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Baldwin, N. S., Gilpin, D., Hughes, C., Kearney, M. P., Gardiner, D. A., Cardwell, C., & Tunney, M. (2009). Prevalence of Methicillin-Resistant *Staphylococcus aureus* colonization in Residents and Staff in Nursing Homes in Northern Ireland. *Journal of the American Geriatrics Society*, 57(4), 620-626. DOI: 10.1111/j.1532-5415.2009

Published in:
Journal of the American Geriatrics Society

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Prevalence of Methicillin-Resistant *Staphylococcus aureus* Colonization in Residents and Staff in Nursing Homes in Northern Ireland

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OBJECTIVES: To determine the prevalence of, and factors associated with, methicillin-resistant *Staphylococcus aureus* (MRSA) colonization in residents and staff in nursing homes in one geographically defined health administration area of Northern Ireland.

DESIGN: Point prevalence study.

SETTING: Nursing homes.

PARTICIPANTS: Residents and staff in nursing homes.

MEASUREMENTS: Nasal swabs were taken from all consenting residents and staff. If relevant, residents also provided urine samples, and swabs were taken from wounds and indwelling devices.

RESULTS: A total of 1,111 residents (66% of all residents) and 553 staff (86% of available staff) in 45 nursing homes participated. The combined prevalence rate of MRSA in the resident population was 23.3% (95% confidence interval (CI) = 18.8–27.7%) and 7.5% in staff (95% CI = 5.1–9.9%). Residents who lived in nursing homes that were part of a chain were more likely to be colonized with MRSA (odds ratio (OR) = 1.91, 95% CI = 1.21–3.02) than those living in independently owned facilities. Residents were also more likely to be colonized if they lived in homes in which more than 12.5% of all screened healthcare staff (care assistants and nurses) were colonized with MRSA (OR = 2.46, 95% CI = 1.41–4.29) or if they lived in homes in which more than 15% of care assistants were colonized with MRSA (OR = 2.64, 95% CI = 1.58–4.42).

CONCLUSION: The findings suggest that there is substantial colonization of MRSA in nursing home residents and staff in this one administrative health area. Implementation of infection control strategies should be given high

priority in nursing homes. *J Am Geriatr Soc* 57:620–626, 2009.

Key words: methicillin-resistant *Staphylococcus aureus*; nursing homes; colonization; infection control

Methicillin-resistant *Staphylococcus aureus* (MRSA) is recognized as a major nosocomial pathogen that has caused problems in hospitals and other healthcare institutions worldwide,¹ with the United Kingdom having one of the highest rates of MRSA in Europe.² Although national plans have been drawn up in many countries, including the United Kingdom, to reduce the incidence of hospital-acquired infection^{3,4} and guidelines have been issued for the control and prevention of MRSA in U.K. healthcare facilities,⁵ the primary focus has been on prevention and spread of infection in secondary care settings. However, because many hospitals report high MRSA colonization rates in older patients⁶ and because it has been shown that *S. aureus* colonization increases with advancing age,^{7,8} concerns have also been expressed that residents in nursing homes represent an important reservoir of MRSA.^{9,10}

Nursing homes provide an ideal environment for the acquisition and spread of MRSA, with residents at greater risk of colonization for a number of reasons, including chronic illness and debilitation, multiple exposure to antimicrobial agents, and presence of pressure ulcers and indwelling devices.^{11–15} Patients discharged from the hospital who are MRSA-positive or colonized staff may introduce MRSA into a nursing home. The subsequent spread of MRSA creates a reservoir of MRSA in the nursing home,⁹ with the potential for further spread within the hospital after admission of colonized residents from the facility.¹⁶ Furthermore, MRSA colonization has been shown to be a marker of mortality risk in nursing home residents.^{17–20}

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DOI: 10.1111/j.1532-5415.2009.02181.x

Given these facts, it is surprising that only a small number of studies have examined the prevalence of MRSA colonization in nursing homes in the United Kingdom, with no studies performed in Northern Ireland. The few U.K. studies undertaken have demonstrated colonization rates in residents of 0.9% to 22%.^{16,21–23} Given that MRSA is principally spread by direct contact from person to person, primarily by the hands of healthcare workers,²⁴ none of these studies determined MRSA prevalence in healthcare workers (nurses and care assistants) and other staff in nursing homes. Furthermore, it is unclear whether the same MRSA strains colonize residents and staff. Therefore, the objectives of this study were to determine the prevalence of MRSA colonization in residents and staff of nursing homes in one geographically defined health administration area in Northern Ireland and the genetic relatedness of the MRSA isolates. Factors associated with MRSA colonization were also identified.

METHODS

Setting

This study was performed in one geographically defined health administration area in Northern Ireland, of which there are four. This health administration area has a total population of 430,500. In the United Kingdom, nursing homes are defined as facilities in which qualified nursing care is available 24 hours a day; in the health administration area studied, there were 62 nursing homes registered with the Regulation and Quality Improvement Authority, which is the independent health and social care regulatory body for Northern Ireland. All 62 nursing homes were invited in a letter to participate in the study after ethical approval from the Office for Research Ethics Committees Northern Ireland. Each of the nursing homes that agreed to take part was given written information about the study and asked to provide this to all residents and staff who were able to give informed consent. Where nursing staff deemed residents unable to give their own consent, next of kin were invited to give consent on their behalf. Residents and all categories of staff (nursing, care assistants, domestic assistants, kitchen, maintenance, and clerical staff) who gave informed consent were enrolled in the study and swab specimens from their anterior nares obtained. Residents with an indwelling urinary catheter also provided a catheter specimen of urine, with wounds and any other indwelling devices also swabbed where appropriate. Samples were collected over a 9-month period, from December 2005 to August 2006, with an infection control nurse visiting each home to collect samples on 1 day only. Therefore, samples were collected only from residents and staff present on the day of sampling. Ethical approval required complete anonymity for residents and staff; therefore, personal medical information could not be accessed.

Resident and Nursing Home Characteristics

The infection control nurse recorded details of participating residents' age and sex. Nursing home characteristics, including ownership (whether part of a chain (defined as more than two homes) or independently owned (no more than two homes) by a single owner or family), number

of beds, and healthcare (nurses and care assistants) staffing levels were also recorded. (In the United Kingdom, there are only two categories of nursing staff: registered nurses and care assistants.) Previous studies had indicated that these variables represented risk factors for MRSA colonization.^{23,25,26}

Microbiological Methods

Anterior nares, wounds, and indwelling devices were swabbed with sterile cotton-top swabs (Amies Transport swabs, Technical Services Consultants, Lancashire, UK). Catheter specimen urine was collected aseptically in sterile McCartney bottles. Swabs and urine samples were inoculated onto cefoxitin-containing chromogenic agar plates (CHROMagar, M-Tech Diagnostics Ltd, Warrington, UK), which were incubated at 35°C for 48 hours. Colonies growing on CHROMagar showing any pink or mauve coloration were considered to be MRSA and were confirmed as such according to a multiplex polymerase chain reaction (PCR) using primers to detect staphylococcal 16S, *nuc*, and *mecA* genes, as described previously.^{27,28} Recovery of isolates confirmed to be MRSA according to PCR from any of the sites sampled was taken to indicate a positive result for MRSA colonization.

Pulsed Field Gel Electrophoresis and Molecular Analysis

Genotyping of MRSA isolates from residents and staff in 10 randomly selected nursing homes was performed using pulsed field gel electrophoresis (PFGE). Genomic deoxyribonucleic acid (DNA) fragments obtained after digestion with *Sma*I (Invitrogen, Paisley, UK) were separated using PFGE as previously described²⁹ using the Chef DR III system (Bio-Rad Laboratories, Hertfordshire, UK). DNA fragments were visualized after staining with ethidium bromide and viewed using ultraviolet light. The image was captured digitally using the Bio-Rad Molecular Imager Gel Doc XR System (Bio-Rad Laboratories) and analyzed using Gel-Compar software (GelCompar II, Applied Maths BVBA, Sint-Martens-Latem, Belgium). A dendrogram of similarities between isolates from the nursing homes was constructed using the DICE coefficient of unweighted pair group method with arithmetic averages. A cutoff value of 70% of genetic similarity was chosen for discrimination between distinct clusters of strains.³⁰ PCR was also used to determine the presence or absence in the isolates of the Panton Valentin Leucocidin (PVL) gene using primers as described previously.³¹ Representative isolates of each pulsed-field group were *spa*-typed at the Statens Serum Institute (Copenhagen, Denmark) using primers and thermal cycling conditions as described previously.³²

Statistical Analysis

To determine MRSA prevalence rates in nursing home residents and staff while accounting for clustering within homes, the proportion of residents and staff with MRSA was initially calculated at the home level. Subsequently, the mean of these proportions was calculated to give a combined prevalence rate for all participating homes and the standard deviation of the proportions used to calculate 95% confidence intervals (CIs).³³ The prevalence of MRSA

colonization in registered nurses and care assistants (ignoring clustering) was compared using the chi-square test.

Analysis of the risk of residents being colonized with MRSA according to nursing home characteristics (ownership, number of beds, healthcare staff (nurses and care assistants), and MRSA-colonized healthcare staff) was performed using generalized estimating equation (GEE) logistic regression models, which allowed adjustments for clustering within homes and for individual-level confounders (age and sex).³⁴ To investigate nursing home characteristics, homes were divided into approximate thirds using tertiles, where possible. Odds ratios (ORs) with 95% CIs were calculated for each of the resident and nursing home characteristic of interest.

RESULTS

Of the 62 eligible nursing homes approached, 45 (72%) agreed to take part in the study. Participating homes ranged in bed size from 15 to 80 beds and were independently owned (28/45; 62%) or owned by healthcare companies (17/45; 38%) operating chains of nursing homes (>2) in the United Kingdom. The 45 homes had 1,678 residents, 1,111 (66%) of whom gave consent to participate in the study. The study population consisted of 330 men and 781 women, with a mean age of 81.0 ± 12.0 (range 24–102). Nasal swabs were collected from all residents, with further samples collected from urine ($n = 26$), wounds ($n = 10$), and indwelling devices ($n = 9$). MRSA was isolated in 267 of the 1,111 residents tested, corresponding to a combined prevalence rate of 23.3% (95% CI = 18.8–27.7%). The prevalence rate in individual nursing homes ranged from 0 to 73% (Figure 1), with 42 of the 45 homes having colonized residents. Twenty-five of the 45 homes (55%) had an individual resident prevalence rate greater than 20%, with a further six of these 25 homes having MRSA resident prevalence rates greater than 40%.

The 45 homes had 655 staff on duty on the day of sampling, 563 (86%) of whom gave their consent to participate in the study. The number of staff swabbed in each of the 45 homes ranged from three to 23. MRSA was isolated in 43 of the 563 staff tested, corresponding to a combined prevalence rate of 7.5% (95% CI = 5.1–9.9%). The prevalence rate for all staff in individual nursing homes ranged from 0 to 28%, with 28 of the 45 homes (62%) having colonized staff. Three of the nursing homes had staff prevalence rates that exceeded the rate for residents. Care assistants demonstrated the highest prevalence for any category of staff (27/266; 10.2%), with prevalence lower in nurses (11/126; 8.7%) and all other staff (6/171; 3.5%). However, there was no evidence of a difference between the prevalence rates in nurses or care assistants (chi-squared, $P = .84$).

Further analysis revealed several statistically significant associations between preselected resident and nursing home characteristics and the risk of MRSA colonization in residents. Resident characteristics associated with MRSA colonization were male sex (OR = 1.47, 95% CI = 1.06–2.04) and older age (e.g., 80–89, OR = 5.75, 95% CI = 1.92–17.22; Table 1). In terms of nursing home characteristics, residents who lived in nursing homes that were part of a chain were more likely to be colonized with MRSA (OR = 1.91, 95% CI = 1.21–3.02) than those living in facilities owned independently, after adjustment for age and sex (Table 2). Despite a trend toward greater risk of resident colonization as the number of beds increased and lower risk at the highest healthcare staff to resident ratio, none of these associations was significant (Table 2), although as shown in Table 3, residents were more likely to be colonized if they lived in homes in which more than 12.5% of all screened healthcare staff (care assistants and nurses) were colonized with MRSA (OR = 2.46, 95% CI = 1.41–4.29) or if they lived in homes in which more than 15% of care assistants were colonized with MRSA (OR = 2.64, 95% CI = 1.58–

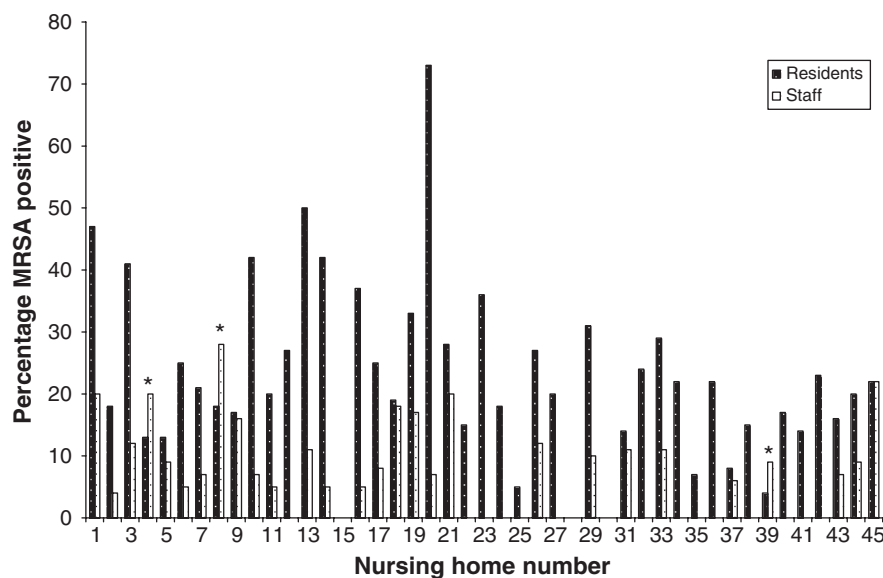


Figure 1. Individual methicillin-resistant *Staphylococcus aureus* (MRSA) prevalence rates for residents and staff in nursing homes in one geographically defined health administration area of Northern Ireland (*nursing homes in which MRSA prevalence is higher in staff than residents).

Table 1. Analysis of Resident-Specific Risk Factors for Colonization with Methicillin-Resistant *Staphylococcus aureus* (MRSA) in Residents of Nursing Homes (N = 1,111)

Risk Factor	n	Residents with MRSA n (%)	Odds Ratio (95% Confidence Interval) P-Value	
			Crude	Adjusted*
Sex				
Female	781	181 (23.2)	1 (reference)	1 (reference)
Male	330	86 (26.1)	1.23 (0.9–1.68) .19	1.47 (1.06–2.04) .02
Age				
<60	69	4 (5.8)	1 (reference)	1 (reference)
60–69	78	10 (12.8)	2.16 (0.61–7.6) .2	2.23 (0.63–7.86) .21
70–79	224	62 (27.7)	5.92 (1.95–18) .002	6.32 (2.08–19.24) .001
80–89	503	119 (23.7)	5.08 (1.71–15) .003	5.75 (1.92–17.22) .002
≥90	237	72 (30.4)	7.44 (2.4–22.5) <.001	8.77 (2.86–26.86) <.001

* Model contains age (in categories) and sex.

4.42). There was no evidence of an association ($P = .92$) between the proportion of nurses colonized with MRSA in a home and the risk of colonization in residents.

PFGE was performed on 79 MRSA isolates, originating from 71 residents and eight staff from 10 randomly selected nursing homes. In these 79 isolates, 23 different clusters were found, at a cutoff value of 70%, with the number of isolates in each cluster ranging from one to 13. There was also widespread variation in the number of clusters detected within each nursing home, with the number ranging from one to eight. In some homes, as many as nine residents were found to be colonized with the same MRSA strain, whereas

in other homes, no single predominant pulsed-field type was identified. Of the eight staff isolates, six were identical to those cultured from residents in the same homes. All MRSA isolates were PVL negative. *Spa*-typing of 23 representative isolates categorized isolates into four types: t022 (3 isolates), t032 (14 isolates), t190 (5 isolates), and t379 (1 isolate).

DISCUSSION

Few studies are currently available detailing the prevalence of MRSA in residents of nursing homes in the United King-

Table 2. Analysis of Nursing Home-Specific Risk Factors for Colonization with Methicillin-Resistant *Staphylococcus aureus* (MRSA) in Residents of Nursing Homes (N = 1,111)

Risk Factor	Nursing Homes n	Residents n	Residents with MRSA n (%)	Odds Ratio (95% Confidence Interval) P-Value	
				Crude	Adjusted*
Ownership					
Independent	28	701	137 (19.5)	1 (reference)	1 (reference)
Chain	17	410	130 (31.7)	1.99 (1.26–3.15) .003	1.91 (1.21–3.02) .006
Number of beds					
≤35	19	373	85 (22.8)	1 (reference)	1 (reference)
36–45	15	381	82 (21.5)	0.97 (0.54–1.7) .90	0.94 (0.53–1.64) .82
≥46	11	357	100 (28.0)	1.43 (0.8–2.55) .22	1.34 (0.76–2.38) .31
Healthcare staff per resident (in tertiles)					
≤0.70	14	377	103 (27.3)	1 (reference)	1 (reference)
0.70–0.80	16	400	101 (25.3)	1.06 (0.61–1.84) .84	1.07 (0.61–1.85) .82
≥0.80	15	334	63 (18.9)	0.63 (0.34–1.16) .14	0.70 (0.38–1.30) .26
Nursing staff per resident (in tertiles)					
≤0.22	14	404	104 (25.7)	1 (reference)	1 (reference)
0.22–0.27	16	386	112 (29.0)	1.33 (0.78–2.26) .29	1.47 (0.85–2.53) .17
≥0.27	15	321	51 (15.9)	0.56 (0.30–1.03) .06	0.71 (0.38–1.32) .28
Care assistants staff (in tertiles)					
≤0.46	15	377	103 (27.3)	1 (reference)	1 (reference)
0.46–0.54	15	400	101 (25.3)	1.50 (0.86–2.59) .15	1.63 (0.94–2.83) .08
≥0.54	15	334	63 (18.9)	0.85 (0.47–1.54) .59	0.88 (0.48–1.61) .67

* Adjusted for age (in categories) and sex.

Table 3. Association Between Healthcare Staff Methicillin-Resistant *Staphylococcus aureus* (MRSA) Status and Resident MRSA Status

Risk Factor	Nursing Homes n	Residents n	Residents with MRSA n (%)	Odds Ratio (95% Confidence Interval) P-Value	
				Crude	Adjusted*
Percentage of screened healthcare staff with MRSA					
0	19	426	74 (17.4)	1 (reference)	1 (reference)
> 0–12.5	14	406	102 (25.1)	1.73 (1.01–2.96) .05	1.69 (0.98–2.91) .06
> 12.5–100	12	279	91 (32.6)	2.42 (1.39–4.19) .002	2.46 (1.41–4.29) .001
Percentage of screened nurses with MRSA					
0	36	897	214 (23.9)	1 (reference)	1 (reference)
> 0–100	9	214	53 (24.8)	1.06 (0.58–1.93) .85	1.03 (0.57–1.88) .92
Percentage of screened care assistants with MRSA					
0	23	509	91 (17.9)	1 (reference)	1 (reference)
> 0–15	11	352	86 (24.4)	1.62 (0.96–2.71) .07	1.57 (0.94–2.64) .09
> 15–100	11	250	90 (36.0)	2.59 (1.55–4.32) <.001	2.64 (1.58–4.42) <.001

* Adjusted for age and sex.

dom, and none has examined MRSA prevalence in staff. In this study, an overall prevalence of 23.3% of residents and 7.5% of staff was observed. Men and older residents were more likely to be colonized. Residents living in facilities that were part of a chain or that had more than 15% of care assistants colonized with MRSA were also at greater risk of colonization.

The prevalence of MRSA in residents in this study was higher than that reported in most other nursing home studies outside of the United Kingdom. Similar studies in other countries have reported MRSA prevalence rates in nursing homes ranging from 1.1% in Germany³⁵ to 4.9% in Belgium,⁶ 6.2% in Israel,⁹ 8.6% in Ireland,⁸ and 22.7% in the United States,³⁶ which may reflect differences in national approaches to the control of MRSA and changing patterns in prevalence over time. In the present study, a large variation in prevalence was also observed between homes, ranging from as high as 73% in one home, to three homes in which no MRSA colonized residents were identified. A recent study from England has also reported high prevalence (22%) in 39 care homes which included 15 nursing homes, but the data were not presented separately for these facilities; as has been reported in this present study, being male was associated with MRSA colonization. Additional risk factors identified included a low ratio of nurses to beds, being in a home in a deprived area, the presence of an invasive device, and being in the hospital for more than 10 days during the previous 2 years.²³

In the present study, being in a home that was part of a chain was found to increase the risk of MRSA colonization in residents. It is unclear why this may be the case. This nursing home characteristic has been found to be associated with other markers of nursing home quality.^{37,38}

This study is unique in that it examined prevalence rates in different categories of nursing home staff. The highest rates of carriage were observed in care assistants, although there was no statistically significant difference between the rates observed in nurses and care assistants. The lowest rates were noted in all other categories of staff, although the numbers in the latter were low. There was a weak association between healthcare staff-to-resident ratio

and the risk of colonization, with a trend (nonsignificant) toward a lower risk of colonization at the highest ratio (i.e., more healthcare staff available). This was also the case when care assistants' and nurses' data were examined separately in relation to colonization. This trend has also been reported in a previous study²³ that found that a low ratio of nurses to beds was independently associated with MRSA colonization. However, of greater significance is the finding that a greater percentage of colonized MRSA healthcare staff (notably care assistants) was associated with a greater likelihood of residents being colonized. Care assistants provide much of the hands-on care to residents in nursing homes, so this may partly account for the association with resident colonization. It might also be the case that many care assistants know little about infection control (compared with nurses), but this was not assessed in this study. A recent review noted that MRSA colonization of healthcare staff generally (not limited to the nursing home setting) was 4.6%, a lower figure than observed in the current study.³⁹ These authors also reported that transmission from healthcare staff to patients was likely in 63 of 68 studies that were reviewed, although it is not possible to state definitively the direction of transmission in this study.

PFGE analysis revealed widespread variation between MRSA isolates identified, with the number of clusters detected within each nursing home ranging from one to eight. Although only a small number of staff isolates were analyzed using PFGE, in the majority of cases, staff and residents were colonized with the same strains. The wide diversity of MRSA strains circulating within nursing homes suggests that transmission of MRSA is not confined to within the facility.¹⁰ The nursing home is not a closed system; there is a constant turnover of residents and individuals who appear to have unique MRSA strains. These individuals may have the same MRSA strain as residents who are no longer in the home or were not available for sampling on the day of the researcher's visit. Many residents may have been in prolonged contact with some facet of the healthcare system (e.g., hospital) before entry into the nursing home, and this may also account for the diversity of MRSA strains observed. The *spa*-types detected in this

study, t022, t032 (ST-22), and t190 (ST-8), are frequently associated with healthcare infections in Ireland and the United Kingdom,⁴⁰ which suggests that residents have acquired these isolates as a result of contact with the healthcare system. Indeed, failure to detect isolates with *spa* types associated with community-acquired infections or PCR products of genes that encode for proteins responsible for PVL toxin production often present in community-acquired MRSA⁴¹ would suggest that the principal source of colonization is likely to have been direct or indirect contact with hospitals or other healthcare facilities.⁴²

Colonization by MRSA primarily in the anterior nares is the major risk factor for MRSA infection, and recent work has linked colonization directly with higher mortality, particularly in residents with impaired cognitive function.²⁰ This colonized state may be transient or persistent, and during this time, there is a major risk of transmission to other individuals, most often through the hands of staff. In the hospital setting, systems are in place to routinely screen those deemed most at risk of MRSA colonization, and standard infection control policies are clearly defined for management of those patients.^{3,4} This approach is largely absent from the nursing home environment,^{43,44} and as a result, a large reservoir of colonized individuals may go unrecognized in these facilities.

There are a number of limitations to this research. The study was confined to one geographical area in Northern Ireland, although the prevalence rate reported is similar to those in some other U.K. studies.^{16,23} Swabs were taken from residents and staff who were available and who provided written, informed consent on the day of the researcher's visit; therefore, the data presented are not a complete picture of MRSA prevalence in the participating homes. Furthermore, not all eligible nursing homes consented to take part in the study. Swabs were collected only from the nose, wounds, and indwelling devices, with none collected from the throat or other potential carriage sites. It is therefore possible that the prevalence rate calculated is an underestimate of the true prevalence, because a number of studies have shown that more-comprehensive swabbing improves the sensitivity of detection.^{45,46} In addition, there was no information about the transfer of MRSA between nursing home and hospital. Nursing home residents are at high risk of admission to the hospital,^{10,25} and therefore, given the high number of MRSA-positive residents in the current study, transfer of these residents to the hospital may contribute to the further spread of MRSA.

CONCLUSION

This is one of the largest studies of MRSA prevalence in U.K. nursing homes, confirming that MRSA is a problem in this setting. Furthermore, to the best of the authors' knowledge, this is the first study that has reported prevalence of MRSA in staff in a number of nursing homes. With little or no attention being given to infection control in nursing homes, MRSA prevalence is unlikely to decrease in this setting. A recent Cochrane review has indicated that there have been no high-quality intervention studies undertaken to examine the effect of a comprehensive infection control program in nursing homes.⁴⁷ The second phase of this research study, in which a randomized control trial will mea-

sure the effect of an infection control intervention on MRSA prevalence within the nursing home environment, will address this deficit.

ACKNOWLEDGMENTS

We wish to thank Gerry McGrillen, School of Pharmacy, Queen's University Belfast, for technical assistance.

Conflict of Interest: The editor in chief has reviewed the conflict of interest checklist provided by the authors and has determined that the authors have no financial or any other kind of personal conflicts with this paper. This study was supported by a Health and Personal Social Services Research and Development Office, Northern Ireland, Doctoral Fellowship Award to Naomi Baldwin.

Author Contributions: Baldwin N, Gilpin DF, Hughes CM, and Tunney MM: study concept and design, acquisition of data, analysis and interpretation of data, preparation of manuscript. Kearney MP: study concept and design, analysis and interpretation of data. Gardiner DA: study concept and design. Cardwell C: analysis and interpretation of data, preparation of manuscript.

Sponsor's Role: None.

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