Hospital Microbiology Department for processing. Each swab was cultured within 24 h on Columbia blood agar (Oxoid, UK) and MRSA selective chromogenic agar (bioMérieux, UK) using standard methods as previously described [26, 27]. Isolates were identified as *S. aureus* by standard diagnostic tests and methicillin resistance was confirmed by resistance to cefoxitin (10 µg disk; Oxoid) [27, 28].

Data collection

Care-home staff completed a paper questionnaire about residents and care-home risk factors that might be associated with MRSA or MSSA carriage. Information was collected regarding resident's age, gender, length of time at the home, level of dependency, level of dementia from previous assessment, ability to move around the home unassisted, hospital admission, surgical procedure in last 6 months, history of MRSA carriage/infection, chronic wound or skin lesions, invasive devices, shared room, use of communal areas, hand to nasal contact, ability to independently wash hands and frequent physical contact with staff or other residents. Care-home risk factors included home type, service provider, number of residents, categories of residents, details of staffing levels, facilities at the home and written infection control policies.

Data analysis

Associations between nasal carriage of either MSSA or MRSA and patient, healthcare or care home-related factors were assessed using χ^2 tests of association and Fisher's exact test. Estimates of relative risk ratios (RRR) were obtained using multinomial (polytomous) logistic regression analysis, with the three categories of MRSA, MSSA or no *S. aureus* nasal carriage as the outcome variable. Initially, the heterogeneity in carriage prevalence of MRSA, MSSA and all *S. aureus* between the care homes was assessed by the use of funnel plots. While there was no strong evidence of heterogeneity the potential lack of independence of carriage of residents within a care home was incorporated into the regression model by estimating standard errors of the estimated odds ratios

that allow for the 'clustering' of residents. In the regression models, Wald tests were used to assess the associations. All analyses were performed using Stata version 10 (StataCorp., USA).

RESULTS

Care homes and residents

In total 51 homes were recruited; 14 residential care homes (7 Gloucestershire, 7 Greater Bristol) and 37 nursing homes (21 Gloucestershire, 16 Greater Bristol). These homes served 1881 residents, of which 361 were too frail to approach. Of the remaining 1520 residents, 772 (51%) residents were excluded; 616 (40%) did not provide consent or assent, 151 (10%) had no nasal swab taken and a remaining five consenting residents were unable to complete a dementia screen (i.e. due to incapacity, inability to communicate or lack of interest). Thus we obtained nasal swabs from 748 (49%) consented or assented residents. The median number of residents recruited from a care home was 13 (range 5–34). The mean age of residents excluded and included was similar (excluded 85.9 years, s.d. = 8.7; swabbed 85.7 years, s.d. = 8.3; $P = 0.7$), but those excluded were significantly more likely to be female [excluded 601 (78%); swabbed 548 (73%); $P = 0.02$].

Prevalence of *S. aureus*

Of the 748 recruited residents, 179 (23.9%, 95% CI 20.9–27.0) were culture positive for *S. aureus*. Of these 121 (16.2%, 95% CI 13.5–18.8) were MSSA and 59 (7.8%, 95% CI 5.8–9.7) were MRSA. There was no strong evidence of a relationship between the carriage of MRSA and MSSA in the 51 care homes (Spearman's correlation 0.1, $P = 0.23$), in fact only one resident carried two strains of *S. aureus*; two MRSA strains, with distinct morphologies and antibiogram patterns. In nine of the homes (18%), no residents had nasal carriage of MSSA or MRSA.

The median prevalence of MRSA carriage was 5.9% (lower quartile 0.0%, upper quartile 11.8%), with some evidence of a difference in MRSA carriage between care homes ($P = 0.05$). The prevalence in one home did exceed the upper 95% confidence limits, but this is an expected observation in a study of this size.

The median prevalence of MSSA was 16.7% (lower quartile 4.8%, upper quartile 24.0%). There was some evidence of a difference in MSSA carriage prevalence

between care homes ($P = 0.005$). For none of the homes did the estimated prevalence exceed the upper 95% confidence limit; however, for 12 homes with between 6 and 16 recruited residents there was no carriage.

Dementia screening

Dementia was present in 499 (66.7%, 95% CI 63.3–70.1) of the 748 residents that had a nasal swab. The AMT was undertaken by 272 residents; 126 (46%) attained a score of ≥ 7 (which excluded dementia) and 146 (54%) residents were considered unable to provide informed consent. The clock-drawing exercise was undertaken by 353 residents; 147 (42%) residents failed to accurately complete the clock-drawing exercise, indicating some level of cognitive impairment and therefore an inability to provide informed consent. A further 290 residents, initially identified by care-home staff as capable of providing informed consent, were considered to have dementia as they were unable to provide consent or attempt an exercise.

Risk factors for nasal carriage of MSSA and MRSA

There was no evidence to suggest that nasal MSSA or MRSA carriage differed in residents with or without dementia (Table 1). Of the 499 residents screened or otherwise considered to have some level of dementia, 84 (16.8%) carried MSSA, compared to 37 (14.9%) of the 249 non-dementia residents ($P = 0.5$). While 39 (7.8%) of the residents considered to have dementia carried MRSA, compared to 19 (7.6%) of the non-dementia residents ($P = 0.9$). In those residents with dementia there was no evidence of a difference in nasal MRSA carriage in those given the AMT (4/77 5.2%), clock-drawing test (9/131 6.9%) or who assented (27/288 9.4%) ($P = 0.5$).

The results from the single variable analysis for all risk factors are presented in Tables 1–3. Many of the risk factors investigated were not significantly associated with carriage of MSSA or MRSA. There were nine factors from the single variable analysis that exhibited some association with nasal *S. aureus* carriage: gender, age, urinary catheterization, admission to hospital in the past 6 months, level of dependency, ability to move around the home unassisted, independently wash hands, number of residents in the home, and home location (Gloucestershire or Greater Bristol). These factors were entered into a

Table 1. Association between resident-related factors and nasal MSSA and MRSA carriage

Factor	No <i>S. aureus</i> (<i>n</i>)	MSSA			MRSA			Overall <i>P</i> value
		<i>n</i>	Estimated RRR (95% CI)	<i>P</i> value	<i>n</i>	Estimated RRR (95% CI)	<i>P</i> value	
Gender								
Male	141	36			23			
Female	428	85	0.78 (0.50–1.20)	0.3	35	0.50 (0.27–0.93)	0.03	0.06
Age group (yr)								
<81	125	25			20			
81–86	153	28	0.91 (0.52–1.61)	0.8	16	0.65 (0.35–1.21)	0.17	
87–90	122	26	1.07 (0.64–1.77)	0.8	8	0.41 (0.19–0.88)	0.02	
≥90	163	41	1.26 (0.68–2.32)	0.5	14	0.54 (0.26–1.09)	0.08	0.10
Age								
Per year	—	—	1.02 (1.00–1.05)	0.07	—	0.96 (0.93–1.00)	0.04	0.01
Previous MRSA								
No	507	109			49			
Yes	36	5	0.65 (0.23–1.83)	0.4	6	1.72 (0.54–5.49)	0.4	0.3
Current MRSA status								
No	542	116			53			
Yes	10	1	0.47 (0.06–3.89)	0.5	3	3.07 (0.72–13.1)	0.13	0.12
Dementia								
No	193	37			19			
Yes	376	84	1.16 (0.72–1.88)	0.5	39	1.05 (0.53–2.09)	0.9	0.8

RRR, Relative risk ratio; CI, confidence interval.

multivariable polytomous logistic regression analysis to assess whether any of these associations could be explained on the basis of confounding. The association for each of these was assessed after allowing for the other variables. If any variable did not exhibit an association, its association with the other variables in the regression model was assessed in order to determine which, if any, could provide an explanation.

When assessed in a model with all nine variables, there was no longer an association between independently washing hands and MSSA or MRSA carriage ($P=0.6$). This was due to the strong association between independently washing hands and the ability of the resident to move around the home. Of the 434 residents that could not independently wash their hands, only 69 (15.9%) residents had the ability to move around the home. Of the 287 residents that could independently wash their hands, 173 (60.3%) were able to move around the home. Therefore the previously observed association between nasal MRSA carriage and independently washing hands could be explained by the confounding effect of the resident's ability to move around the home, which appeared to be associated with both independent hand washing and MRSA carriage.

After removing independently hand washing from the regression model, the association between nasal MRSA carriage and urinary catheterization was also not significant ($P=0.5$). On removal of urinary catheterization from the regression model, there was no strong evidence of an association between level of dependency and MSSA or MRSA carriage ($P=0.17$). Further, after the removal of independently hand washing, urinary catheterization and level of dependency from the regression model, there was no strong evidence of an association between gender and the carriage of MSSA or MRSA ($P=0.14$).

The remaining five variables (age, region, ability to move around the home unassisted, hospital admission, and number of residents per home) all had some evidence of an association with nasal MSSA or MRSA carriage (Table 4). For age there was an unusual association, with MSSA carriage increasing as age increased ($P=0.03$), while MRSA carriage was found to decrease with increasing age ($P=0.05$). Those residents able to move around the home unassisted were at a lower risk of MRSA carriage (RRR 0.53, 95% CI 0.30–0.98, $P=0.04$); however, this variable did not appear to be associated with MSSA carriage (RRR 0.91, 95% CI 0.56–1.47, $P=0.7$).

Table 2. Association between healthcare-related factors and nasal MSSA and MRSA carriage

Factor	No <i>S. aureus</i> (<i>n</i>)	MSSA			MRSA			χ^2 <i>P</i> value
		<i>n</i>	Estimated RRR (95% CI)	<i>P</i> value	<i>n</i>	Estimated RRR (95% CI)	<i>P</i> value	
Invasive devices								
No	489	104			41			
Yes	79	17	1.01 (0.50–2.07)	>0.9	15	2.26 (1.11–4.64)	0.03	0.03
Urinary catheter								
No	491	104			41			
Yes	65	16	1.16 (0.56–2.40)	0.7	14	2.58 (1.22–5.47)	0.01	0.02
Central or peripheral venous catheters								
No	491	106			41			
Yes	7	0	—		0	—		0.4
Times admitted to hospital as in-patient in previous 6 months								
0	491	94			45			
1	58	21	1.89 (1.04–3.45)	0.04	11	2.07 (0.98–4.39)	0.06	
2	10	1	0.52 (0.07–4.14)	0.5	2	2.18 (0.47–10.0)	0.3	
≥3	3	1	1.74 (0.19–16.4)	0.6	0	Not estimable	—	0.13
Times admitted to hospital as in-patient in previous 6 months (binary)								
0	491	94			45			
≥1	71	23	1.69 (1.01–2.84)	0.05	13	2.00 (1.03–3.89)	0.04	0.03
Attended hospital as outpatient in previous 6 months								
No	461	91			43			
Yes	99	25	1.28 (0.84–1.94)	0.2	11	1.19 (0.60–2.38)	0.6	0.6
Undergone a surgical procedure in the past 6 months								
No	529	108			53			
Yes	33	12	1.78 (0.87–3.66)	0.12	5	1.51 (0.61–3.78)	0.4	0.2
Chronic wound								
No	509	108			49			
Yes	47	11	1.10 (0.57–2.12)	0.8	7	1.55 (0.68–3.52)	0.3	0.6
Nasogastric tube or PEG								
No	493	106			41			
Yes	10	1	0.47 (0.07–3.13)	0.4	1	1.20 (0.19–7.54)	0.8	0.7
Tracheotomy								
No	492	106			41			
Yes	0	1	Not estimable		0	Not estimable		0.2*

RRR, Relative risk ratio; CI, confidence interval; PEG, percutaneous endoscopic gastrostomy.

* Fisher's exact test.

For both MRSA and MSSA there was some evidence to suggest that those residents admitted to hospital within the past 6 months were more likely to have nasal carriage (MRSA: RRR 1.84, 95% CI 0.89–3.77, $P=0.10$; MSSA: RRR 1.67, 95% CI 1.03–2.70, $P=0.04$).

Nasal MSSA carriage was significantly lower in Gloucestershire care homes while MRSA carriage showed a similar reduction that was not significant (MSSA: RRR 0.49, 95% CI 0.30–0.81, $P=0.006$; MRSA: RRR 0.56, 95% CI 0.27–1.17, $P=0.13$) when compared to homes in Greater Bristol. There was a significant association with the number of residents per home for MSSA, with those homes with 31–38

resident exhibiting an increase in carriage compared to all other groups ($P=0.006$). While the number of residents was not associated with MRSA carriage ($P=0.2$).

DISCUSSION

We found that dementia was not a significant risk factor for the carriage of either MSSA (16.2%) or MRSA (7.8%) in care-home residents. However, residents able to move around the home unassisted were at a lower risk of MRSA carriage ($P=0.04$). Carriage of MSSA increased with increasing age ($P=0.03$), while MRSA carriage decreased. Hospitalization in

the last 6 months increased the risk of both MSSA ($P=0.04$) and MRSA ($P=0.10$) carriage.

O'Sullivan & Keane in 2000 [14] investigated risk factors associated with MRSA colonization via a retrospective questionnaire, completed by 786 residents screened for MRSA, living in six Eastern Health Board long-term residential care facilities. They identified cognitive impairment as a risk factor predictive of higher MRSA carriage rate; however, it did not remain an independent risk factor significant on multivariable analysis. In our study, researchers approached and assessed the mental capacity of 815 residents using validated and robust dementia assessment tools [20–25]. From these in-depth assessments, we found that diminished cognitive impairment was not associated with a higher rate of MSSA or MRSA. Therefore excluding residents with dementia from future care-home studies investigating *S. aureus* carriage would not be detrimental.

A similar care-home study conducted in Leeds by Barr and colleagues found that age was not associated with MRSA colonization [13]. They assessed 715 residents from 39 care homes, with a median age of 85 years (range 61–103 years). The most significant age-related finding was associated with those residents aged ≥ 90 years, with the crude odds ratio on single variable analysis of 1.45, suggesting that age may have been a causative risk factor; however, the 95% confidence interval crossed unity (0.85–2.48) and, therefore, a definite association could not be determined. In Gloucestershire, we found that residents aged < 81 years were significantly more likely to carry MRSA, whilst MSSA carriage was significantly higher in residents aged > 90 years.

Our study suggests that the risk of colonization varies with geographical area, with MSSA carriage lower in Gloucestershire homes compared to Greater Bristol homes and lower than in Leeds in 2005, which showed an MRSA prevalence of 22% [13]. Differences may also be due to hospital rates of MRSA. Although our study was not designed to determine this, mandatory data on bacteraemia rates does give an indication of MRSA rates in these areas; Leeds Teaching Hospital rate for 2004/2005 at 2.62 compared to North Bristol and University Hospitals Bristol in 2007/2008 with rates of 2.10 and 1.59, respectively. Clearly more work is needed to understand the variables associated with regional differences in carriage rates.

The ability of residents to move around the home unassisted was found to be protective for MRSA

carriage, but not significant for MSSA colonization. This finding suggests that those residents reliant on staff assistance for care and movement around the home were at a higher risk of MRSA carriage. This was also indicated in the single variable analysis as level of dependency, inability to wash hands independently and presence of a urinary catheter were all associated with increased carriage of MRSA. This result suggests that residents are acquiring MRSA via cross-infection due to staff members and demonstrates the need for stricter hygiene standards in care homes.

Other studies have identified hospitalization as a risk factor for MRSA colonization [8–12, 29, 30]. Our study also found that residents recently admitted (≤ 6 months) to hospital as in-patients were at a higher risk of both MRSA and MSSA carriage. This supports the widely held view that hospitals act as a reservoir for *S. aureus*, with residents returning to care homes after acquiring strains endemic in the hospitals. However, more work is required to investigate whether this is the case and the level of transmission via this route; this would necessitate detailed type identification of care-home isolates and their corresponding regional hospitals.

Previous work into the colonization of the anterior nares with *S. aureus* has shown that it is unusual for individuals to be colonized with more than one strain of *S. aureus* or both MSSA and MRSA, suggesting that colonization with MSSA is protective and prevents individuals becoming colonized with MRSA [31]. This explains why no residents were identified in our study with co-colonization of both MSSA and MRSA. In fact the only resident with more than one *S. aureus* isolate was found to be carrying two different strains of MRSA.

The original sample size calculations made assumptions, based on published work, that 20% of residents would have nasal carriage of MRSA and 30% of residents would have dementia [13, 19]. The observed MRSA carriage was about 8%, while the prevalence of dementia was 67%. This has the effect of reducing the power of detecting a relative increase in carriage of 75% from 90% to 50%. However, the 95% confidence intervals around the estimated increase in carriage would exclude a doubling of *S. aureus* carriage in those with dementia.

To our knowledge, this is the only UK study that has assessed care-home residents for dementia; enrolling residents with cognitive impairments and assessing the burden of *S. aureus* carriage within this

Table 3. Association between care-home-related factors and nasal MSSA and MRSA carriage

Factor	No <i>S. aureus</i> (<i>n</i>)	MSSA			MRSA			χ^2 <i>P</i> value
		<i>n</i>	Estimated RRR (95% CI)	<i>P</i> value	<i>n</i>	Estimated RRR (95% CI)	<i>P</i> value	
Use of communal lounge area								
Never	159	32			17			
<4 h per day	160	29	0.90 (0.55–1.47)	0.7	19	1.11 (0.58–2.12)	0.8	
4–8 h per day	158	40	1.26 (0.75–2.10)	0.4	10	0.59 (0.22–1.57)	0.3	
>8 h per day	88	20	1.13 (0.65–1.98)	0.7	11	1.17 (0.47–2.93)	0.7	0.5
Use of communal dining areas								
No meals	146	26			17			
1–2 meals	259	62	1.34 (0.86–2.09)	0.19	27	0.90 (0.43–1.86)	0.8	
≥3 meals	157	33	1.18 (0.71–1.97)	0.5	12	0.66 (0.30–1.43)	0.3	0.6
Use of other communal areas								
Never	269	51			30			
<4 h per day	215	56	1.37 (0.90–2.09)	0.14	20	0.83 (0.44–1.59)	0.6	
4–8 h per day	24	4	0.88 (0.31–2.46)	0.8	1	0.37 (0.05–2.96)	0.4	
>8 h per day	27	3	0.59 (0.16–2.16)	0.4	3	1.00 (0.31–3.24)	>0.9	0.5
Geographical area								
Bristol	237	68			37			
Gloucester	332	53	0.56 (0.35–0.90)	0.02	21	0.41 (0.22–0.76)	0.005	<0.0001
Frequent physical contact through touch with other residents or staff								
No	115	29			13			
Yes	432	89	0.82 (0.52–1.29)	0.4	44	0.90 (0.42–1.94)	0.8	0.7
Frequent hand to nasal contact								
No	178	44			22			
Yes	353	73	0.84 (0.52–1.34)	0.5	33	0.73 (0.40–1.35)	0.3	0.4
Independently wash hands								
No	324	72			40			
Yes	225	49	0.98 (0.66–1.45)	0.9	15	0.54 (0.31–0.95)	0.03	0.14
Level of dependency								
No nursing care	105	13			3			
Low	101	21	1.67 (0.69–4.07)	0.3	12	4.16 (1.34–12.86)	0.01	
Medium	229	70	2.47 (1.13–5.41)	0.02	22	3.36 (1.19–9.52)	0.02	
High	124	17	1.11 (0.44–2.80)	0.8	20	5.64 (1.89–16.87)	0.006	<0.0001
Level of dependency (dichotomized, no or yes)								
No	105	13			3			
Yes	454	108	1.92 (0.89–4.17)	0.10	54	4.16 (1.53–11.33)	0.005	0.006
Share bedroom								
No	534	111			53			
Yes	26	8	1.48 (0.71–3.10)	0.3	5	1.94 (0.51–7.33)	0.3	0.3
Ability to move around the home								
No	359	79			45			
Yes	206	41	0.90 (0.58–1.42)	0.7	13	0.50 (0.27–0.93)	0.03	0.10
Type of home								
Private	440	101			49			
Local authority	41	7	0.74 (0.26–2.16)	0.6	5	1.10 (0.47–2.56)	0.8	
Voluntary	5	1	0.87 (0.67–1.14)	0.3	0	—		
Other	83	12	0.63 (0.34–1.16)	0.14	4	0.43 (0.18–1.06)	0.07	0.5
Resident numbers grouping								
<31	143	23			15			
31–38	108	38	2.19 (1.05–4.54)	0.04	8	0.71 (0.28–1.79)	0.4	
39–51	178	30	1.05 (0.47–2.32)	0.9	12	0.64 (0.28–1.48)	0.3	
>51	140	30	1.33 (0.61–2.90)	0.5	23	1.57 (0.67–3.67)	0.3	0.006

Table 3 (cont.)

Factor	No <i>S. aureus</i> (<i>n</i>)	MSSA			MRSA			χ^2 <i>P</i> value
		<i>n</i>	Estimated RRR (95% CI)	<i>P</i> value	<i>n</i>	Estimated RRR (95% CI)	<i>P</i> value	
Staff to residents ratio grouping								
<0.75	158	27			16			
0.75–0.99	118	27	1.34 (0.61–2.93)	0.5	12	1.00 (0.42–2.41)	>0.99	
1–1.124	149	40	1.57 (0.82–3.00)	0.17	16	1.06 (0.48–2.34)	0.9	
>1.124	144	27	1.10 (0.56–2.17)	0.8	14	0.96 (0.34–2.72)	0.9	0.8
Nurse to residents ratio grouping								
<0.09	164	33			11			
0.09–0.159	128	34	1.32 (0.72–2.44)	0.4	16	1.86 (0.81–4.30)	0.15	
0.16–0.219	151	27	0.89 (0.42–1.90)	0.8	20	1.97 (0.74–5.33)	0.17	
>0.219	126	27	1.06 (0.52–2.17)	0.9	11	1.30 (0.46–3.72)	0.6	0.4

RRR, Relative risk ratio; CI, confidence interval.

Table 4. Association between variables and nasal MRSA carriage in the multivariable model

Factor	MSSA		MRSA		Wald test <i>P</i> value
	Estimated RRR (95% CI)	<i>P</i> value	Estimated RRR (95% CI)	<i>P</i> value	
Age					
Per year	1.030 (1.003–1.058)	0.03	0.964 (0.929–1.00)	0.05	0.004
Geographical area					
Bristol	Ref.		Ref.		
Gloucester	0.49 (0.30–0.81)	0.006	0.56 (0.27–1.17)	0.13	0.02
Ability to move around the home					
No	Ref.		Ref.		
Yes	0.91 (0.56–1.47)	0.7	0.53 (0.30–0.98)	0.04	0.06
Admitted to hospital in past 6 months					
No	Ref.		Ref.		
Yes	1.67 (1.03–2.70)	0.04	1.84 (0.89–3.77)	0.1	0.07
Number of residents					
<31	Ref.		Ref.		
31–38	2.21 (1.01–4.98)	0.05	0.71 (0.29–1.73)	0.5	
39–51	1.27 (0.54–2.94)	0.6	0.65 (0.26–1.63)	0.4	
>51	0.91 (0.45–1.85)	0.8	1.19 (0.54–2.64)	0.7	0.001

RRR, Relative risk ratio; CI, confidence interval.

cohort. We recruited a wide range of nursing and residential care homes, including a selection of private, voluntary and local authority homes. All care homes were approached in a random order and those homes unwilling to participate were similar to those enrolled. It is, therefore, likely that the 51 care homes recruited were an unbiased representation of the types of homes throughout Gloucestershire and Greater Bristol and representative of other homes in the UK.

In line with the Mental Capacity Act 2005, a large number of care-home residents were not recruited due to the rigorousness of our assent procedure [32].

Nonetheless, excluded residents were similar in terms of age when compared to those residents who took part in the study. A recent study found that nasal swabs alone detected only 75% of all MRSA-colonized subjects [33]. Due to the frailty and severe dementia of many of the residents enrolled in our study, researchers were only able to obtain a nasal swab for the investigation of staphylococcal carriage. Thus, our results may be an underestimate of the true prevalence of *S. aureus* in the care-home setting, but there was no practical alternative for investigating carriage in this cohort.

We performed direct culture of all nasal swabs onto non-selective and chromogenic agar. Although some previous research indicates that the enrichment broth method is more sensitive for isolation of MRSA [26], the introduction of new chromogenic agar media over the last few years has brought this finding into question. Notably the UK National Standard Methods recommend routine screening by direct plating on chromogenic medium, commenting that the advantage of enrichment over direct plating has yet to be confirmed with chromogenic medium [27]. Additionally, recent research has shown that incubation of chromogenic agars for 48 h significantly increases the sensitivity of these media [34, 35].

Clearly the control of MSSA and MRSA in care homes requires more focus on infection control interventions, such as the National Patient Safety Agency 'clean your hands' campaign [36] or the recent Health Protection Agency DVD on the 'Introduction to infection control in care homes' [37]. In addition, the confirmed relationship of MRSA with recent hospitalization stresses the importance of controlling MRSA in the hospital setting, as this should reduce colonization and morbidity in care homes.

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DECLARATION OF INTEREST

None.

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