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NHS Scotland MRSA Screening Pathfinder Programme

Final Report Volume 1: An Investigation of the Clinical Effectiveness of Universal MRSA Screening

Prepared for the Scottish Government HAI Task Force
by Health Protection Scotland

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1 Executive summary

This large prospective cohort study (pathfinder study) of MRSA screening in three NHS boards, including six acute hospitals in NHSScotland and 81,438 admissions (one third elective and two thirds emergency), indicated an overall MRSA colonisation prevalence of 3.9%. The starting colonisation prevalence of 5.5% reduced to 3.5% by month twelve of the study.

Factors influencing the prevalence of colonisation included: number of admissions per patient, specialty of admission, age, source of admission – other hospital or care home. Patients older than 65 years were twice as likely to be colonised as those under 50 years. Almost two thirds of all MRSA colonisations were in patients with repeat admissions to hospital. Those presenting from care homes or from other hospitals comprised a small (2%) proportion of admissions to hospital overall, but were three times more at risk of being colonised on admission. The programme identified around 2% prevalence in patients with no prior history of MRSA infection or colonisation.

Patients who were colonised on admission were 15 times more likely to develop hospital associated MRSA infection (i.e. arising >48 hours after admission). However, around half of all the MRSA infections detected were in those admissions who screened negative on admission. This could be due to the effectiveness of the screening test and is the subject of a special study.

The role of cross transmission during the hospital stay also requires further investigation. This will help determine the interventions which would maximise the reduction of infections not preceded by confirmed colonisation. However, it is reasonable to propose that at least the majority of infections in those screening negative could be prevented by reducing colonisation, in the population at risk, to very low levels and by maximising measures to reduce risks of transmission within the hospital.

A number of the 'community onset' MRSA infection cases may have been associated with colonisation associated with previous healthcare interventions – one third of these infections were in patients who had been in hospital within the previous 30 days. Further research is required on the risks of colonisation and infection in the community, particularly for patients with multiple admissions, to clarify if continued decolonisation after discharge would be appropriate for some categories of patient.

MRSA infection incidence was 7.5 per 1,000 patient days over the year but, as with colonisation rates, significantly reduced within the year across the pathfinder boards. MRSA bacteraemia was already reducing in NHSScotland prior to the implementation of the pathfinder study, but there were early indications of a temporal association between the initiation of the universal screening and a decline in MRSA infections,

as defined by the number of first clinical isolates from hospital-based laboratory MRSA cases as a proportion of all *S. aureus* during the study. The reduction reached statistical significance within all pathfinder hospitals, although of course this does not necessarily prove that the screening caused the reduction. However, the decreasing trend persisted during the period after the introduction of the screening. Furthermore, the patients had similar baseline characteristics during the time of the study and the decreasing trend was not seen in the comparator control acute hospitals within the pathfinder NHS boards. No statistically significant change in meticillin sensitive *Staphylococcus aureus* (MSSA) occurred in any of the pathfinder boards. This is consistent with other smaller studies published to date, but requires monitoring longer term.

The two interventions following screening for MRSA are (i) decolonisation (suppression) of confirmed positive cases, and (ii) isolation of those at high risk of, or confirmed as being, colonised.

Decolonisation therapy was initiated for 44% of patients who screened positive during their hospital stay, and for 46% of those who screened positive pre-admission. Shortening length of stay in hospital plays a part in reducing the risk of infection whilst the patient is in hospital, but reduces the availability of laboratory information (turnaround time 48 hours) and the ability to complete decolonisation (minimum of five days for treatment and at least eight days for repeat testing). It may be argued there is little point in screening if an intervention cannot follow in a timely manner so as to reduce risk of disease, and only 3.1% of those who screened positive at admission successfully completed the decolonisation process by demonstrating three negative screening samples. Nonetheless, those patients initiated on decolonisation (as opposed to completion) had a significantly lower infection incidence during their stay (2.7 versus 4.2 infections per 1000 patient days), implying that even partial application of the regimen may be effective in decreasing risk of infection in these patients by suppressing colonisation.

Use of the topical antibiotic mupirocin significantly increased following the initiation of MRSA screening, as more patients were identified for decolonisation. No significant increase in mupirocin resistance was seen within the pathfinder boards during the year of the intervention; however, antimicrobial resistance may increase with longer term mass usage to suppress colonisation during hospital stay. Mupirocin resistance levels in NHSScotland remain low at around 3% at present; however, careful monitoring will be required throughout the remainder of the pathfinder programme and in the longer term as policy develops.

The second intervention associated with the screening is physical (single room) or functional (cohort) patient isolation. Around half of those patients identified as colonised were isolated at some point during their stay. Where single room facilities were not available, the patients were cohorted or 'separated' from exposure to other patients through enhanced infection prevention and control measures.

Factors affecting isolation during hospital stay included the availability of single room facilities and (as with the decolonisation intervention) short lengths of stay relative to laboratory test turnaround times. Given the lack of strong evidence for efficacy of these interventions and delays in implementation for patients with a short stay in hospital, questions arise about how best to maximise the overall impact of the interventions in reducing risks of infection.

Nasal screening alone identified 86% of all confirmed cases of colonisation. Other cases were identified through screening wounds, other body sites and invasive devices. Many of those identified as colonised were discharged before their results were known, and therefore the role of clinical risk assessment in assessing the likelihood of colonisation at the point of admission becomes an important consideration in the context of a microbiology test with an average turnaround time of two days for positive cases. One or more of the risk factors found to be important in determining colonisation status on admission (age over 80 years, readmissions within the year, and admission from a care home or other hospital) were found in 78% (2,124 of 2,717) of confirmed colonisations but also in 54% (36,098 of 66,728) of those who were negative. More research is required to refine a clinical risk assessment tool that could be used as an adjunct to or in place of laboratory based screening and is subject to a special study within this programme.

Epidemiological data from the HPS antimicrobial resistance (AMR) surveillance programme suggests that there were no changes in the incidence of infections caused by organisims other than MRSA as a result of introducing screening, and MRSA was not replaced by MSSA. However, one year is a short time frame and these organisims will require monitoring in the longer term.

The majority of the public health principles which should underpin a national screening programme have been largely met, although questions remain about the most clincally and cost effective approach in the current acute healthcare delivery context.

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5 Background

Staphylococcus aureus (*S. aureus*) is a gram-positive bacterium carried by 30% [1] of the healthy human population. Colonisation or carriage of *S. aureus* means that the organism is present on the body (at any site) but is causing no adverse affects to the individual. If *S. aureus* enters the body it may cause infection. Infections with *S. aureus* can range from relatively minor soft tissue infections to life threatening bloodstream infections.

The introduction of penicillin in the 1940s to treat staphylococcal infections led to the rapid development of resistance, firstly to penicillin and then to newer antibiotics as they became available. The introduction of meticillin in 1959 initially appeared to have solved the problem. However, in 1961 meticillin resistant *S. aureus* (MRSA) was identified and subsequently epidemic strains have emerged. MRSA strains have been endemic in United Kingdom (UK) healthcare facilities since the 1990s.

Infections due to MRSA, in comparison with meticillin sensitive *S. aureus* (MSSA), are associated with greater risk of treatment failure, increased patient mortality and higher costs [2-7] Across Europe, MRSA continues to be a major public health contribution to healthcare associated infection (HCAI) [8]. Around a third of European countries, including Scotland and the rest of the United Kingdom, have a high endemic proportions of 25% or higher in bacteraemias. A quarter of European countries have observed an increasing trend in MRSA proportions. The UK has seen a decreasing trend over the last few years [9].

MRSA can be categorised as being hospital associated (HA-MRSA), community onset (CO-MRSA), or community associated (CA-MRSA). Community associated (CA-MRSA) strains are distinct from the HA-MRSA strains with regards to epidemiology, microbiology and clinical manifestation. The prevalence of CA-MRSA remains low in Europe and is estimated to be below two percent in the UK [10-12].

5.1 Epidemiology of MRSA in Scotland

S. aureus bacteraemias in NHSScotland are monitored by Health Protection Scotland (HPS) and publically reported on a quarterly basis [13]. *S. aureus* bacteraemias are monitored because, although they do not include all the infections in an institution, they are at present the best indicator for invasive infection. *S. aureus* infections, other than those in the bloodstream, include infections in a wide range of anatomical sites [14]. MRSA is a particular challenge in hospitals as patients with open wounds, invasive devices and weakened immune systems are at greater risk of infection than the general public.

MRSA bacteraemia rates within NHSScotland were relatively stable in 2004 when the Health Technology Assessment (HTA) on MRSA screening [15] was commissioned by the Healthcare Associated Infection (HCAI) Task Force, and had been for the previous three years. This was against a background of rising incidence throughout the 1990s.

Since the introduction of the Health Improvement Efficiency Access and Treatment Target (HEAT) in 2005/06 [16] aimed at reducing *S. aureus* bacteraemia in Scotland by 30% by 2010,

the numbers of MRSA bacteraemia reported to HPS and isolates referred to the Scottish MRSA Reference Laboratory (SMRSARL) have decreased [13]. The annual decrease since 2005 has been 12.1% (95% Confidence Interval (CI) 8.7-15.5). The number and rate of MRSA bacteraemia reported in the period 1 July 2008 to 30 September 2008 [13] was the lowest reported since the initiation of the national surveillance programme in 2001. These data also indicate that the specialities where MRSA bacteraemia were most commonly found in Scotland were general medicine, renal medicine and general surgery.

The annual number of *S. aureus* bacteraemias (both MRSA and MSSA) reported in Scotland has decreased by 6.9% per year (2006-2009), (95% CI 3.1-10.6) against the HEAT baseline of 1 April 2005 to 31 March 2006 [13] , although it is worthy of note that the reduction in MSSA bacteraemia is not of the same magnitude as MRSA, and is not statistically significant.

Information from referrals to the Scottish MRSA Reference Laboratory indicates that the most common MRSA strain types found in NHSScotland patients over the last few years are the healthcare associated epidemic strains EMRSA 15 and EMRSA 16, and that community associated strains (PVL) have a low prevalence in Scotland.

Selection of drug resistant strains of MRSA may arise as a result of usage of antibiotics for both prophylaxis and treatment. The time course for evolution and spread of an antibiotic-resistant strain is unpredictable, but antibiotic use needs to adapt in a timely fashion to both national and sometimes local changes in prevalence of resistance [17] .The prevalence level at which an antimicrobial drug treatment ceases to be the drug of choice in a patient group is debatable, but a level of ten percent resistance has been used empirically as a guide for avoiding use [17].

High level plasmid mediated resistance is therefore monitored in NHSScotland. HPS currently monitors antimicrobial resistance of *S. aureus* from bacteraemia for key classes of antibiotics [13]. Current data suggest that the proportion of MRSA bacteraemia isolates resistant to mupirocin is approximately 5% (around 3% of all clinical isolates are resistant). This trend varies between NHS boards and there is considerable local variation within the boards. The overall rate of resistance has remained relatively low and intelligence from all isolates indicates this has been around three percent; however, if mupirocin resistance was to reach levels of around ten percent, this may have consequences for decolonisation following positive screening results [17] as it could not be used empirically and may result in treatment failure.

The changing epidemiology and microbiology of MRSA in Scotland and worldwide provides an important context for decision making with regard to interventions for prevention and control. Patients who are colonised or have MRSA infection act as a reservoir of the organism whilst in hospital. Transmission occurs from: patient to patient directly, indirectly via the hands of hospital staff after contact with a patient who is colonised or infected, or after handling contaminated materials [18], or by direct patient contact with contaminated environment. Infection prevention and control measures are aimed at minimising the risk of transmission to prevent healthcare associated infection.

Healthcare Associated Infections (HCAIs) cause damage and distress to patients and their families. The associated morbidity and mortality also have an impact socially and economically.

The last prevalence survey of HCAI in NHSScotland [14] indicated that one in ten patients at any one time in acute hospitals and one in thirteen patients in non acute hospitals have a HCAI. These infections were estimated to cost £183 million per annum in acute hospitals [14] due to attributable extended length of stay in the NHS in Scotland.

It has been estimated that at least one in five patients with an HCAI in hospital, at any one time, have a confirmed laboratory diagnosis of MRSA [14]. Recorded mortality associated with MRSA has shown a rise over the last five years [19]. Whilst this may be due to raised awareness with reporting, 196 deaths were recorded as being associated with MRSA in hospitals in Scotland for 2008 [19]. A further 18 deaths which were recorded outwith hospital settings add to this burden [19]. Therefore MRSA remains an important public health issue and is of public concern.

5.2 Policy – control of MRSA

NHSScotland is undertaking a range of activities aimed at reducing HCAI. The main advisory body to the Scottish Government (SG) addressing these issues is the HAI task force. The HAI task force was established in 2003 and its remit includes the co-ordination of the development and implementation of an Action Plan to reduce HCAI across NHSScotland.

The outputs of the HAI task force encompass generic guidance and policies which also apply to the control of MRSA – e.g. the HCAI Code of Practice [20], the National Cleaning Services Specification [21] and the linked compliance monitoring scheme, the National Hand Hygiene Programme [22] and Model Policies for Standard Infection Control Precautions [23] and Transmission Based Precautions [24]. NHS Quality Improvement Scotland (NHS QIS) has also recently published revised HCAI Standards [25] with an underpinning self assessment framework to assist compliance with those standards. MRSA guidance is included in the Scottish Management of Antimicrobial Resistance Action Plan (SCOTMARAP) (2007) [26] which builds on the 2005 policy for acute hospitals Antimicrobial Prescribing Policy and Practice [27].

The Scottish Government has also established a HEAT target specifically including MRSA, which requires a 30% decrease in all *S. aureus* bacteraemia (MRSA and MSSA) cases by March 2010 [16]. A national strategy on MRSA comprising a portfolio of recommended interventions has been in development for some time; however, completion of this document is critically dependent on a policy decision on MRSA screening and will follow in due course.

Interventions to prevent infection and control spread of MRSA include: surveillance, infection prevention and control, screening, and isolation or cohorting of patients. There is considerable uncertainty over the effectiveness of any single infection prevention or control measure. It is difficult to determine the contribution of individual measures compared with others when they do not act independently [28;29] and are often implemented concurrently [30]. Cooper *et al*, 2003 [28] found evidence that a combination of infection prevention and control efforts can substantially reduce MRSA prevalence. The Society for Healthcare Epidemiology of America (SHEA) guidelines [31] have noted that multiple studies implementing surveillance (inclusive of screening) and contact precautions have resulted in

a significant reduction in the rates of both MRSA colonisation and infection. The European Centre for Disease Prevention and Control have recently tendered for guidelines to be produced for the prevention and control of MRSA [32]. These guidelines should be released by end of June 2010.

Screening identifies patients who are colonised or infected, who can then be managed to reduce the risk of endogenous infection and transmission to other individuals. Laboratory based screening involves taking swabs from potential sites of colonisation, and analysing these in the laboratory. Universal screening of all patients for MRSA colonisation continues to be debated in the literature [33-35]. The most recent UK guidance on MRSA [36] suggests targeted screening; however, this has not been implemented in a consistent manner nationally. Currently, MRSA screening practice within NHSScotland is locally defined by NHS boards and as a result there is considerable variation in practice. It is generally targeted on the basis of risk assessment of the likelihood of MRSA carriage and its assumed significance in a particular group of patients.

Universal screening of hospital patients for MRSA has had recent policy development in all four UK countries.

Table 5-1: UK guidance for MRSA Screening

UK Health Department	Title of Guidance	Weblink	Comments
Department of Health (England)	MRSA screening - operational guidance [37]	http://www.dh.gov.uk/en/Publicationsandstatistics/Lettersandcirculars/Dearcolleagueletters/DH_092844	Routine screening for all elective patients except – day case ophthalmology, day case dental, day case endoscopy, minor dermatology procedures, children/ paediatrics, maternity/ obstetrics (except elective caesareans and high risk cases), mental health patients
Department of Health, Social Services and Public Safety (N Ireland)	Best practice guidance on screening for MRSA colonisation [38]	http://www.dhsspsni.gov.uk/hss-md-12-2008.pdf	Trusts to review screening policies to be in line with risk assessed approach
Welsh Assembly Government	Methicillin-Resistant *Staphylococcus aureus* (MRSA) screening [39]	http://www.dhsspsni.gov.uk/hss-md-12-2008.pdf	Follows Hospital Infection Society Guidance – No formal screening guidance in place
Scottish Government Health Directorates	New funding for the National MRSA Screening Programme [40]	http://www.sehd.scot.nhs.uk/mels/CEL2008_55.pdf	Preparation for screening

The decision on MRSA screening policy development in Scotland has been influenced by public concern regarding MRSA and the publication of the Scottish NHS QIS HTA [15] on the clinical and cost effectiveness of MRSA screening. Scotland is, to date, the only country within the UK undertaking a study to investigate the basis for universal MRSA screening in practice. A recent Parliamentary report has recommended that the Department of Health produce a report regarding England's first year of screening specifically on its cost effectiveness and to consider the effect on patients [41].

5.3 Background to the Health Technology Assessment of MRSA Screening

In July 2004, the then Scottish Executive commissioned NHS QIS to undertake an HTA [15] to assess the most clinically effective and cost effective strategy to screen patients for MRSA colonisation on admission to hospital. This request was made in response to conflicting advice from professional bodies regarding the effectiveness and costs of microbiological testing and perceived variation in practice between Scottish hospitals [36].

A Steering Group was convened by NHS QIS with representation from: clinicians, professional bodies, the Scottish Executive, other NHS organisations, patient support groups and external advisors to oversee the development and publication of the HTA.

The HTA involved a critical review of evidence of clinical and cost benefits associated with MRSA screening programmes, and assessed the potential impact of the findings in terms of patient management, the patients themselves and the NHSScotland. Evidence identified by systematic literature searching and provided by experts and patient interest groups was critically appraised. Peer review and wide public consultation were undertaken to ensure that all views were considered.

Patient issues and concerns were considered both by critical review of the research relating to public understanding of MRSA and from experience of staff and public in the management of MRSA in hospitals. Focus groups were commissioned to directly ascertain the opinions of staff and members of the public.

A survey conducted in 2005 was used to assess the level and type of MRSA screening undertaken in Scottish hospitals. Data from the survey and other information sources were used to asses the organisational issues associated with delivering an effective MRSA screening programme within NHSScotland.

5.4 Results of the HTA

An economic model based on that of Cooper *et al*., 2003 [28] was developed, incorporating clinical parameters derived from a series of systematic reviews of the literature. However, most publications reported on observational studies, infection outbreaks or routine information collection and, as a result, the literature base was considered methodologically weak. Costs associated with undertaking screening tests, nursing patients in isolation or cohort and providing decolonisation were incorporated into the model.

Six screening strategies were tested and the most clinical and cost effective strategy for screening was shown to be universal screening utilising chromogenic agar. The most clinically effective strategy for reducing MRSA prevalence rates was screening using clinical risk assessment and microbiological testing of all patients. This included isolation of those identified as potential carriers; however, the model predicted that screening all patients by microbiological testing without pre-emptive isolation while being only marginally less effective would incur lower costs. Screening by microbiological testing of only those patients admitted to high-risk specialty units was the least effective strategy for reducing MRSA prevalence.

The impact of MRSA on hospital resources was measured as the number of days needed to treat patients whose hospital stay was prolonged as a result of MRSA infection. Assuming colonisation prevalence on admission of 7.1%, not implementing a screening and isolation policy in a 750 bed tertiary referral hospital would result in 1,671 MRSA infections over five years when compared with treating the population in the absence of MRSA. Screening all patients using chromogenic agar would reduce the total number of MRSA infections to around 80, saving £2.9 million, which would allow around 4,000 additional patients to be treated in the hospital over five years. Strategies using chromogenic agar as the laboratory test resulted in fewest infections and the lowest costs. The total costs to NHSScotland of screening all patients for MRSA on admission to hospital using a chromogenic agar test were estimated to be approximately £14.3 million in the first year reducing to £9.7 million by the fifth year, giving a total of £55 million over a five year period.

Evidence was found to show that patients do not always understand the nature and implications of MRSA colonisation or infection, or the requirement for contact precautions. Both the literature and focus groups highlighted the fear that individuals have of MRSA infection, which is associated with the stigma of individuals with infection being perceived as 'contaminated'. The focus group emphasised the absence of clear information about MRSA and their reliance on sources such as the media and the internet.

A review of the implications for NHS hospitals of screening all patients for MRSA identified the following issues: ethical considerations, such as the right of the individual to make an informed choice and the balance of benefit over harm associated with MRSA screening and subsequent patient management; a requirement for additional laboratory staff, facilities, equipment and consumables; an increase in nursing resources; and additional isolation facilities to accommodate patients who test positive for MRSA.

The HTA economic model indicated that microbiological screening of all patients would be the most effective strategy. However, the report detailed significant limitations associated with this work including: the weak evidence base for many of the model parameters; the simplification of patient management in the economic model structure; the assumptions made regarding the effectiveness of isolation to reduce transmission; and the narrow focus of the assessment (i.e. no consideration was given to other HCAI or alternative interventions for infection prevention and control).

The report recommendations, published in October 2007 [15], were as follows:

Recommendation 1

A primary study should be set up in acute in-patient care within a whole NHS board area (which should include a tertiary referral hospital and one or more large general hospitals) to assess whether screening all patients for MRSA is effective in preventing MRSA infection as predicted by the economic model. Data from this study should be collected for at least one year to decide whether MRSA screening results in a reduction in prevalence of MRSA. The Scottish Government should fund and manage this study.

Recommendation 2

There is currently insufficient evidence on staff MRSA transmission to determine an appropriate schedule of screening and subsequent management. Therefore, current guidelines indicating screening on occasion of unexplained outbreaks should be followed. Further research on the extent and implications of staff colonisation is urgently required.

Recommendation 3

Systems should be developed to collect patient-based data on the prevalence of MRSA colonisation and infection to determine the effectiveness of infection prevention and control strategies. The resource implications of establishing such systems are recognised; however, these are necessary to plan and evaluate future strategies to control MRSA.

Recommendation 4

High-quality patient information on MRSA, the purposes of screening and methods to achieve infection prevention and control should be distributed to all patients and relatives on admission to hospital.

Recommendation 5

Care of patients isolated as a result of MRSA colonisation or infection should not result in their being or feeling unnecessarily disadvantaged. Much distress will be avoided with high-quality patient information and effective communication between healthcare staff and patients about their condition and its management.

This HPS MRSA Screening Programme of work aims to address recommendations one, three, four and five. Recommendation two requires a special research study.

6 Introduction

6.1 Development of an MRSA Screening Programme in Scotland

Implementation of MRSA screening is estimated to cost on average £16 million per annum for a population of around 1.3 million in-patient acute admissions [42] across 45 acute hospitals in Scotland [15]. This annual cost is estimated to decrease over a five year period resulting in a total expenditure of £55 million over the five year implementation period. This is a significant investment of health service monies; therefore, in order to develop the pathfinder project, HPS examined the public health principles of implementing a national MRSA screening programme to ensure robust characterisation of its effectiveness and viability.

The UK National Screening Committee (NSC) published a comprehensive list of criteria [43] for appraising the viability, effectiveness and appropriateness of a screening programme. As part of the development of this work on national MRSA screening, HPS mapped the HTA findings against these criteria to identify any gaps, establish objectives and identify priority areas for focus in the pathfinder project. These were detailed in the interim report [44].

Table 6-1: Timeline of events leading to development of MSRA Pathfinder Screening Programme

S. aureus bacteraemia surveillance begins and rates remains stable	2001
QIS asked to undertake HTA	July 2004
QIS HTA published	October 2007
HPS asked to undertake pathfinder programme	November 2007
HPS develops protocol and recruits pathfinder boards	December 2007
Pathfinder boards submit tenders	March 2008
Pathfinder boards tenders awarded	April 2008
Planning and recruitment in pathfinder boards	June 2008
DOH England announce implementation of screening for elective patients by March 2009, and phased implementation on screening for all patients	July 2008
Strategy 2 implemented in pathfinder boards	August 2008
Interim Report published on formative results	March 2009
SGHD announce interim policy	March 2009
DOH England target date of implementation of screening in elective patients	March 2009
Report published on summative results	December 2009
DOH target date for implementation of all emergency admissions	July 2011

6.2 Public Health Principles

Public Health Screening Programmes are formally approved by the UK National Screening Committee (NSC) prior to implementation within the NHS. MRSA screening does not meet their definition of a screening programme and as such does not require their approval. Nonetheless, HPS considered it important to develop the MRSA Screening Programme using public health principles and therefore used the framework to develop the MRSA Screening Programme.

Criteria for the condition, test, treatment and screening programme overall were examined, and a number of gaps were identified as priority areas for evaluation in order to inform rollout of the MRSA Screening Programme. A full description of these were given in the interim report [44].

6.3 Approach to the Development of a National MRSA Screening Programme

HPS adopted an evaluation approach to the development of this programme. This formative evaluation was published in the interim report in April 2009. This report is a summative evaluation.

Formative evaluations strengthen or improve the intervention. They help develop it by: examining the delivery of the programme or technology, the quality of its implementation and the assessment of: organisational context, personnel, procedures and input. The formative evaluation as presented in the interim report, encompassed short-term monitoring of system wide effects in the three pathfinder project NHS boards. This short-term monitoring (six months) drew upon a variety of data sources including document review, observation and other local intelligence at the pathfinder sites as well as indicators from routine information systems.

This final report presents the year long summative evaluation which complements the shorter-term monitoring, by providing more reliable information on the model assumptions over at least one year of data collection. It also assesses the programme rollout in relation to the public health principles of implementing a national screening programme [43]. Intelligence takes account of emerging issues in healthcare, technology and epidemiology which could impact on the implementation of the national MRSA screening programme in NHSScotland.

This report presents the results from the NHSScotland MRSA screening programme to date, inclusive of the results from the pathfinder project in three NHS boards (NHS Ayrshire and Arran, NHS Grampian and NHS Western Isles) and other intelligence gathered by HPS in order to inform the rollout of the MRSA screening programme in acute hospitals within NHSScotland. This report includes "Red Flag" issues which were identified by pathfinder boards during the implementation of universal screening. "Red Flag" issues are defined as issues identified with a high impact on the delivery on the implementation of the delivery of the universal screening programme.

6.4 Vision of the MRSA Screening Programme

The vision of the programme is to make changes to hospital MRSA screening practices which enable healthcare workers to identify and reduce MRSA colonisation in in-patients in acute care to a minimal level; whereupon, the risk of MRSA infection to hospital in-patients is low enough to prevent healthcare associated MRSA infection in the in-patient population; thereby reducing the negative impact on patients and any additional burden on healthcare resources.

7 Pathfinder Programme Aims and Objectives

7.1 Pathfinder Programme Aims

The public health aim of the MRSA screening programme is to reduce MRSA infections in acute care in NHSScotland. To achieve this in the longer term, the MRSA Screening Pathfinder Programme aims were:

1. To investigate the clinical effectiveness of MRSA screening as an intervention on outcomes (colonisation / infection / bacteraemia rates) in pathfinder boards (*addressed in Volume 1*).
2. To test the estimates of the NHS QIS HTA economic model assumptions in pathfinder boards (*addressed in Volume 2*).
3. To determine the acceptability of screening for MRSA all acute in-patient admissions in pathfinder boards to patients and staff (*addressed in Volume 3*).
4. To evaluate the feasibility and potential for rollout of the MRSA screening programme in the non-pathfinder boards (*addressed in Volume 4)*.

Aims 1 to 3 (presented in Volume 1-3 of this report), have been delivered through the pathfinder project in three NHS boards over at least one year, with some additional data from comparator Boards and the National MRSA reference laboratory.

Aim 4 (presented in Volume 4 of this report), has been addressed through intelligence gathering from the literature and special studies during the pathfinder project timeline.

7.2 Objectives

Table 7.1 to Table 7.4 contain the objectives of the MRSA Screening Programme.

7.2.1 Aim One Objectives

Aim one: To investigate the clinical effectiveness of MRSA screening as an intervention on outcomes (colonisation / infection / bacteraemia rates) in pathfinder boards.

Table 7-1: Pathfinder programme objectives relating to the Aim one

	Objective
1	To identify the prevalence on admission of MRSA colonisation amongst the patients being admitted (by age, sex and specialty).
2.	To describe the proportion of patients by specialty and colonisation status who develop MRSA infection.
3	To evaluate the impact on outcome (MRSA colonisation/infection/bacteraemia) of the screening programme.
4	To monitor the trends in mandatory surveillance data outputs undertaken by HPS examining the key indicators of HCAI. This will include; *S. aureus* bacteraemia, Surgical Site Infection (SSI).
5	To monitor mupirocin antibiotic usage over the study period.
6	To evaluate the success of decolonisation.
7	To assess the validity of nasal swabs for universal screening.
8	To assess the validity of the testing strategy described by NHS QIS HTA.
9	To identify new epidemiology.
10	To evaluate other emerging issues from the published literature relating to the screening programme.
11	To evaluate if the public health principles of introducing a screening programme are met.
12	To monitor any increase of mupirocin resistance.
13	To assess the impact on selected hospital epidemiology of introducing MRSA screening of inpatients.
14	To monitor the trends in pathfinder board laboratory confirmed infection data on organisms other than MRSA pre and post MRSA screening intervention.

7.2.2 Aim Two Objectives

Aim two: To test the estimates of the NHS QIS HTA economic model assumptions in Pathfinder boards.

Table 7-2: Pathfinder programme objectives relating to the Aim two

	Objective
1	To identify the proportion of patients admitted electively who attend pre-assessment clinics and the proportion that are screened.
2	To identify the proportion of emergency admission and specialty transfer (between hospitals) patients who are screened on admission.
3	To monitor the turnaround time (TAT) for reporting from sample collection to reporting by laboratories and where the potential delays are in the system.
4	To identify the proportion of patients with a positive MRSA screen identified at a pre-assessment clinic who are not subsequently admitted as planned.
5	To identify the proportion of patients screened for MRSA who are admitted to high risk and low risk specialty wards.
6	To evaluate the proportion of those patients pre-emptively isolated who subsequently are identified as MRSA colonised.
7	To evaluate the proportion of MRSA positive patients who receive decolonisation.
8	To evaluate the distribution of patient length of stay by specialty i.e. who can be screened and treated.
9	To describe the number of single bed rooms available per ward.
10	To evaluate the proportion of patients identified as colonised who are isolated or cohorted.
11	To describe the reasons for not isolating colonised patients
12	To evaluate the proportion of patients identified as colonised and not decolonised (and the reason for this).
13	To describe the reasons why all in-patient admissions are not screened.
14	To examine the potential for new technologies or approaches to offer better value for money.
15	To identify new technologies to take account of for MRSA screening.
16	To quantify the staff time taken to carry out screening for MRSA colonisation (versus previous risk assessment time).
17	To carry out an economic analysis of the cost effectiveness of the programme in the context of other possible interventions to reduce MRSA in NHSScotland.

7.2.3 Aim Three Objectives

Aim three: To determine the acceptability of screening for MRSA all acute in-patient admissions in Pathfinder boards to patients and staff.

Table 7-3: Pathfinder programme objectives relating to the Aim three

	Objective
1	To develop evidence based information on the programme for patients.
2	To develop a communications package and materials for the programme.
3	To assess the impact on the staff of introducing MRSA screening of all patients (ward nurses, managers, bed managers, surgeons, theatre staff, microbiology laboratory staff, laboratory managers, infection control nurses/ doctors/ managers, public health nurses/ consultants, General Practitioners (GPs) and other community staff, NHS procurement, NHS 24 calls, HPS enquiries)
4	To assess the clinical, social and ethical acceptability of MRSA screening in staff and patient groups.
5	To assess the impact of the screening programme on overall patient experience.
6	To assess any negative impact on patients from introduction of MRSA Screening.
7	To evaluate the acceptability of isolation from the patient, family and wider population perspective.
8	To assess the staffing needs/ training for MRSA screening.
9	To evaluate the best approach for engaging patients in the process.

7.2.4 Aim Four Objectives

Aim four: To evaluate the feasibility and potential for rollout of the MRSA screening programme in the pathfinder boards.

Table 7-4: Pathfinder programme objectives relating to the Aim four which will be addressed within the interim report.

	Objective
1	To identify how many patients each year will be screened and their characteristics.
2	To describe current practice in the Pathfinder site and how much additional resource is required to implement MRSA screening of all acute in-patients.
3	To assess the projected supply of equipment and consumables needed to implement screening.
4	To describe the resources required for implementation of the programme.
5	To describe the organisational structures that will be established in the Pathfinder sites for the purpose of implementation.
6	To evaluate the staffing needs/ training at pathfinder board level rollout.
7	To assess the technological needs for the initiation of the Pathfinder screening project.
8	To assess the equipment required for the Pathfinder project.
9	To assess the requirements for the procurement process involved.
10	To evaluate what data collection processes are needed initially for the Pathfinder Boards and totally for monitoring MRSA screening.
11	To determine the process for patient management when the patient is found positive at a pre-admission clinic.
12	To determine the process for patient management when the patient is discharged without a result and this is subsequently found to be positive.
13	To develop a Standard Operating Procedure (SOP) on chromogenic agar product, testing and organism identification, including confirmation of isolates in MRSA colonisation and infection.
14	To assess and fulfil the legal and ethical requirements for the programme
15	To assess if primary and secondary prevention measures are specified, resourced, in place and monitored in the Pathfinder Boards.
16	To assess the impact on service delivery of introducing MRSA screening of all patients. Inclusive of the following:
a)	the impact on current working practice and impact on workload in laboratory.
b)	the impact upon cancellation/delayed rates for surgical procedures and scheduled admissions.
c)	the impact on the pre-admission clinics
d)	the impact on Accident and Emergency units.
e)	the impact on GP services.
f)	the impact on pharmacy services.
g)	the impact on the patient pathway.
17	To monitor any unintended consequences/impacts of introducing MRSA screening of patients (pathfinder boards and HPS).
18	To develop a standard discharge protocol for those with unknown colonisation status and those not completing treatment.

	Objective
19	To describe current practice in Scotland and determine how much additional resource is required for rollout of MRSA screening.
20	To define the scope for future screening in terms of who and where (inclusions and exclusions).
21	To assess whether there is adequate staffing and resources for the wider implementation of the programme.
22	To project how many patients each year will be screened and their characteristics.
23	To project the supply of products needed to implement screening and the national procurement implications.
24	To describe the organisational structure needed for governance of the programme nationally.
25	To describe the board level management arrangements are required.
26	To evaluate the staffing needs/ training at board level rollout.
27	To assess the technological needs for the programme.
28	To determine the equipment required for the programme and the costs of that equipment.
29	To determine the start-up costs and capital investment required.
30	To project the operating costs of the ongoing screening programme.
31	To develop a plan for quality assurance of the programme.
32	To evaluate what data collection processes are needed for long term monitoring MRSA screening.
33	To evaluate the availability of laboratory facilities in NHSScotland.
34	To assess if primary and secondary prevention measures are specified, resourced, in place and monitored in NHSScotland.
35	To project the revenue implications for the programme post 2011
a)	SGHD / boards and how much shall be required
b)	MRSA reference laboratory implications
c)	HPS in Key Performance Indicator (KPI) monitoring role

8 Methods

Three NHS boards inclusive of six acute hospitals participated in the pathfinder project which was initiated in April 2008. Details on the recruitment approach and initiation of this project were given in the interim report [44]. These pathfinder boards together accounted for 13% of adult acute hospital admissions per year in Scotland and served around an eighth of the Scottish population. These boards were:

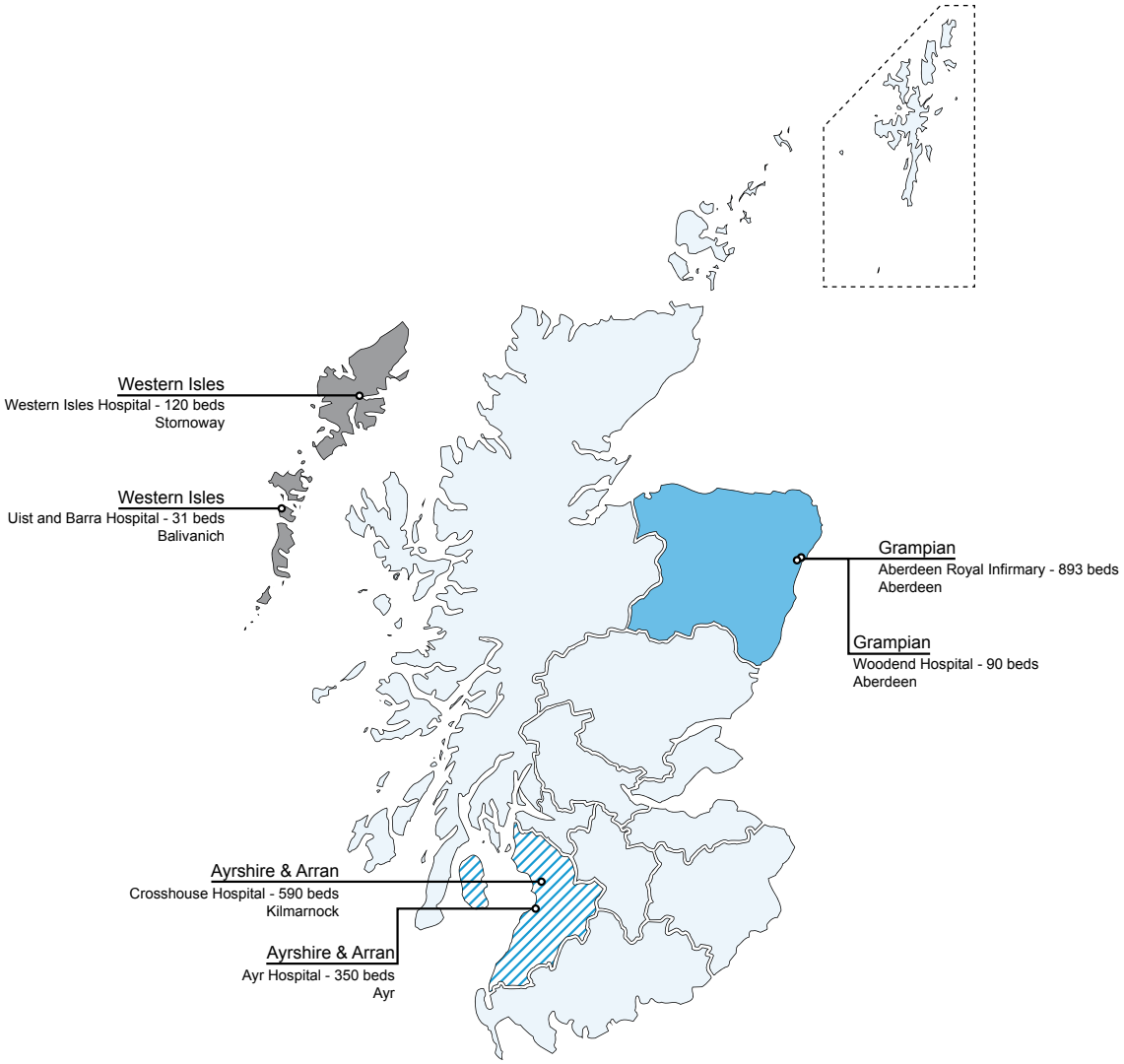
- NHS Grampian including Aberdeen Royal Infirmary, (a teaching hospital with 893 beds which admitted 47,543 in-patients in 2007) and Woodend Hospital Aberdeen, a multiple specialty hospital (within Woodend Hospital only Elective Orthopaedics specialty is included within the pathfinder project – this includes 90 beds, which admitted 4,210 in-patient admissions in 2007).
- NHS Ayrshire and Arran including two district general hospitals: Ayr Hospital, (a district general hospital with 350 beds which received 21,616 adult in-patient admissions in 2007) and Crosshouse Hospital, (a district general hospital with 590 beds which receive 38,329 adult in-patients admissions in 2007).
- NHS Western Isles, an Island NHS board, including Western Isles Hospital, (a consultant-led rural General Hospital with approx 120 beds which receives 4475 admissions per year) and Uist and Barra Hospital, (a GP-led community hospital with acute care provision hospital with 31 beds which receives 400 adult admissions per year).

The selection of three NHS boards promoted a representative collaborative model for the MRSA Screening Pathfinder Programme. The following methods were implemented within the three pathfinder boards. All the issues encountered in implementing this strategy were recorded at a local level and reported to HPS. The HPS team worked closely with the pathfinder boards, and developed the pathfinder study protocol in collaboration with the teams in the pathfinder boards and colleagues in NHS QIS. Governance was provided by both local project steering boards and through the overall MRSA Programme Steering Board.

8.1 Inclusion and Exclusion Criteria

8.1.1 Board level

Figure 8-1: Location of pathfinder NHS boards – Grampian, Western Isles and Ayrshire and Arran



8.1.2 Hospital Level Inclusions

Ayrshire and Arran

- Ayr Hospital
- Crosshouse Hospital

Grampian

- Aberdeen Royal Infirmary
- Woodend Hospital Aberdeen, (orthopaedic unit)

Western Isles

- Western Isles Hospital
- Uist and Barra Hospital

8.1.3 Hospital Level Exclusions

All hospitals in NHSScotland outwith those outlined above.

8.1.4 Specialty Level Inclusion Criteria

The specialties of the pathfinder hospitals were classified as high and low risk as described within the HTA document [15] (table 6-2 page 56 of the QIS HTA). There was considerable discussion and debate within the teams as to the placing of the specialties within the pathfinder boards. In particular, Cardiology was moved to high risk due to the severity of the illness of patients within the specialty and the use of invasive devices, and Ear Nose and Throat (ENT) was moved to low risk. There were a number of specialties catered for within the pathfinder boards which were not considered within the HTA model, for example oral surgery and hyperbaric medicine. The criteria used by Coia *et al* (2006) [36] were used to map these specialties into the pathfinder project high and low risk specialties. Patient speciality was defined as the speciality of the consultant caring for the patients.

Table 8-1: Specialties to be included within pathfinder project showing high and low risk of MRSA colonisation categories

High Risk	Low Risk
Anaesthesia	Accident and Emergency
Cardiac surgery	Care of the elderly
Cardiology	Clinical Pharmacology
Coronary care unit	Communicable diseases
Gastroenterology	Dermatology
General surgery (excluding vascular)	Diabetes medicine
Gynaecology	Endocrinology
Haematology	ENT (Ear Nose and Throat)
High dependency unit	General medicine
Intensive care unit	General practice
Medical oncology	GUM (Gen to-Urinary Medicine)
Nephrology (renal)	Hyperbaric Medicine
Neurosurgery	Infectious Diseases
Oncology	Medical other
Ophthalmology	Neurology
Oral surgery and medicine	Obstetrics specialist
Orthopaedics elective	Orthodontics
Orthopaedics trauma	Radiotherapy
Plastic surgery and burns	Rehabilitation medicine
Renal	Respiratory medicine
Thoracic surgery	Restorative dentistry
Urology	Rheumatology
Vascular surgery	Spinal paralysis
Maxillofacial	Stroke

8.1.5 Specialty Level Exclusion Criteria

Obstetrics, Psychiatric and Paediatric specialties were excluded from the study, as these were excluded from the HTA model [15].

8.1.6 Admission Level Inclusion Criteria

Definition of admission: An in-patient admission occurred when a patient who occupied an available staffed bed in a hospital and remained overnight whatever the original intention; or who was expected to remain overnight.

This included:

- All elective admissions in acute hospitals
- All emergency admissions in acute hospitals
- Transfers from another hospital

8.1.7 Admission Level Exclusion Criteria

- Day patients who were discharged on the day they were admitted
- Non acute services

8.1.8 Patient Level Inclusion Criteria

All in-patients admitted to an acute adult specialty. Patients were given the right to refuse screening. The number of patients who refused screening was recorded.

8.1.9 Patient Level Exclusion Criteria

Patients refusing to consent for screening

8.2 Study Design and approach

8.2.1 Sample Size

This was a prospective cohort study design over one year within three NHS boards. This exceeded the recommendations within the HTA [15] of one year of data collection within one NHS board and the therefore the sample size was deemed sufficient to test the HTA model assumptions. A total of 100,000 patients were estimated to be treated as in-patients within the three pathfinder boards throughout the 12 month duration of the study. These accounted for 13% of adult acute hospital eligible admissions per year in Scotland and the chosen hospitals served around an eighth of the Scottish population.

8.2.2 Recruitment

The pathfinder boards commenced recruiting additional workforce requirements and identified the management structures to support the project from its initiation in April 2008. The run in time for this part of the project was expected to be three to four months.

8.2.3 Training

The pathfinder boards developed a training plan, trained the additional staff according to the protocol and confirmed changes to working practices for the purposes of the project. Prior to commencement, educational sessions were conducted and information leaflets provided to healthcare professionals working within the three pathfinder boards. This provided them with information about the study and emphasised the importance of the work.

The HPS Programme Manager and Epidemiologist trained the data collectors within the pathfinder boards in using the data collection tool and definitions used.

8.2.4 Communication Plans

- A Communication plan for staff and public was developed by the pathfinder boards in conjunction with HPS.
- A generic patient information leaflet on the Pathfinder Screening Programme was produced in collaboration between the pathfinder boards and HPS.
- Pathfinder boards continued to use their current information leaflets to inform patients of the implications of having a positive MRSA test.
- A monthly MRSA screening pathfinder board meeting with HPS and the SGHD was scheduled during the initiation phase of the project to resolve issues, monitor progress and identify risks to the study.
- A monthly MRSA Screening Technical Group meeting with HPS and the SGHD was scheduled to resolve issues, monitor progress and identify risks to the study relating to the epidemiology, microbiology and other technical issues.
- The pathfinder project managers were in contact with the HPS Project Manager on a fortnightly basis to develop the project and monitor progress.

8.3 HTA Strategy 2: universal screening

The pathfinder boards were asked to follow the strategy recommended by QIS [15]. The HTA found that Strategy 2 (of the six possible strategies investigated) was both the most cost effective and clinically effective approach to MRSA screening.

Strategy 2 recommended universal screening for all overnight admissions in adult specialties (excluding psychiatric, obstetric and paediatrics). Those patients identified as MRSA positive (either colonised or infected) were to be isolated. Patients who were being cared for under a specialty deemed as high risk were also to be decolonised and patients who were cared for under a specialty deemed as low risk should be isolated but not decolonised (see QIS HTA [15] page 142 Figure 13-2).

This methods section describes the actual methods initiated within the pathfinder boards and details of where it was necessary for the pathfinder boards to differ from the model assumptions underpinning the HTA Strategy 2.

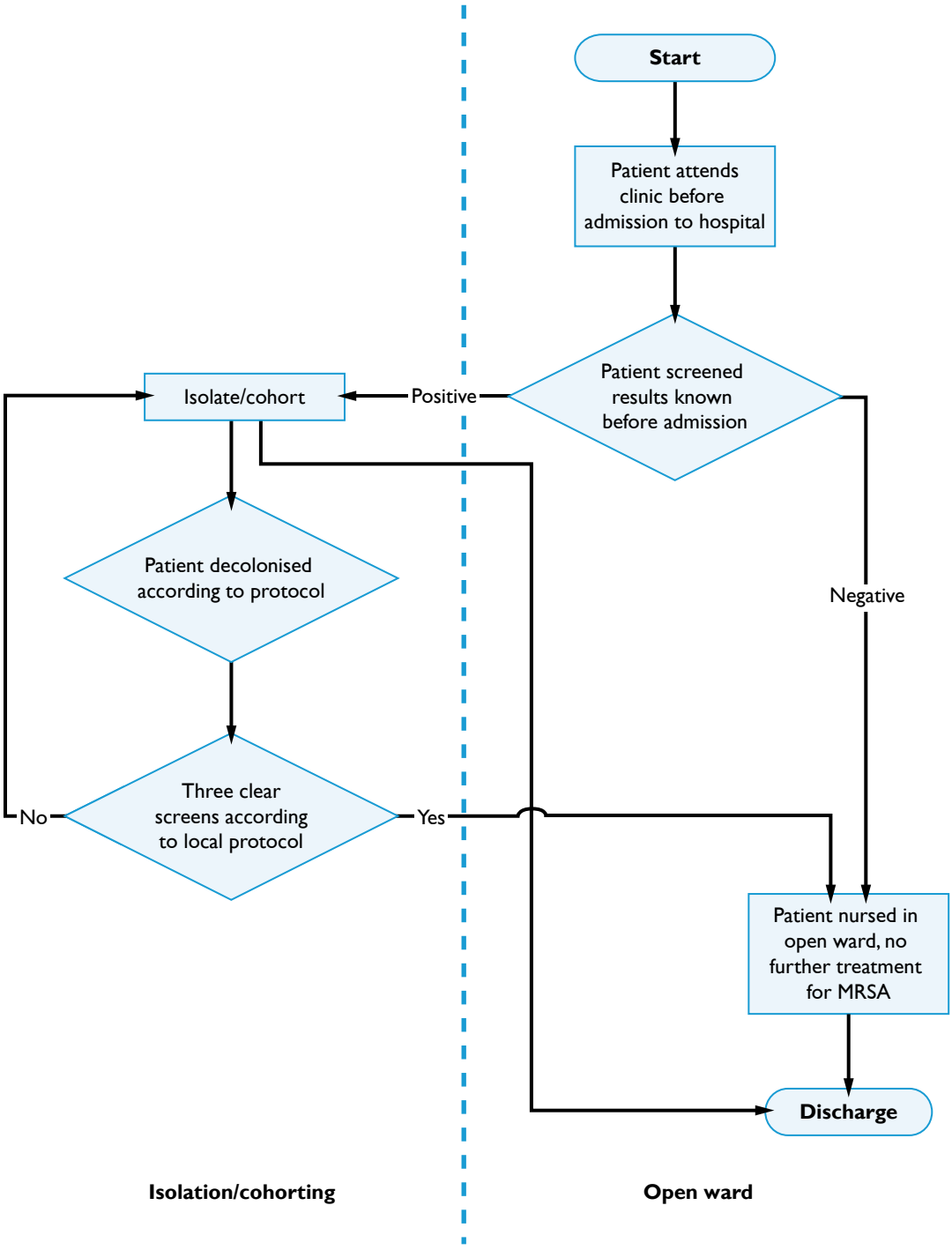
8.3.1 Admissions

Each patient admission to hospital was considered as a single patient episode. It was acknowledged from the initiation of the programme that many patients may have multiple admissions within the year of the pathfinder project data collection; therefore, mechanisms were put in place to monitor this. Patients were categorised as 'elective' or 'emergency' for each admission.

8.1.2 Elective Admissions

Eligible patients for elective admission to acute hospitals in the pathfinder boards were screened for MRSA colonisation, at a pre-admission clinic where possible. Patients found to be MRSA positive were contacted by the local pathfinder teams and provided with decolonisation. If patients did not receive three consecutive negative screens post decolonisation before they were due to be admitted, they were considered to be colonised and therefore automatically isolated or cohorted on admission and their decolonisation continued if appropriate. Patients who were admitted electively but who had not attended a pre-admission clinic, or attended a pre-admission clinic and had not been screened, were screened on admission.

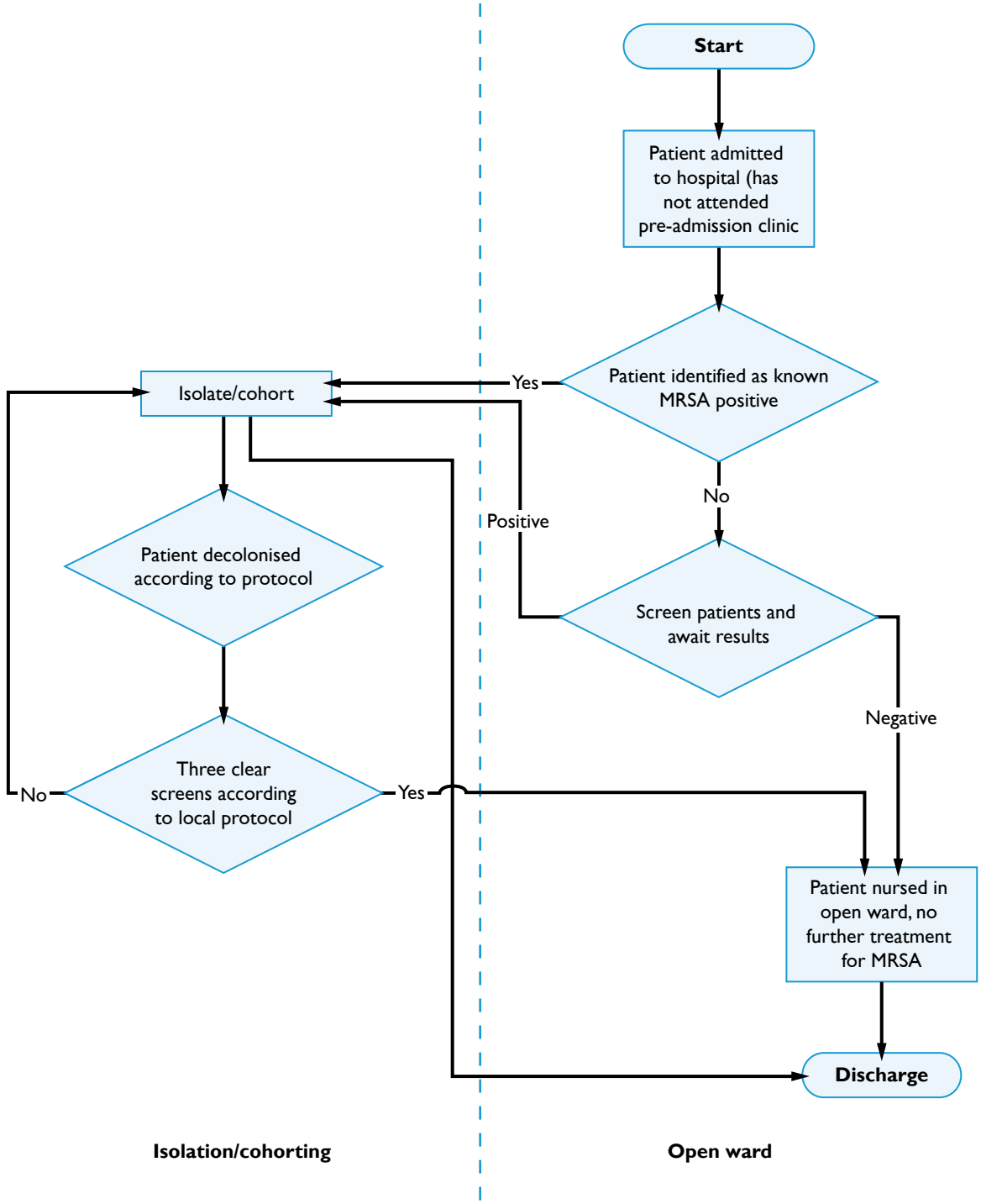
Figure 8-2: Flowchart of the patient pathway for pre-admission screening according to Strategy 2 HTA recommendation for MRSA screening



8.3.3 Emergency Admissions

Patients being admitted as emergencies from home or through inter-hospital transfer were screened on admission to their receiving unit or ward.

Figure 8-3: Flowchart of the patient pathway for emergency admissions according to Strategy 2 HTA recommendation for MRSA screening for patients.



8.3.4 Patient Information and Communication

Upon admission to a pathfinder hospital, all patients received the "MRSA Screening – Information for Patients" leaflet [45] containing information about the study detailing what MRSA is, why it is important to screen for MRSA, and why the study was being undertaken. An MRSA Project team contact was available to provide further information and answer questions. This leaflet is now a national one produced by HPS. The leaflet has been made available in the main languages spoken in Scotland, in Braille and large font [45].

If a patient was found to be MRSA positive during their stay they were given a further information leaflet providing detailed information on MRSA colonisation and the implications of that diagnosis for them and their treatment. If patients were undergoing decolonisation they received a specific information sheet on the correct use of the decolonisation. These information leaflets were already in use in the pathfinder boards.

8.3.5 MRSA Screening Method

Sample collection was the responsibility of the staff member admitting emergency patients or running pre-assessment clinics, or of a designated 'screener' within the pathfinder boards.

Screeners were trained to take a nasal swab correctly (See [46] SOP for Nasal Screening) and compliance was monitored throughout the study period by the project teams at each board. Each screen required a few minutes with each patient to gain verbal consent, discuss the reasons for taking the swab, collect the swab, complete a laboratory request form, and place the sample in the dispatch box.

An MRSA screening sample was taken from the anterior nares of both nostrils using one swab. Any wounds or sites of invasive devices were also sampled on separate swabs. If additional sites were swabbed according to local policy and the patient was found positive as a result of these swabs the results were recorded on the data collection form for the pathfinder project.

All samples from the wards were collected as soon as possible, by normal portering services, and transferred to the microbiology laboratories within the boards.

Patient refusal to be screened was documented on the data collection forms. In such cases the patient was individually clinically assessed according to the local board protocol and isolated or cohorted if appropriate.

8.3.6 Patient Management from Admission to Screening Results

The QIS HTA estimated that the turnaround time from swabbing the patient to reporting the results would be 24 hours. During this time the patients MRSA status is unknown to the clinical team. Patients who were previously known positive on admission were pre-emptively isolated until their screening result was available. The pathfinder boards continued to manage patients as they had done before implementing the QIS HTA Strategy 2 by undertaking their current clinical risk assessment and isolating patients they identified as high risk of MRSA colonisation. Patients who had no previous history of MRSA and no risk factors were nursed on the open ward, and remained there unless a positive MRSA screening result was reported.

A limitation of the model is that there is period where patients MRSA status is unknown, and during that time patients are nursed on the open ward. The HTA assumed that patients remained in the receiving ward until their result was known and, if testing positive, they would be isolated. Bed management processes within the acute care sector of the NHS and availability of single room facilities do not necessarily match these assumptions.

8.3.7 Testing Procedure/ Laboratory Protocols

The swab(s) were plated directly onto selective for MRSA chromogenic agar, and any characteristic colonies were further tested to confirm their identity by the latex slide test, followed by a disc diffusion test for antibiotic sensitivity on isolates identified as MRSA. (See [46]: SOP for Laboratory Testing).

8.3.8 Communication of Results to the Wards

All results, both positive and negative, were made available on the laboratory reporting system (to which all relevant ward staff have access) immediately upon confirmation of the test results by laboratory staff. Positive MRSA results within the pathfinder boards were communicated directly by phone to nurses on the wards. The time when the laboratory entered MRSA test results on the laboratory system and the result was communicated to the ward was recorded. This was used to calculate turnaround time from the screen to confirmed test result. The decision to isolate or institute decolonisation (whichever was first) was taken as a proxy for time to clinical decision making on the basis of laboratory result.

8.3.9 Patients Developing MRSA Infection

Patients were followed within the study throughout their stay in the hospital. MRSA infections were reported to the infection control team from the ward staff after a positive report from the laboratories on non screening samples. This information was used to identify patients who developed MRSA infection during their hospital stay. Data were collected on the pathfinder data collection form for any MRSA infection arising during the patient's hospital stay. Data were not collected on infections arising after discharge from hospital.

8.4 Management of Patients Found to be Colonised

8.4.1 Isolation and Cohorting

MRSA positive patients were isolated whenever possible. If isolation was not possible, cohorting of patients was undertaken as a second line of infection prevention and control practice. Isolation or cohorting was recorded in detail from admission; the reason for leaving isolation was recorded and used to report the feasibility of isolation/cohorting according to HTA Strategy 2.

On those occasions where single rooms were not available, when operationally possible, wards with several patients colonised with MRSA nursed those patients together in one bay and dedicated a specific nurse to care for the patients (cohort nursing). When cohort nursing was not possible patients were nursed in a separated area or bay and nursed using standard infection prevention and control precautions by clinical staff working on the open ward [47]. If a side room or cohort area was not available, or if the patient needed to be observed, the individual was nursed on the open ward. For these patients local infection prevention and control practices were observed, gloves, aprons and alcohol gel were placed at the end of the bed and the patient was commenced on decolonisation where appropriate [47].

The feasibility of balancing the needs of patients positive for MRSA against the availability of single rooms was investigated. It was recognised that isolation and side rooms would often be required for reasons other than MRSA isolation, e.g. for very ill patients or patients with other infections.

8.4.2 Decolonisation (suppression) Protocols

Each pathfinder site undertook decolonisation according to current guidelines [36;47]. The QIS HTA [15;36;47]Strategy 2 describes therapy with mupirocin nasal ointment administered three times daily for five days in conjunction with five days use of antiseptic wash. Decolonisation was always undertaken with patient and clinician agreement. The HTA [15;36;47] Strategy 2 recommended decolonisation of high risk patients only. This strategy was adopted in NHS Ayrshire and Arran from 1 August as this was considered to be their current practice but NHS Grampian and NHS Western Isles continued to decolonise all

MRSA positive patients from 1 August 2008. This approach was initially considered a valuable opportunity to compare the two approaches (see interim report [36;44;47]). However after one month of implementation in Ayrshire and Arran, it became apparent that patient movement within the hospital, from low risk to high risk specialties within an admission period, precluded the practical implementation of this approach and a decision was made to decolonise all patients admitted to low risk and high risk specialties who screened positive.

8.4.3 Elective Admission Decolonisation

Patients found to be MRSA positive at a pre-admission clinic admitted to all specialties were contacted by the local pathfinder teams and provided with a course of decolonisation. Patients were provided with decolonisation either by recorded delivery directly from the pathfinder pharmacy (Ayrshire and Arran) or by posting a pre-paid prescription to the patient (Grampian and Western Isles). If patients did not receive three consecutive negative screens before they were due to be admitted they were automatically isolated or cohorted on admission and their decolonisation continued where appropriate.

8.4.4 Emergency Admission Decolonisation

Patients admitted as emergencies without a current or past history of colonisation were screened in the ward to which they were admitted. Patients found to be positive were managed by isolation or cohorting with other MRSA positive patients and underwent decolonisation.

8.4.5 Post-Decolonisation Testing

MRSA testing post decolonisation was commenced at least two days after the cessation of the five days of decolonisation. This required three repeat nasal swabs taken at an interval of at least 48 hours between each sample. When a patient had three consecutive negative post-decolonisation samples the patient was advised that MRSA decolonisation had been successful, although this was qualified by an explanation of accuracy of the screening test. If a test result was positive, and provided there were no contraindications, a further course of decolonisation was attempted as above. Normally a maximum of two decolonisation courses were given. If a patient remained positive after the second course, appropriate infection prevention and control advice was offered to the patient. If there were reasons to persist with decolonisation, then advice on subsequent therapy was sought from the Consultant Microbiologist within the pathfinder board.

8.4.6 Data Collection

A Core Dataset was required for every eligible patient and was collected by pathfinder boards according to the project data collection procedures defined in the protocol and reported to HPS monthly. Data collection was carried out for one year. Data collection began on 1 August 2008 in the three pathfinder boards.

8.4.7 Changes to Initial Protocol

NHS Ayrshire and Arran followed their initial protocol for the first two months of the study. During this time it was noted that it was not practical to only decolonise patients who were deemed high risk and changed to decolonising all patients who were found to be MRSA colonised. A detailed analysis of the issues surrounding this was included in the interim report [36;44;47]. An exception report was prepared for the Pathfinder Programme Board and SGHD which was accepted. As a result, patients found to be MRSA colonised and being admitted to any specialty within Ayrshire and Arran from 28 of October 2008 were decolonised according to the SOP for decolonisation in every pathfinder board.

8.4.8 Primary Care Interface

The pathfinder boards notified their local GPs and practice managers of the project as volumes of identified colonised patients were expected to increase. Practice continued in the boards as before the pathfinder, whereby those patients who were positive during their stay had this noted on the discharge summary, and those whose results were returned after discharge had a letter sent to their GP from the hospital to inform them.

9 Data collection

Data collectors were employed by each pathfinder board to undertake the follow-up of the eligible in-patient admissions. Data were collected prospectively for each eligible inpatient beginning on 1st of August 2008 (with the exception of Grampian who, despite initiating screening in all areas at this time were unable to collect data on this date due to issues around data collector recruitment, and data were collected retrospectively for the first few months). Full implementation of universal screening was achieved by September 2008 in all pathfinder boards. Data collection was undertaken on weekdays and data were entered by hand onto a TELEform® data collection form (See Interim report Appendix 8: [36;44;47]Data Collection Form).

Data collectors followed a local protocol consistent with local patient management and laboratory information management systems. Information on newly admitted patients came from local patient management systems. New cases of MRSA isolates were flagged by laboratory reports to the infection control teams for assessment of infection and data were collected by staff trained by the HPS Programme Manager and Epidemiologist in the interpretation of the Centre for Disease Control (CDC) nosocomial infection definitions (See Interim Report Appendix 4 [44]).

9.1 Data management

Data were collected using TELEform® data collection forms. These forms were posted by registered delivery, in line with data protection requirements, from the pathfinder boards to HPS on a weekly basis. Forms were then scanned into the TELEform® database at HPS and verified to examine the accuracy of scanning. After successful verification of each data collection form, the data were transferred into HPS's central SQL® database. A Microsoft

Access database was developed to run standard queries against the SQL® database which were run on a fortnightly basis to check data quality. A data management standard operating procedure (SOP) was followed by the HPS data manager. After the SOP was applied, the local nominated project manager at the pathfinder hospital was notified of any anomalies electronically and asked to supply responses and updates for these by return. The updates were then added to the master Microsoft Access® database on a monthly basis by running an update against HPS's central database which corrected records. At the end of the defined period of data collection, a procedure was run against the HPS central database within Microsoft Access® to create an extract file for further data analyses.

10 Other sources of data used for the pathfinder project

10.1 Routine laboratory data from the pathfinder boards

Laboratory data from the pathfinder NHS boards (Ayrshire and Arran and Grampian) were used as an outcome measure within the project. The pathfinder boards agreed at the outset to flag screening samples for the study within their laboratory systems in order to be able to differentiate screening samples from other clinical samples. First clinical isolates of MRSA and MSSA (non screening samples) were used as an outcome proxy measure for infection with historical comparators within the pathfinder hospitals (pre and post the intervention of universal screening) and for non pathfinder comparator hospitals within the NHS pathfinder boards. Non pathfinder hospitals were the acute care hospitals within the board not participating in the universal screening. For Grampian this was Dr Grays hospital and for Ayrshire and Arran this was Ayrshire Central Hospital. These data were exported from the laboratories within the pathfinder boards to HPS and de-duplicated. Community (GP) samples were excluded from these analyses.

10.2 Antibiotic usage data from pathfinder pharmacies

At the outset of the pathfinder project it had been agreed that the Hospitals Medicines Utilisation Database (HMUD) would be used to monitor antibiotic usage. However implementation of this national project has been delayed and as a result data were exported from the pathfinder pharmacy systems to HPS for the purposes of the study. Data on Daily Defined Doses (DDDs) per 100 occupied bed days were used to monitor mupirocin usage before and after the introduction of universal screening in each board.

10.3 National mandatory surveillance datasets

National data held on *S. aureus* (MRSA and MSSA) bacteraemia, and Surgical Site Infection (SSI) (hip arthroplasty) were used to examine differences between the pathfinder and non pathfinder boards during the time before and after the implementation of universal MRSA screening for this study. These surveillance systems are mandatory and use consistent standardised case definitions for infection within NHSScotland; the datasets are comprehensive, covering every laboratory and every NHS board in Scotland. All the datasets are historic and thus, in addition to providing non pathfinder hospital comparisons, provide a historical comparator prior to the intervention of universal screening.

S. aureus bacteraemia national data in Scotland are collected via the Electronic Communication of Surveillance System (ECOSS) which is an electronic reporting mechanism connecting all the laboratories in Scotland to HPS. This data are then de-duplicated and reported as episodes each quarter by HPS.

Surgical site infection data are collected prospectively by every NHS board in Scotland using clinical CDC definitions for SSI. Data are collected on in patient infections for all procedures. For hip arthroplasty readmission surveillance to day 30 post operatively is also conducted by all NHS boards. Therefore only in patient rates of SSI are included for this procedure within this report to ensure consistency in reporting between NHS boards.

10.4 Routine laboratory data available via The Electronic Communication of Surveillance in Scotland (ECOSS)

Data on other antimicrobial resistant organisms were examined using the ECOSS dataset. ECOSS is a national laboratory extract dataset held within HPS. It holds data on selected organisms from all NHS laboratories in Scotland. Data on Gram positives and Gram negative bacteria were analysed by the Antimicrobial resistance (AMR) team within HPS and defined according to EARSS episodes [48].

10.5 Infection control audit data

An independent auditor was employed by HPS to audit infection control practice at two points during the pathfinder project. This involved visiting the pathfinder hospitals and directly observing practice with respect to use of isolation facilities and compliance with standard infection control precautions. Compliance was recorded on a paper data collection form and reported to HPS and the pathfinder boards. These data were used to provide a narrative with respect to outcome within the study.

10.6 Scottish MRSA reference laboratory (SMRSARL) data

The national MRSA reference laboratory is commissioned by Health Protection Scotland (HPS) to provide national MRSA reference services and is based in the Microbiology Department of NHS Greater Glasgow and Clyde at Stobhill Hospital. The laboratory accepts isolates from laboratories throughout Scotland. The service includes confirmation of MRSA status, antibiotic sensitivity monitoring, detection of toxin genes and epidemiological typing of strains.

Isolates referred to the SMRSARL through standard referral processes and as part of the national rolling snapshot programme for all Scotland were utilised to provide historical and control hospital comparators for the pathfinder study. The pathfinder hospitals also submitted all screening isolates for the year of the study and these data were also utilised in the analyses for 'within pathfinder' comparisons.

Phenotypic confirmation of MRSA status was carried out on all isolates received. Isolates were phenotypically typed using biotypes and antibiograms. Genotyping was by PCR-ribotyping (MSSA) and PFGE (MRSA). Phenotypic characteristics of Scottish MRSA are still being monitored. Isolates were tested for resistance to 22 antibiotics, using an automated antimicrobial susceptibility test (VITEK® 2 System by Biomerieux) and several others by disc diffusion testing. The resulting antibiograms were used to monitor changing resistance patterns. Isolates with reduced susceptibility to mupirocin were further tested by PCR for the presence of the mupA gene to distinguish between high and low level mupirocin resistances. All isolates were included for some analyses to examine the burden overall, and bacteraemia data only for others in order to ensure consistency in comparison over time

11 Analysis

11.1.1 Univariate statistics

One sample t-tests were used to compare the means of the data with hypothesized values, where data were normally distributed. [49] Probability distribution was tested with The Shapiro-Wilk test. [50] The Wilcoxon signed-rank tests were used as non parametric alternatives to the t-tests. [51] Pearson's chi-square test of independence was used to assess whether paired observations on two variables, expressed in a contingency table, were independent of each other. The results were evaluated by reference to the chi-square distribution. [49]

11.1.2 Multivariate regression techniques

Multivariable regression techniques were used to investigate which variables were independently associated with e.g. screening positive. This was important as a high prevalence of colonisation among e.g. the care of the elderly specialty may be due to the age of those admitted rather than the specialty itself. Similarly high prevalence of colonisation among the specialties of renal and oncology may be due to the frequency of admission in these specialties rather than the specialties themselves. For each of objectives associated with aims 1 and 2 of the interim report a multivariable analyses was carried out, if appropriate, to try to understand better which variables were most important in each given situation.

If the outcome variable in the objective was binary, such as screened yes/no or screened positive yes/no then multivariable logistic regression was carried out. If the outcome variable was dependent on the hospital length of stay, such as the acquisition of hospital associated infection, then Poisson regression was used with log length of stay (in days) as the offset. In other situations where the outcome variable was continuous then ordinary regression analyses were performed.

All of the multivariable analyses were clustered, by patient, to control for the lack of independence of the admissions caused by many patients being admitted more than once. Some variables were identified as being of interest in all regression analyses namely, age at admission, gender, type of admission (elective/emergency), frequency of admission in the study year, hospital and specialty admitted to and where the patient was admitted from (home or not). Other variables were included in the analyses if appropriate such as time and day swab was taken for analyses of time taken to return swab result. Each variable was analysed on its own and if the P value was < 0.25 it was included in the multivariable analyses. Interactions with age group, gender and type of admission were tested for each objective.

The regression tables summarise the results for the significant variables in the multivariable regression analyses. These are followed by tabulations of these same variables from the study data.

11.1.3 Time series analyses

For analysing impact on outcome the principal hypotheses to be tested was expressed as follows: (i) do MRSA/MSSA rates in pathfinder hospitals decrease after screening starts in August 2008; (ii) do trends in MRSA/MSSA rates in pathfinder hospitals differ from those in non pathfinder hospitals after screening starts in August 2008. Trends in the MRSA/MSSA rates, month, year, in pathfinder hospitals and non pathfinder hospitals (within the same health board) were compared within a Poisson regression model. The months were coded one to 24 with month one corresponding to August 2007, Month 12 to July, 2008 (immediately before screening starts) and Month 24 to July 2009 (the end of the one year Pathfinder study).

Equation i: "change-point" model

$$\text{Log}(count_y) = \beta_{0i} + \beta_i\,(y\text{-}12) + \beta_2(y\text{-}12)I(y \geq 12) + \beta_3 Pathfinder + \beta_4 Pathfinder\,(y\text{-}12) = \beta_3 Pathfinder\,(y\text{-}12)I(y \geq 12)$$

A "change-point" model was therefore used, in which the term $I(y>12)$ is an indicator which permitted there to be a different slope after screening started compared to before the start of screening. The parameter (β_0) gives the estimated log MRSA/MSSA count in non pathfinder hospitals in the month before screening started and β_3 represents the difference from this value in pathfinder hospitals. *A priori,* a difference was anticipated as we did not have appropriate denominator data and differences between the pathfinder hospitals and non pathfinder hospitals may just reflect the size of the hospitals. The lack of denominator data was not crucial to this analysis as we were comparing trends within pathfinder hospitals within trends within non pathfinder hospitals, and the assumption that the denominators within the two sets of hospitals were constant over time is likely to be reasonable.

The slope of the relationship between log MRSA/MSSA counts and month is given by β_1 in the non pathfinder hospitals and $\beta_1+\beta_4$ in pathfinder hospitals; thus β_4 represents the difference in slopes, prior to the beginning of the screening study. The parameter (β_2) gives an estimate of any change in slope from the beginning of screening onwards compared to pre screening and before in the non pathfinder hospitals. If there was no change then the estimated value was about zero, if there have been detection advances then a positive estimate would be expected, if there have been effective methods to control MRSA/MSSA then a negative estimate would be expected. In the pathfinder hospitals the change in the slope post screening is given by $\beta_2+\beta_3$. Thus β_5 is the crucial parameter in the analysis as it measures the different slope in the pathfinder hospitals compared to the non pathfinder hospitals from August 2008 onwards.

The goodness of fit of the model was established on the basis of residual plots and hypothesis tests were based on Wald tests. A possible criticism of this analysis is that it assumes a change point model with linear trends for year. August 2008 is the beginning of the period at which there was a different practice with regard to MRSA testing in pathfinder hospitals compared to non pathfinder hospitals and so represents the earliest time at which any changes in trend associated with the universal screening program might theoretically begin. Any other choice of reference period, such as September 2008 or later, could be open

to criticism on the basis of a post hoc choice even although it could be argued that the earliest time one might begin to see a real benefit from screening is when uptake was higher after the introduction of the programme. If there is an effect of the universal screening program on the MRSA/MSSA rates then using the earlier date (August 2008) will tend to give conservative results as there may be no difference in the rates in the two regions for a period after the introduction of the universal screening programme.

In an attempt to find an appropriate control against which to compare the effect on MRSA of implementing screening against another institution where screening was not implemented. Within these analyses the best comparator hospitals were the small non acute hospitals with fell within the pathfinder health boards but which were not part of the Pathfinder studies. These were selected as the patient population should have similar overall demographics and have been undergoing similar infection control practises. Both sets of clinical isolate data which were used within these analyses were deduplicated using an identical protocol.

11.1.4 Records and criteria included for analyses

Data validation and verification was undertaken throughout the programme and where possible pathfinder sites were asked to review and amend or provide missing data. Records were only included if both admission and discharge date gender and age were recorded for the admission. All patients with zero length of stay were excluded for the final analysis. This reduced the total number of records from n=93,278 which were received by HPS to n=81,438 records which were included within the analysis. Only patients with a screen result (n=69,445) were included within the logistic regression tables. Where a subset of the data has been used for analysis the total will be provided in the figure or table caption.

11.2 Readers Notes

11.2.1 Patient Admissions

Each admission was regarded as a discrete event. Patients who were admitted more than once during the project were counted as multiple admission events. These episodes are referred to as 'admissions' throughout the report.

11.2.2 Admission Data

Admission data were included only if both admission and discharge information was available and where there was a minimum data set completed which included admission date, discharge date, gender and age.

11.2.3 Tables

Tables are consistently presented with pathfinder boards in alphabetical order; Ayrshire and Arran, Grampian and Western Isles. A consistent colouring system has been adopted throughout the report for each health board.

In each table the whole population values are presented within a category in the first column labelled (N). The number of patients within each sub-category is shown in the next column and labelled (n) and the percentage proportion of patients is represented as a percentage and calculated as described in Equation ii

Equation ii: Proportion of patients affected.

$$(n \div N) \times 100 = \%$$

11.2.4 Multiple admissions

It is important to note that results are presented in terms of number of patient admissions unless otherwise specified.

11.2..5 MRSA Colonisation

Patients identified as colonised through confirmed laboratory test at point of contact with the service (whether this is at pre-admission clinics or at emergency or elective admission), as a percentage of total emergency or elective admissions.

11.2..6 Known positive

Patients who have a previous laboratory confirmed MRSA colonisation status recorded within their casenotes.

11.2.7 MRSA Burden

'MRSA Burden' is used to describe those patients who are identified as 'possible' MRSA carriers because of the increased risk of previous positive MRSA status.

This includes:

- Patients positive for MRSA colonisation as identified by admission screen
- Patients who were previously known to be colonised prior to admission
- Patients who previously had an MRSA infection prior to current admission
- Patients who were colonised at pre-admission clinics and who were not successfully decolonised pre-admission

11.2.8 Healthcare associated infections (HCAI)

Healthcare associated infections are generally defined as infections which are acquired in hospitals or as a result of healthcare interventions. As healthcare interventions can take place in non-hospital settings, and some infections can present after discharge from hospital, the term HCAI encompasses all of these infections no matter where they arise.

Hospital associated (HA) and community onset (CO) infection have very distinct definitions relating to the time period prior to onset of symptoms. HA refers to infection that develops 48 hours or more following admission to the healthcare system, while CO is assumed if symptoms develop either before admission or within 48 hours of admission. The 48 hour time limit is arbitrary given the variation in incubation periods of different organisms; however it is a useful standard definition and has remained the precedent for many years.

11.2.9 Multiple infections

It is important to note the difference between the "count of admissions" and "count of infections". It should be noted that there is a proportion of patient admissions who have multiple MRSA infections.

11.2.10 Rounding

Percentages have been rounded to one or two decimal places. (Two decimal places have been used where numbers are very small in order to allow a clearer ranking of categories). As a consequence there are instances where a column with percentage values does not sum precisely to 100%.

11.2.11 Descriptive Measures: Mean, Median, Mode

The mean value is obtained by adding all the values in a population or sample and dividing the total by the number of samples that are added.

The median: of a finite set of values is that value which divides the set into two equal parts such that the number of values equal to or greater than the median is equal to the number of values equal to or less then the median. If the number of observations is odd, the median will be the middle value when all values have been arranged in order of magnitude, when the number of observations is even, the median is the mean of the two middle observations.

The mode of a set of values is that value which occurs most frequently. These terms will be used in particular with reference to patient's length of stay.

11.2.12 Box plots

Box plots were used to display values for Length of Stay (LOS) by speciality and hospital. The vertical line in the centre of the box represents the median value and the outer edges of the box refer to the quartiles. The dots outside the box represent unusually large values (outliers).

11.2.13 Inter Quartile range

The inter quartile range for a distribution is the distance between the first and third quartiles. The quartiles split the distribution into four equal parts with the median being the second quartile. Consequently the inter quartile range is the range containing the middle 50% of the data.

Quartiles and percentiles are related. The first quartile, often denoted Q1, is the 25% percentile and is the value in the data with 25% of observations below it and 75% of observations above. The third quartile, often denoted, Q3, is the 75% percentile and is the value in the data with 25% of observations above it and 75% of observations below. The median, or second quartile (Q2), is the 50% percentile and is the value in the data with 50% of observations above it and 50% of observations below.

11.2.14 Bar Charts

Bar charts were used to display distribution characteristics of those in the study population with and without MRSA colonisation and/ or infection.

11.2.15 Pareto Graphs

The Pareto chart is a histogram that ranks categories (for example the number of MRSA positive patients in particular specialties) in the chart in order of most frequent to least frequent from left to right. The X axis on the left represents the total number of patients within any specialty. The X axis on the right represents the cumulative percentage proportion of the total number of patients who are included within the categories.

11.2.16 Turnaround time

For the purpose of the Pathfinder project turnaround time was calculated as the time the screening sample was taken till the time the laboratory informed the clinical unit of the results. It represents the minimum time to act from obtaining a sample till information is available on MRSA status of each admission.

12 Results

12.1 Summary

Table 12-1 shows the numerical value of the different elements of MRSA burden and prevalence. The number of admissions who screened positive for MRSA at pre-admission clinics as a percentage of all patients who were screened at pre-admission clinics was 135/6411 (2.1%). The number recorded as successfully decolonised prior to admission as a percentage of all patients screened positive at pre-admission clinic was 18/135 (13.3%). When considering the total admission population, the proportion screened positive and the proportion successfully decolonised prior to admission was very small (0.16% and 0.02% respectively).

The total prevalence of MRSA colonisation on admission (identified either at pre-admission clinic or on admission) as a percentage of all patients screened was 3.9% (2,717/69,445), while the percentage of admissions with a previous history of MRSA from total admissions was 6.1% (4,964/81,438). Two percent of admissions screened were newly identified MRSA colonisations. The total burden (and therefore the number and percentage of all patients requiring isolation facilities or cohorting on admission) was 7.71% (6,280/81,438). This figure includes:

- confirmed colonisations screening positive at admission or pre admission clinics (n= 2,717)
- patient admissions considered probable until results were confirmed and who were at higher risk of MRSA colonisation because of previous positive MRSA status (n= 4,964).

Table 12-1: Key results from the MRSA Screening Programme August 2008 – July 2009

	Point of Observation (Numerator)	Denominator	%	95% Confidence Interval	
				Lower	Upper
A	Pre-admission screen positive (135)	All Admissions (81,438)	0.17	0.14	0.19
A1	Pre-admission screen positive (135)	All pre admissions screened (6,411)	2.11	1.74	2.47
B	Decolonised pre-admission (18)	All Admissions (81,438)	0.02	0.01	0.03
B1	Decolonised pre-admission (18)	All pre admissions screened positive (135)	13.33	7.54	19.13
C	Admission screen positive (2,611)	All Admissions (81,438)	3.2	3.1	3.4
C1	Elective admission screen positive (585)	All screened (21,640)	2.7	2.5	2.9
C2	Emergency admission screen positive (2,132)	All Emergency Admissions screened (47,805)	4.5	4.2	4.7
D	Overall preadmission or admission screen positive (2,717)	All Admissions (81,438)	3.33	3.18	3.49
D1	Overall preadmission or admission screen positive (2,717)	All screened (69,445)	3.90	3.70	4.10
D2	Known on admission (previous positive MRSA from case notes) (4,964)	All Admissions (81,438)	6.10	5.84	6.35
E	Total burden of MRSA positive (previous positive, pre-admission screen not decolonised, admission screen positive, previous MRSA infection) Patient admissions in more than one of these categories have not been double counted.(6,280)	All Admissions (81,438)	7.71	7.43	7.99

12.2 Introduction

All pathfinder boards implemented MRSA screening in August 2008 and were fully operational in all areas by 1 September 2008. During the period of the pathfinder project a total of 81,438 admissions were recorded: 34,613 from Ayrshire and Arran, 44,080 from Grampian and 2,745 from Western Isles (Table 12-2). The overall recorded screening compliance was 85%.

Table 12-2: Number and percentage of admissions and admissions screened, by hospital and health board, during the study period August 2008 – July 2009, N=81,438

Pathfinder Board	Total Admissions	Admissions Screened	
	N	n	%
Ayrshire and Arran	34,613	30,367	87.7
Ayr Hospital	15,115	13,652	90.3
Crosshouse Hospital	19,498	16,715	85.7
Grampian	44,080	36,479	82.8
Aberdeen Royal Infirmary	40,848	33,581	82.2
Woodend Hospital	3,232	2,898	89.7
Western Isles	2,745	2,599	94.7
Western Isles Hospital	2,310	2,173	94.1
Uist and Barra Hospital	435	426	97.9
Total	**81,438**	**69,445**	**85.3**

Uptake was calculated from data supplied to HPS which met the inclusion criteria for the study. In fact the compliance was probably higher at an individual board level, as some patients may have been screened but not recorded as having been screened. Overall compliance increased over time during the study.

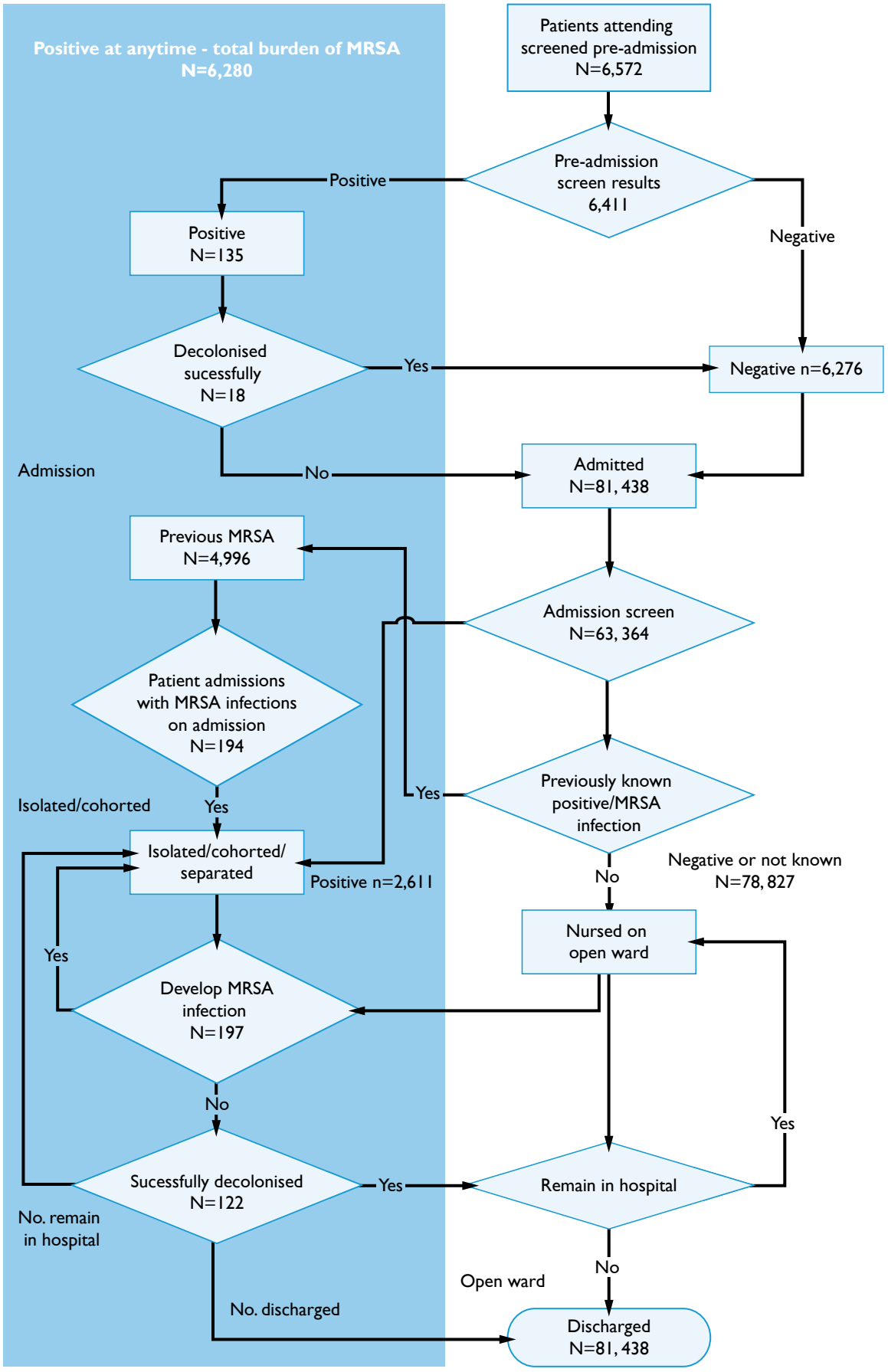
There were 56,069 (68.8%) emergency admissions and 25,369 (31.2%) elective admissions (Table 12-3). The proportion of emergency to elective admissions was found to vary by hospital and region. Grampian had the highest proportion of elective admissions at 38.4%. Woodend Hospital had the highest proportion of elective admissions at 99.2%. Woodend Hospital is unique in its composition of elective orthopaedic and care of the elderly wards only. The orthopaedic unit is considered as an annexe to Aberdeen Royal Infirmary and, as such, only this unit was included in the pathfinder project.

Table 12-3: Elective, emergency and total admissions between August 2008 and July 2009, by hospital and pathfinder board, N=81,438

Pathfinder Board	Total Admissions	Elective Admissions		Emergency Admissions	
	N	n	%	n	%
Ayrshire and Arran	34,613	7,823	22.6	26,790	77.4
Ayr Hospital	15,115	3,897	25.8	11,218	74.2
Crosshouse Hospital	19,498	3,926	20.1	15,572	79.9
Grampian	44,080	16,910	38.4	27,170	61.6
Aberdeen Royal Infirmary	40,848	13,703	33.5	27,145	66.5
Woodend Hospital	3,232	3,207	99.2	25	0.8
Western Isles	2,745	636	23.2	2,109	76.8
Western Isles Hospital	2,310	508	22.0	1802	78.0
Uist and Barra Hospital	435	128	29.4	307	70.6
Total	**81,438**	**25,369**	**31.2**	**56,069**	**68.8**

Figure 12-1 shows a summary of the patient - hospital pathway and identifies the screening opportunities, the number of admissions screened and the numbers identified as positive for MRSA infection or colonisation and those decolonised throughout the journey.

Figure 12-1: Breakdown of MRSA Admission throughout patient journey

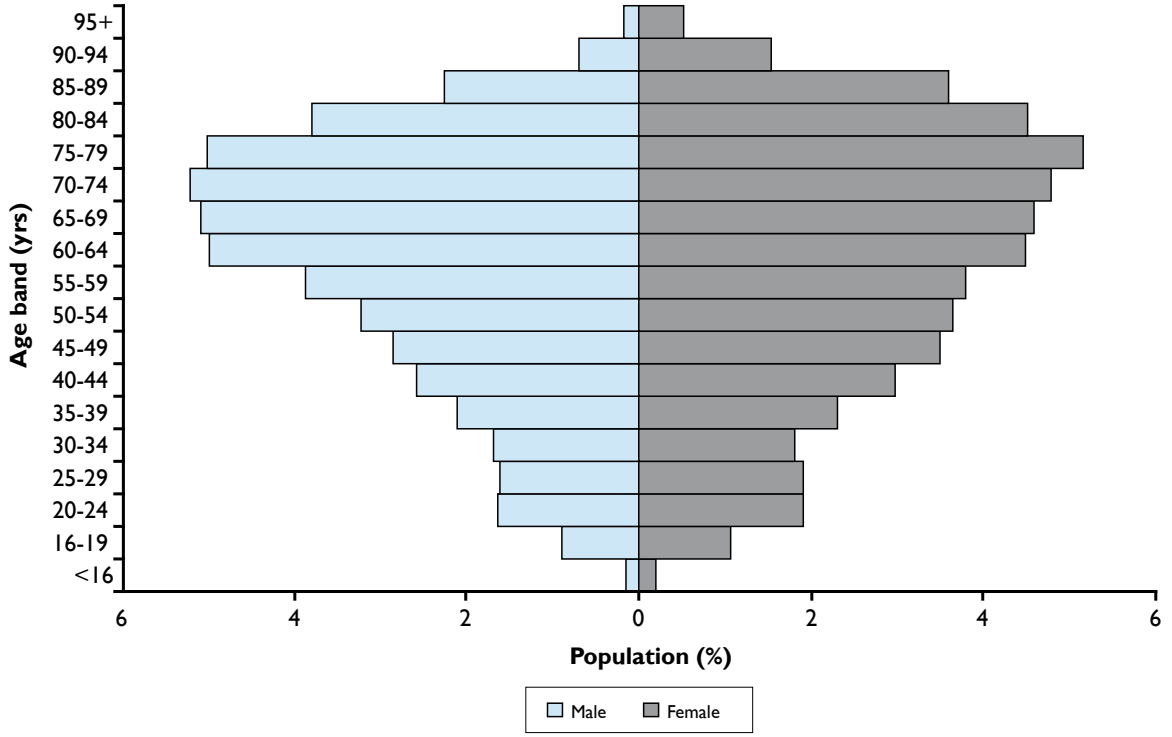


12.3 Demographics

Figure 12-2 shows the age band specific percentage population by gender for the total pathfinder population.

There were 38,874 male recorded admissions and 42,564 female recorded admissions in the pathfinder population. Age range proportions were distributed fairly evenly for males and females but with a slightly higher proportion of females in the higher age bands. Age range for males was 16 - 108 years and for females 16 -109 years. Median age for both males and females was 63 years (IQR: males 47 - 74 years, females 46 - 77 years).

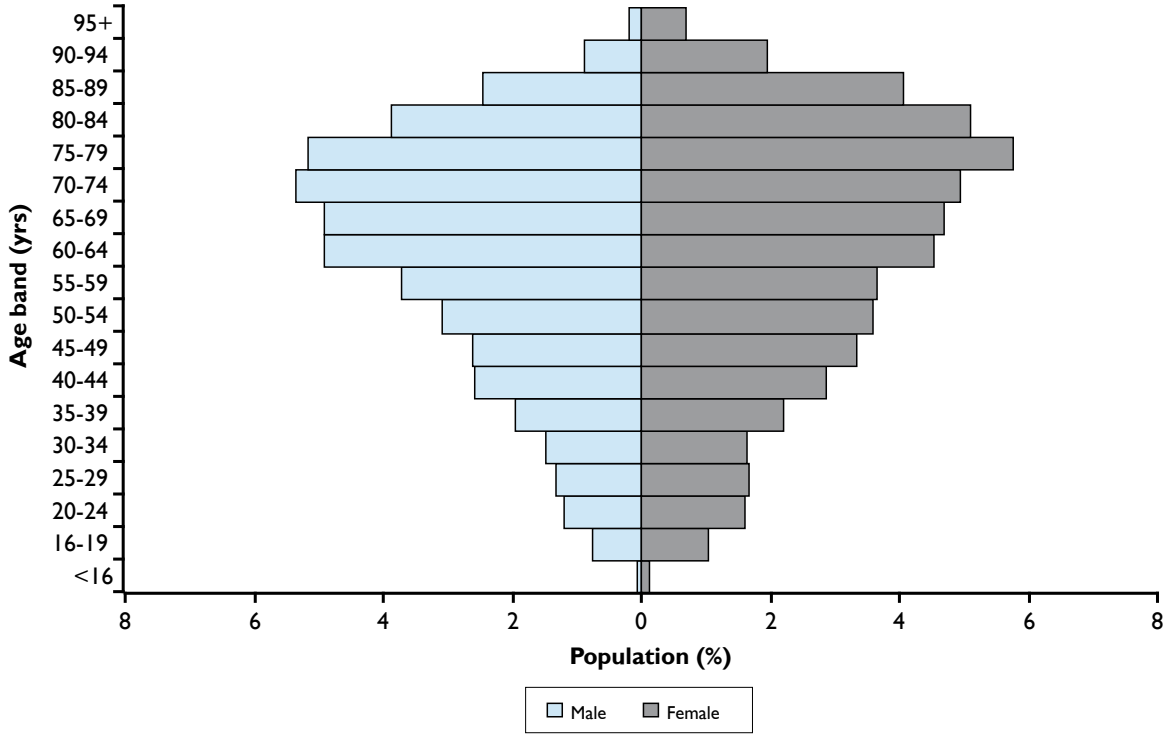
Figure 12-2: Population pyramid for total project population during study period August 2008 – July 2009 N=81,438



There was little variation in NHS Board specific demographics. In Ayrshire and Arran 16,105 (46.5%) males and 18,508 (53.5%) were females. Age ranged from 16 – 109 years (males 16 – 108 years, females 16 – 109 years). The median age for Ayrshire and Arran was 64 years for males and 65 years for females (IQR: males 49– 75 years, females 48 – 78 years).

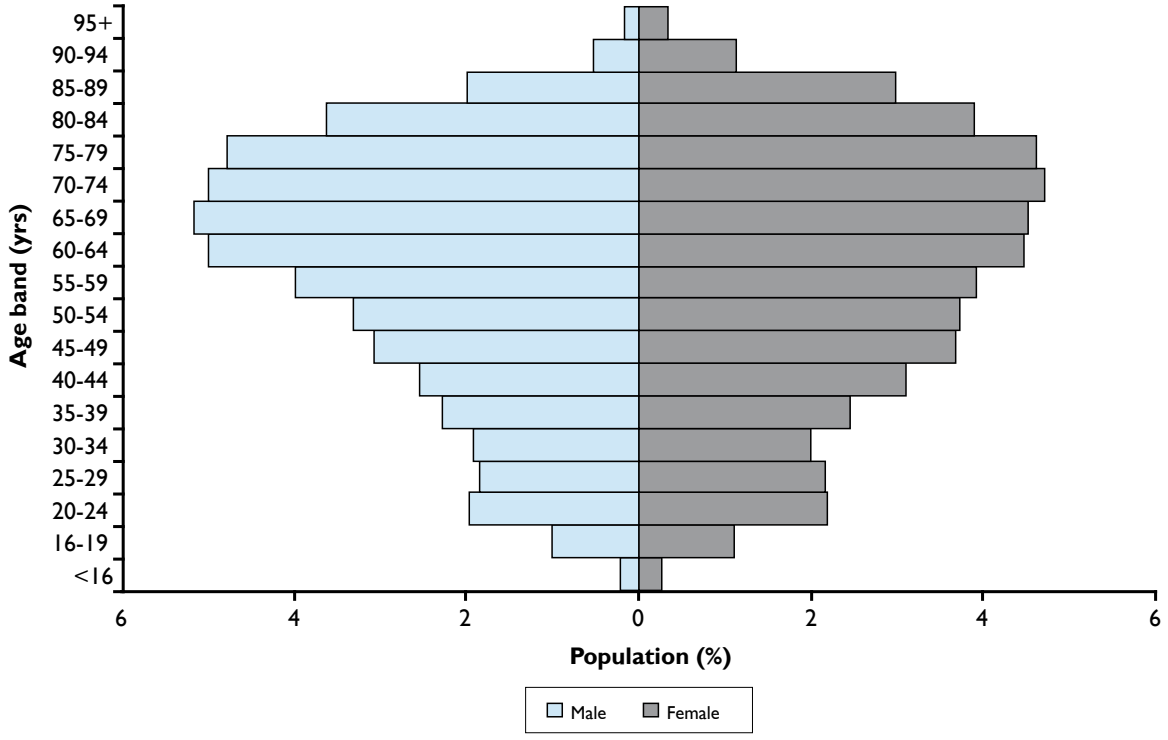
Figure 12-4 and Figure 12-5 show the age and gender by percentage of total admissions to that pathfinder board during the study period. There was little variation in NHS Board specific demographics. In Ayrshire and Arran 16,105 (46.5%) males and 18,508 (53.5%) were females. Age ranged from 16 – 109 years (males 16 – 108 years, females 16 – 109 years). The median age for Ayrshire and Arran was 64 years for males and 65 years for females (IQR: males 49– 75 years, females 48 – 78 years).

Figure 12-3: Population pyramid Ayrshire and Arran NHS Board during the study period August 2008 – July 2009, N = 34,613



In Grampian the population comprised 21,425 (48.6%) males and 22,655 (51.4%) females. Age ranged from 16 – 108 years for both males and females. The median age was 61 years for both males and females (IQR: males 45 -73 years, females 44 – 75 years).

Figure 12-4: Population pyramid for Grampian NHS Board August 2008 – July 2009, N= 44,080



In the Western Isles the study population comprised 1,344 (49%) males and 1,401 (51%) females. Age ranged from 16 – 105 years (males 16 -105 years, females 16 – 100 years). Median age was 68 years for males and 72 years for females (IQR: males 54 - 77 years, females 55 - 83 years).

Figure 12-5: Population pyramid for Western Isles NHS Board August 2008 – July 2009 N= 2,745

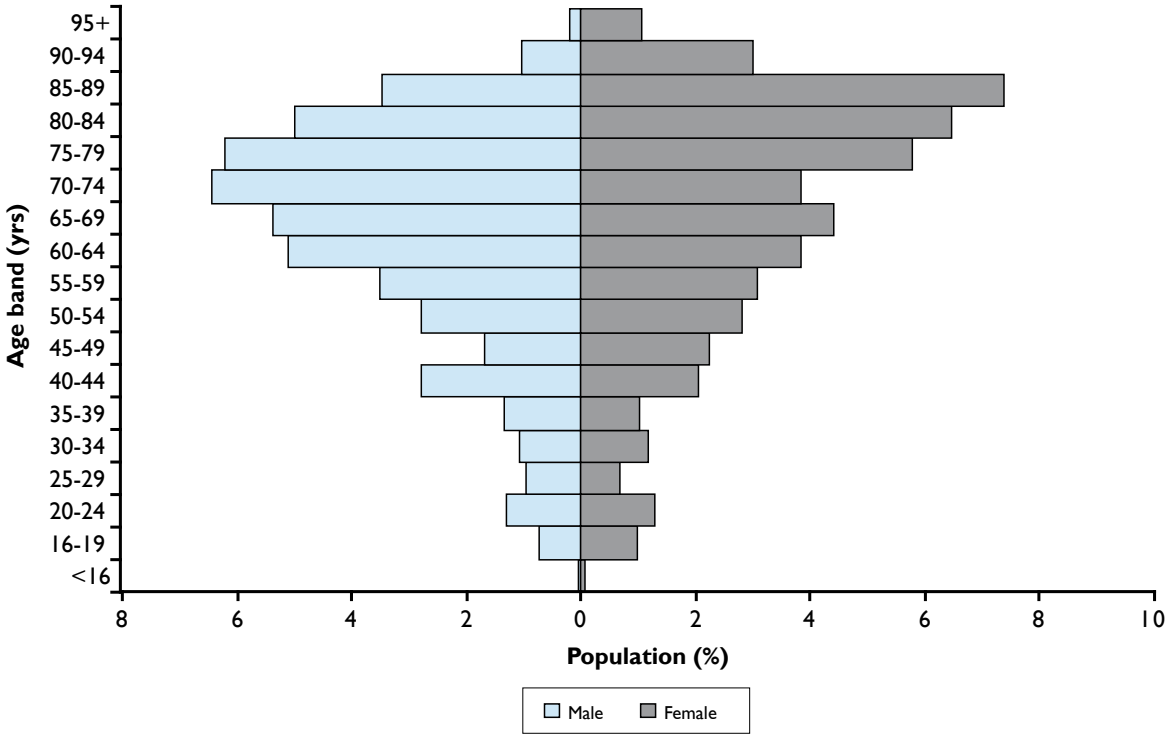


Table 12-4 shows where patients were admitted from. The largest number and proportion of patient admissions were admitted from home (75,775 93.0%). Transfers from other hospitals accounted for 2,308 (2.8%) of the total recorded, while those admitted from care homes accounted for 1,465 (1.8%). The 'other or not known' category which accounted for 1,890 (2.3%) of patient admissions and mainly comprised of patients who were admitted directly from trauma incidents, temporary places of residence, student residence, holiday accommodation, or those whose origin was unknown.

Table 12-4: Numbers and percentages of source of patient admissions by NHS Board N= 81,438

Pathfinder Board	Total Admissions	Admissions							
		Home		Hospital		Care Home		Other / NK	
	N	n	%	n	%	n	%	n	%
Ayrshire and Arran	34,613	33,150	95.8	348	1.0	675	2.0	440	1.3
Grampian	44,080	40,190	91.2	1,836	4.2	661	1.5	1,393	3.2
Western Isles	2,745	2,435	88.7	124	4.5	129	4.7	57	2.1
Total	81,438	75,775	93.0	2,308	2.8	1,465	1.8	1,890	2.3

There were 81,438 admissions within the study period, of which 69,445 were screened. The total admissions included 59,170 individual patients (Table 12-5). Of those patients 52,163 patients were screened at some point (88% of total patients). Many patients (13,521) were admitted more than once within the study period (Table 12-6). Within the results sections the text will state if analyses have been undertaken using number of admissions, number of admissions screened, or patients.

Table 12-5: Total number of admissions and patients within the study period August 2008 – July 2009 N=81438

	Number of admissions	Number of patients
Ayrshire and Arran	34,613	24,655
Grampian	44,080	32,641
Western Isles	2,745	1,874
Pathfinder Project	81,438	59,170

There were 35,789 admissions which were repeat admissions within the study period (44.0% of total) (Table 12-6). Within the study period 57 patients were admitted more than 10 times.

Table 12-6: Number of patients within the study period August 2008 – July 2009 N= 59,170

Number of admissions during study period	Number of patients
1 admission	45,649
2 admissions	8,891
3 admissions	4,104
>=4 admissions	1,894
Total	**59170**

12.4 Results to address Aim 1

12.4.1 Aim 1 Objective 1: To identify the prevalence on admission of MRSA colonisation amongst the patients being admitted

Of all admissions screened 3.9% (2,717/69,445) were identified as colonised on admission representing 3.3% (2,717/81,438) of total admissions.

Multivariable logistic regression, clustered by patient admissions, was carried out to investigate the prevalence on admission of MRSA colonisation among the study population. All 69,445 admissions meeting the analysis criteria described in (See Section 11.1.4) who were screened were included in the regression. The outcome variable was "screened positive on admission". Variables included in the model were age at admission, gender, type of admission (elective or emergency), frequency of admission in the study year, hospital, specialty admitted to, and where the patient was admitted from (home or other).

Interactions with age group, gender and type of admission were tested and found to be not significant. The significant variables are displayed in Table 12-7. In order of importance the variables that best predicted screening positive on admission were age, whether or not admitted from home, frequency of admission, specialty and type of admission. Table 12-7 shows that the odds of screening positive in those over the age of 80 years were 3.8 times higher than the baseline under 50 years age group.

The odds of screening positive in those 65-79 years of age were 2.1 times higher than the under 50 year age group. The odds of screening positive among those who were admitted from places other than home (such as care homes and other hospitals) were three times higher than those who were admitted straight from home. Higher odds of screening positive were also associated with those admitted three or more times in the year compared with those admitted once. Odds of screening positive were higher in care of the elderly specialties, ITU and medical specialties compared with surgical admission specialties. The odds of screening positive were 1.26 times higher among emergency admissions than among those elective admissions.

Table 12-7: Results of multivariable clustered logistic regression analyses of screening positive among the N=69,445 admissions who were screened during the study period July 2008 – August 2009

Table	Subgroup	Regression Coefficient (standard error)		P Value	Odds Ratio (95% CI)
Age Group	<= 49 yrs (baseline)	0	-	-	1
	50- 64 yrs	0.242	0.096	0.012	1.273 (1.054 - 1.538)
	65-79 yrs	0.760	0.087	<0.0001	2.139 (1.803 - 2.537)
	80+ yrs	1.343	0.086	<0.0001	3.831 (3.240 - 4.530)
Frequency of Admission	1 admission (baseline)	0	-	-	1
	2 admission	0.347	0.056	<0.0001	1.415 (1.268 - 1.579)
	3 admission	0.639	0.073	<0.0001	1.895 (1.642 - 2.187)
	4+ admission	0.910	0.083	<0.0001	2.484 (2.111 - 2.923)
Admitted from	Admitted from home (baseline)	0	-	-	1
	Not admitted from home	1.107	0.061	<0.0001	3.025 (2.685 - 3.407)
Speciality	Surgery (baseline)	0	-	-	1
	Accident & Emergency	-0.177	0.140	0.205	0.838 (0.637 - 1.101)
	Cardiology	-0.211	0.110	0.054	0.809 (0.653 - 1.004)
	Care Of the Elderly	0.381	0.121	0.002	1.464 (1.155 - 1.854)
	Anaesthesia/ Intensive Care Unit/ HDU	0.378	0.151	0.012	1.459 (1.086 - 1.962)
	Medicine	0.228	0.061	<0.0001	1.256 (1.114 - 1.415)
	Oncology	-0.419	0.190	0.028	0.658 (0.453 - 0.956)
	Orthopaedic	-0.234	0.084	0.006	0.792 (0.671 - 0.934)
	Nephrology/Renal	0.134	0.123	0.276	1.143 (0.898 - 1.455)
Type of Admission	Elective (baseline)	0	-	-	1
	Emergency	0.233	0.059	<0.0001	1.262 (1.125 - 1.416)
	constant	-4.758	0.121		
Log Likelihood: -10640.530		Degrees of Freedom: 17			AIC: 21315.060

Table 12-8 shows the number, percent of admissions, the number and percentage of positive screens among those screened, for the variables which were found to be important independent predictors of screening positive in the regression analyses. This table shows that the 80 years of age and over group accounted for 17.7% (12,305/69,445) of all screened patients, 1,024/2,717 (37.7%) of the admission receiving a positive screen, and had a prevalence of 8.3% (1,024/12,305).

Another large group with a high prevalence (over 5%) screening positive were those who were admitted three or more times in the year. They represented 36% (974/2,717) of all positive screens. A small group of patients were not admitted from home, (6.6%, 4,549/69,445 of all screened admissions) but they had a high prevalence of 10.5%. Other groups with high prevalence in the screened population were those admitted to care of the elderly, intensive care, medical and renal specialties.

Table 12-8: Number and percentage of admissions, and number and percentage screening positive among the N=69,445 admissions who were screened during the study period July 2008 – August 2009; by age (years) at admission, frequency of admission, place of admission, type of admission and specialty of admission

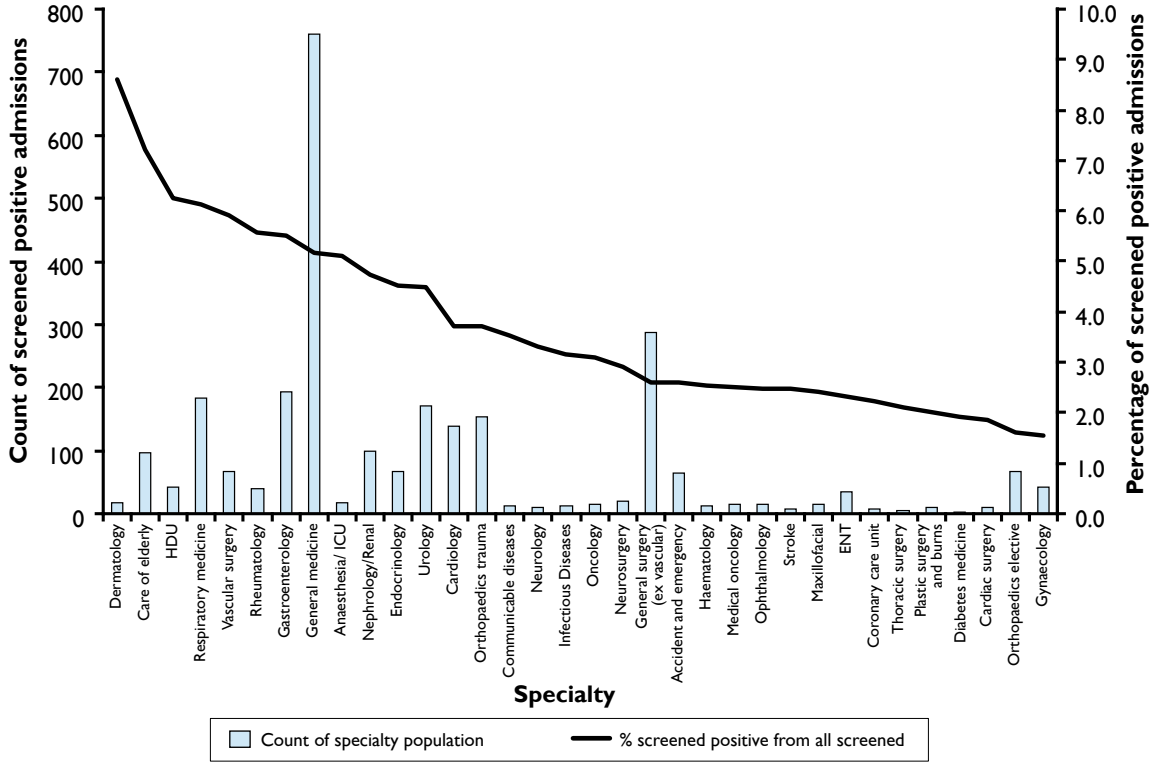
Variable	Subgroup	Admissions Screened		Admissions Screened Positive	
		N	%	n	%
Age Group	<=49 yrs	19,087	27.5	358	1.9
	50-64 yrs	16,745	24.1	414	2.5
	65-79 yrs	21,308	30.7	921	4.3
	>= 80 yrs	12,305	17.7	1,024	8.3
Frequency of Admission	1 admission	38,885	56.0	1,085	2.8
	2 admission	15,246	22.0	658	4.3
	3 admission	7,058	10.2	417	5.9
	4+ admission	8,256	11.9	557	6.7
Admitted from	Admitted from home	64,896	93.4	2,238	3.4
	Not admitted from home	4,549	6.6	479	10.5
Type of Admission	Elective admission	21,640	31.2	585	2.7
	Emergency admission	47,805	68.8	2,132	4.5
Specialty	Accident & Emergency	2,501	3.6	65	2.6
	Cardiology	4,018	5.8	145	3.6
	Care of the elderly	1,346	1.9	97	7.2
	Anaesthesia/ Intensive Care Unit/ HDU	990	1.4	58	5.9
	Medicine	25,099	36.1	1,306	5.2
	Oncology	1,556	2.2	42	2.7
	Orthopaedic	8,253	11.9	220	2.7

Variable	Subgroup	Admissions Screened		Admissions Screened Positive	
		N	%	n	%
	Nephrology/Renal	2,114	3.0	100	4.7
	Surgery	23,523	33.9	681	2.9
	Not known	*	*	*	*
Total		**69,445**	**100.0**	**2,717**	**3.9**

*Indicates values that have been suppressed due to the potential risk of disclosure

Figure 12-6 shows the specialties which had the highest number and proportion of MRSA colonised admissions. It can be seen that the highest numbers of admissions were found within the specialties of general medicine and general surgery; however the highest proportions were found within dermatology and care of the elderly, followed by high dependency, respiratory medicine, vascular surgery rheumatology and gastroenterology. The specialties found to be highest within the interim report (renal-nephrology, care of the elderly, dermatology and vascular surgery) were found to have a high proportion of admissions colonised with MRSA, and were all found within the top ten by proportion of admissions colonised.

Figure 12-6: Number and percentage of MRSA colonisation by specialty of admission during the study period July 2008-August 2009. N=69,387 (only specialties with one or more MRSA colonised admission are included in this figure).



12.4.2 Aim 1 Objective 2: To determine the proportion of patients by specialty and colonisation status who develop hospital associated MRSA infection

A total of 422 MRSA infections were diagnosed using CDC infection criteria during the Pathfinder study period. Three hundred and eighty four admissions had one or more MRSA infections during the year of the study. There were 349 admissions with a single infection, 32 with two infections and three with three infections; leading to 422 infections in total of which 203 were community onset and 219 hospital associated. The infection incidence was 7.5 per 1000 bed days. These infections were classified by infection type in Table 12-9. There was little difference in the proportion of infection type by hospital associated or community onset with the exception of surgical site infections (Table 12-9).

Table 12-9: Type of MRSA infection type by community onset and hospital associated during the study period August 2008 – July 2009, N=422

Infection Type	Community onset-MRSA	Hospital associated-MRSA	Total
Skin Soft Tissue	84	75	159
Surgical Site Infection	7	37	44
Urinary Tract Infection	33	25	58
Lower Respiratory Tract Infection	31	29	60
Blood Stream Infection	17	21	38
Eye, Ear, Nose an Throat	8	6	14
Pneumonia	14	17	31
Gastrointestinal	0	4	4
Bone and Joint	3	2	5
Cardio Vascular System	1	2	3
Reproductive System Infection	3	0	3
Not known	2	1	3
Total	**203**	**219**	**422**

Table 12-10 presents infection incidence by specialty and indicates that there is no significant difference in the incidence of infection in high or low risk specialties.

Table 12-10: Number and percentage of infections by patient admission specialty and community onset or hospital associated MRSA infection N=81,438

Speciality	Total Admissions	Community Onset MRSA Infection	Healthcare Associated MRSA Infection	Total MRSA Infections	Incidence of all Infections for all Admissions %	95% Lower Limit for Incidence of all Infections for all Admissions %	95% Upper Limit for Incidence of all Infections for all Admissions %
High risk total	**50,000**	**95**	**121**	**210**	**0.4**	**0.360**	**0.480**
Anaesthesia /ICU	369	*	*	8	2.2	0.675	3.661
Cardiac Surgery	623	*	*	8	1.3	0.406	2.162
Cardiology	4,376	11	12	22	0.5	0.293	0.712
Coronary care unit	346	*	*	*	*	*	*
Gastroenterology	4,026	13	8	21	0.5	0.300	0.743
General surgery (excluding vascular)	12,515	25	27	50	0.4	0.277	0.522
Gynaecology	3,445	*	*	*	*	*	*
Haematology	771	*	*	*	*	*	*
High dependency unit	717	*	*	*	*	*	*
Maxillofacial	851	*	*	*	*	*	*
Medical Oncology	779	*	*	*	*	*	*
Nephrology / Renal	2,471	12	8	19	0.8	0.424	1.114
Neurosurgery	905	*	*	5	0.6	0.070	1.035
Oncology	612	*	*	*	*	*	*
Ophthalmology	920	*	*	*	*	*	*
Oral surgery and medicine	39	*	*	*	*	*	*
Orthopaedics elective	4,581	*	*	*	*	*	*
Orthopaedics trauma	4,813	7	13	20	0.4	0.234	0.597
Plastic surgery and burns	777	*	*	*	*	*	*
Thoracic surgery	308	*	*	*	*	*	*
Urology	4,336	5	10	15	0.3	0.160	0.532
Vascular surgery	1,420	14	14	26	1.8	1.137	2.525
Low risk total	**31,438**	**99**	**76**	**174**	**0.6**	**0.462**	**0.646**
Accident and Emergency	3,142	*	*	6	0.2	0.038	0.344

Speciality	Total Admissions	Community Onset MRSA Infection	Healthcare Associated MRSA Infection	Total MRSA Infections	Incidence of all Infections for all Admissions %	95% Lower Limit for Incidence of all Infections for all Admissions %	95% Upper Limit for Incidence of all Infections for all Admissions %
Care of the Elderly	1,506	*	*	9	0.6	0.209	0.987
Clinical Pharmacology	24	*	*	*	*	*	*
Communicable disease	456	*	*	*	*	*	*
Dermatology	237	*	*	*	*	*	*
Diabetes medicine	115	*	*	*	*	*	*
Ear Nose and Throat	2,312	*	*	*	*	*	*
Endocrinology	1,667	*	*	*	*	*	*
General Medicine	16,271	57	55	111	0.7	0.550	0.814
General Practice	*	*	*	*	*	*	*
Hyperbaric medicine	*	*	*	*	*	*	*
Infectious Diseases	482	*	*	*	*	*	*
Medical Other	*	*	*	*	*	*	*
Neurology	415	*	*	*	*	*	*
Obstetrics Specialist	*	*	*	*	*	*	*
Orthodontics	*	*	*	*	*	*	*
Respiratory medicine	3,553	21	6	27	0.8	0.335	1.185
Restorative dentistry	*	*	*	*	*	*	*
Rehabilitation medicine	*	*	*	*	*	*	*
Rheumatology	774	*	*	*	*	*	*
Spinal paralysis	*	*	*	*	*	*	*
Stroke	417	*	*	*	*	*	*
Not known	50	*	*	*	*	*	*
Total	**81,438**	**194**	**197**	**384**	**0.5**	**0.419**	**0.524**

Hospital Associated MRSA Infections

Of those MRSA infections 219 (51.9%) were classified as hospital associated on the basis of diagnosis greater than 48 hours after admission. The remaining 203 were classified as community onset. Though many of these could be healthcare associated. A number of admissions had multiple infections.

Multivariable Poisson regression, clustered by patient admissions, was carried out to investigate the presence of a hospital associated infection among those with known length of stay of at least two nights, and not successfully decolonised on admission. Poisson regression included as an offset term the length of stay (log scale). Table 12-11 details the number and percentage of admissions whose length of stay was two nights or more.

The outcome variable was "hospital associated infection yes or no". Variables included in the model were age at admission, gender, type of admission (elective or emergency), frequency of admission in the study year, hospital and specialty admitted to, where the patient was admitted from (home or not) and screening result on admission. Interactions with age group, gender and type of admission were tested and found to be not significant.

One hundred and ninety seven admissions were found to have had a hospital associated infection. Of those 197 with hospital associated infection with admissions of more than two nights 94 (47.8%) were found to be positive from an admission screen and 96 (48.7%) were found to be negative on admission. Seven patients did not have their screen result recorded (Table 12-11).

Table 12-11: Number and percentage of admissions, and number and percentage of hospital associated infections among N= 58,849 admissions who had length of hospital stay of two or more nights during the study period July 2008 – August 2009; by screening result.

Type	Admissions with LOS two or More Nights		Admissions with LOS two or More Nights and HAI	
	N	%	n	%
Screen Positive	2,302	3.9	94	4.1
Screen Negative	50,076	85.1	96	0.2
Screen Not Known	6,471	11.0	7	0.1
Total	**58,849**	**100**	**197**	**0.3**

The incidence of infection was significantly lower in those who received decolonisation treatment. Those who commenced decolonisation treatment had an HAI infection incidence of 2.7 per 1,000 patient days which was a significantly lower rate of infection than those who did not receive decolonisation (4.2 per 1,000 patient days). This indicates that even a day of decolonisation may have a protective effect.

A univariate Poisson regression analysis was also carried out on those patients who screened positive on admission and those screening positive at preadmission clinics and were not successfully decolonised. The outcome variable was 'hospital associated infection yes or no'. The Poisson regression included as an offset term the length of stay. Since numbers were small all patients initiated on decolonisation treatment were included in the

analysis. The probability of infection were significantly lower in those who had commenced decolonisation treatment as a result of admission screening compared with those who had not (OR 0.69 95% CI 0.524 – 0.899).

The most significant variable for risk of MRSA hospital infection was the result of the admission screen (Table 12-12). Among this group 2,302 screened positive on admission, accounting for 29,661 nights in hospital and 94 hospital associated infections (rate: 94/29,661, 3.2 per 1,000 hospital in-patient nights) compared with the 50,076 people who screened negative on admission with 459,628 nights in hospital and 96 hospital associated infections (rate: 96/459,628 = 0.2 per 1,000 hospital in-patient nights).

Table 12-12: Results of multivariable Poisson regression to investigate the presence of a hospital associated infection N=58,849

Variable	Subgroup	Regression Coefficient (standard error)		P Value	Odds Ratio (95% CI)		
Screen Positive	Screen Negative (baseline)	0	-	-	1		
	Screen Positive	2.698	0.144	<0.0001	14.850	(11.191, 19.707)	
	Screen Not Known	-0.433	0.392	0.269	0.648	(0.301, 1.399)	
	constant	-8.474	0.103	-			
Log Likelihood: -947.7655		Degrees of Freedom: 3			AIC: 1901.531		

Figure 12-7 shows the number of hospital associated infections per specialty recorded where a diagnosis of MRSA infection was confirmed, and the percentage of admissions with an MRSA infection. General medicine and general surgery recorded the greatest number of hospital associated MRSA infections (55 and 27 respectively); however the large patient volume in these specialties mean that the proportion of patient admissions with hospital associated MRSA infection was relatively low (0.3% general medicine, 0.2% general surgery). In contrast, specialties with lower numbers of infections such as intensive care units (ICUs) and anaesthesia, cardiac surgery, thoracic surgery and vascular surgery may appear to have higher proportions of total patient admissions who develop hospital associated infections (1.9% anaesthesia, 1.3% cardiac surgery, 1.0% vascular surgery, 1.0% thoracic surgery, 0.9% diabetes medicine, 0.8% dermatology) however the confidence intervals around the incidence of infection overlap (Figure 12-8).

Figure 12-7: Hospital associated infections by specialty of diagnosis N=197 and percentage of admission population to each specialty

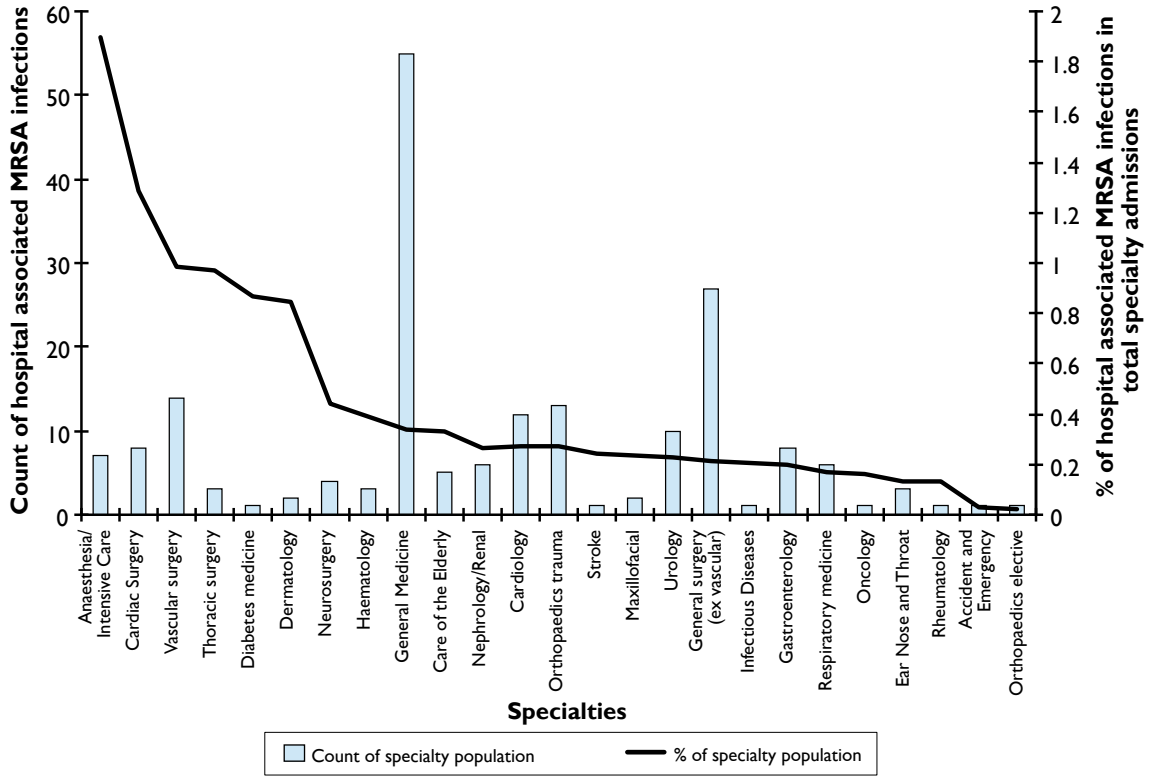
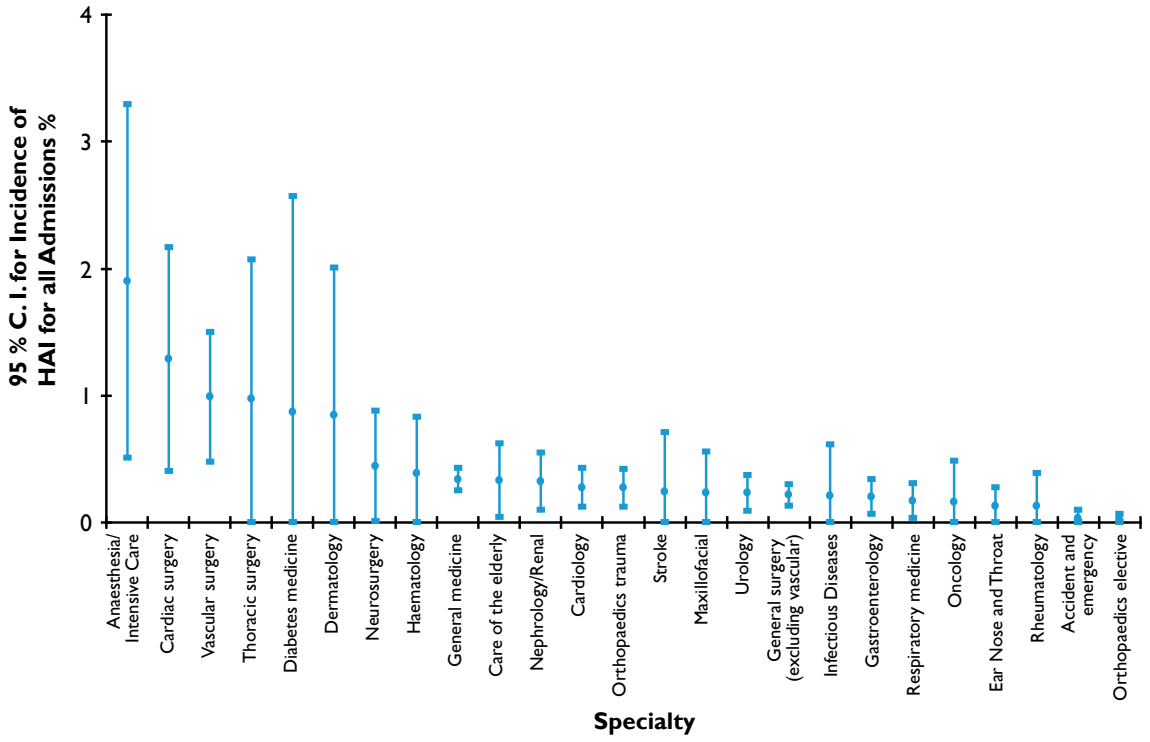


Figure 12-8: Hospital associated infections by specialty of diagnosis N=197 and percentage of admission population to each specialty



Community Onset or Healthcare Associated Infection?

One hundred and ninety seven admissions were classified as hospital associated MRSA infections; however this may be an underestimate of the actual total. One hundred and fifty two admissions were re-admissions who had no diagnosis of MRSA infection on discharge but were subsequently found to have an infection on re-admission; among those 152 admissions were 156 infections. Of these, 79 were classified as community onset infections and 77 were classified as hospital associated infections. Four admissions had both community onset and hospital associated infections during their stay.

Table 12-13 shows the number of days until re-admission and the number of infections classified as either community onset or hospital associated on admission. Table 12-13 shows that 11 infections were classified as community onset infections on re-admission following seven days or less from discharge. Given the incubation period for MRSA infection varies greatly and that the definition of hospital associated infection is diagnosed 48 hours after admission, there may be a number of infections classified as community onset infections which were actually associated with an acute hospital admission which were either incubating, or not diagnosed before discharge.

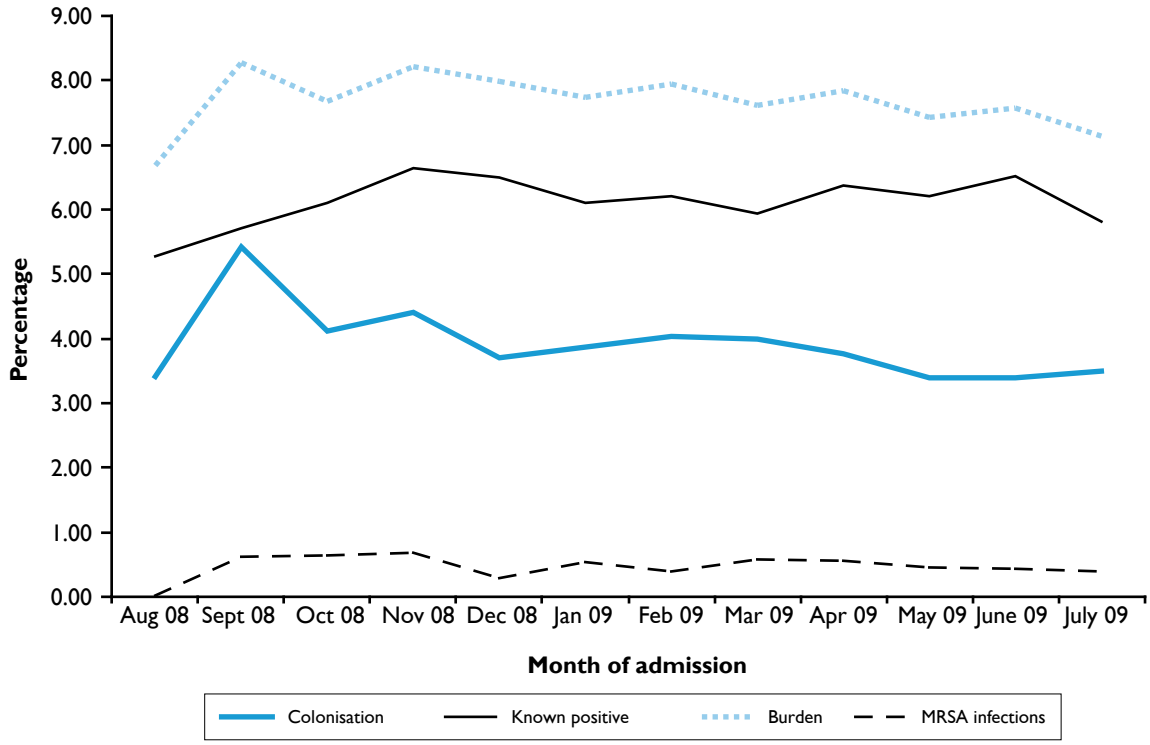
Table 12-13: Length of time from previous discharge and infection classification on re-admission N= 156

Days from discharge to readmission	Number classified as community onset on readmission	Number classified as hospital associated on readmission
0-7 days	11	17
8-14 days	7	9
15-28 days	11	14
29-56 days	18	16
> 56 days	32	21
Total	**79**	**77**

12.4.3 Aim 1 Objective 3: To evaluate the impact on outcome MRSA colonisation/ infection/ bacteraemia of the screening programme

Figure 12-9 shows the percentage of admissions per month who were colonised with MRSA, known positive, total burden and total MRSA infection for those admissions where an admission date and MRSA status have been recorded.

Figure 12-9: Colonisation status, history of MRSA, total burden and MRSA infection by month of admission and percentage of admission population



Poisson regression analyses were conducted with only time as an independent variable and as offset the appropriate denominator for each percentage. Observations from August 2008 were excluded as full implementation did not occur until September 2008 (see methods section). For the number of colonised (screened positive) admissions per month use the total of screened admissions per month were analysed (a total of 66,804 in the 11 months) as offset.

For the number of known positive admissions per month, the total number of admissions with known MRSA histories were used (i.e. whether positive or not; a total of 76,977 in the 11 months) per month. For the MRSA burden per month, the total number of admissions was used (a total of 77,728 in the 11 months) per month. For the number of total MRSA infections per month, the total number of admissions was used (a total of 77,728 in the 11 months) per month. (Note that one admission episode per patient may have more than one infection associated with it).

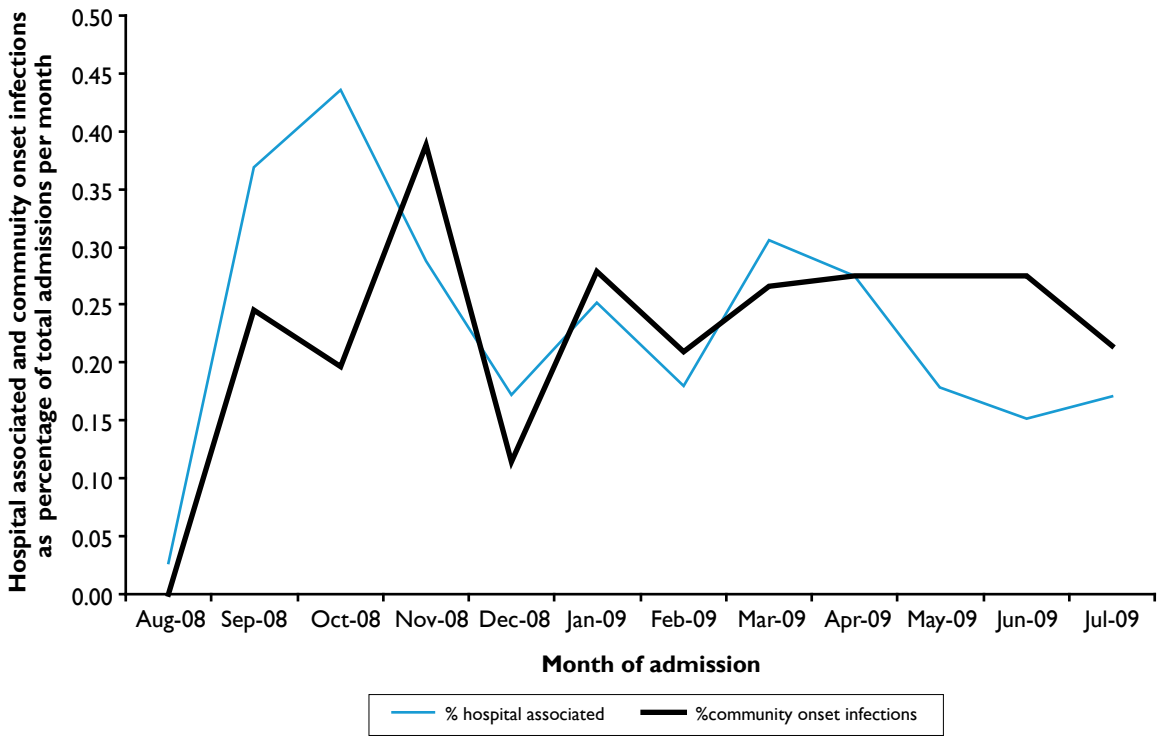
The percentages of colonised admissions, burden and infections all have statistically significant ($p<0.05$), decreasing linear trends during the year of implementation of MRSA screening. The percentage of infections decreased at a similar rate to the percentage of colonised admissions while the percentage burden decreased at a smaller rate (see coefficients in Table 12-14). The number of known positives did not appear to have a significant linear trend and thus was modelled just by a constant.

Table 12-14: Summary table of Poisson regression analyses with time as an independent variable

	P-value	Coefficient	95% Lower Limit	95% Upper Limit
Colonised Admissions	<0.0001	-0.0344	-0.0467	-0.0221
Known Positives	0.93	0.0004	-0.0086	0.0095
Burden	0.0127	-0.0102	-0.0183	-0.0022
Infections	0.0209	-0.0374	-0.0691	-0.0057

Figure 12-10 shows the percentage of hospital associated and community onset infections overall for all pathfinder boards by month during the pathfinder project.

Figure 12-10: Percentage of hospital associated and community onset MRSA infections by month of admission, N=81,438

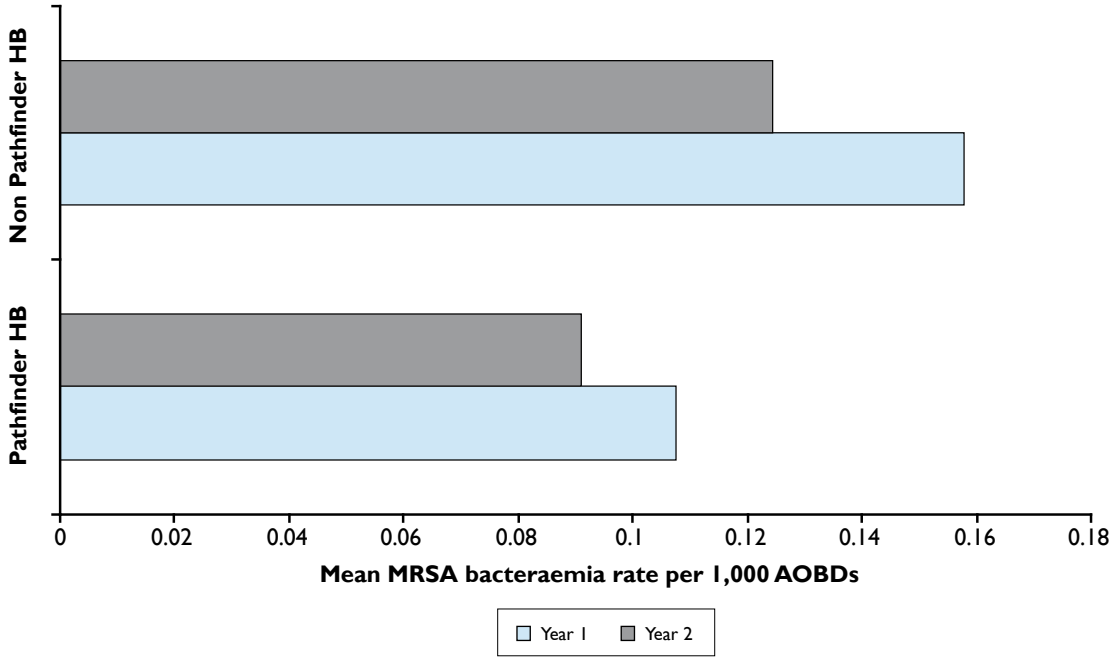


Poisson regression analyses were carried out on the national mandatory surveillance of MRSA bacteraemia data held at HPS. The Poisson regression showed that the rate in the Pathfinder boards decreased by 15.2% from 0.107 per 1,000 AOBDs in the year ending July 2008 to 0.091 per 1,000 AOBDs in the year ending July 2009; this change was not statistically significant. (Note the numbers are small therefore the statistical power is affected).

The MRSA bacteraemia rate in the non pathfinder boards decreased by 21.1% from 0.158 per 1,000 AOBDs in the year ending July 2008 to 0.125 per 1,000 AOBDs in the year ending July 2009, this change was statistically significant ($P<0.001$).

The interaction term in the Poisson regression tested if these percentage changes were statistically significantly different between the pathfinder and non pathfinder boards. It showed that the percentage changes in rates between the pathfinder and non pathfinder boards between the two years were not statistically significantly different (Figure 12-11).

Figure 12-11: Multiple bar chart of MRSA bacteraemia for pathfinder and non pathfinder NHS Boards



A time series analysis of first clinical (non screening) isolates of MRSA from laboratory data for the year prior to and after screening implementation was carried out for two pathfinder boards, (Ayrshire and Arran and Grampian), the Western Isles was excluded as these data contained such small numbers. In this analysis the data from Ayrshire and Arran were combined with those from Grampian and a factor used to differentiate between them. There was no statistical evidence that any of the trends in the piecewise linear model varied between Grampian and Ayrshire and Arran ($F=0.46$ on 4, 84 degrees of freedom, $p=0.76$, within the quasi Poisson model) and so it is reasonable to pool the data over the two boards to display the trends.

12.4.3.1 Time series analyses

First new clinical isolates of MRSA within a year (in non screening samples) were used for time series analysis. One year before the analysis was deduplicated to ensure that the initial months did not show an artifically large number of first new clinical isolates. Each analyses used an identical protocol. If a patient had many samples taken and a number of those samples showed MRSA to be isolated, either within a single or multiple admissions, within one year they were removed. Only the first incidence of a MRSA clinical isolate with in a year was included within the analyses.

A comparison of total first new clinical isolates of MRSA within a year in Pathfinder hospitals for year one and year two was carried out to determine if there was a difference before and after screening.

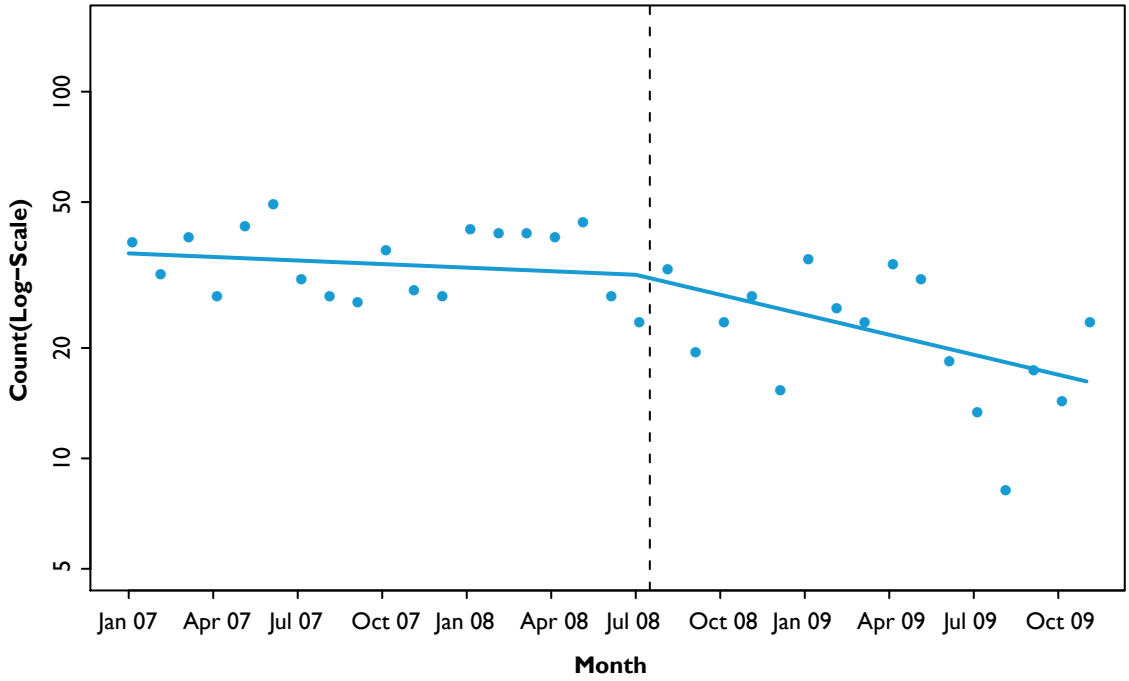
Historical Comparator

In pathfinder hospitals a reduction in first clinical isolates of MRSA was seen from year one to year two. The magnitude of this reduction was 15% (445 to 378 in Grampian) and 27% (397 to 292 in Ayrshire and Arran) respectively. The combined reduction across pathfinder boards during the implementation of the screening was 20% (842 to 670). Statistical analysis of this reduction indicates this is/ is not statistically significant.

In addition to comparing the year before with the year after screening was implemented it was possible to analyse these data using a piecewise linear model to look at the trends in the numbers of MRSA clinical isolates month by month before and after screening was implemented in July 2009.

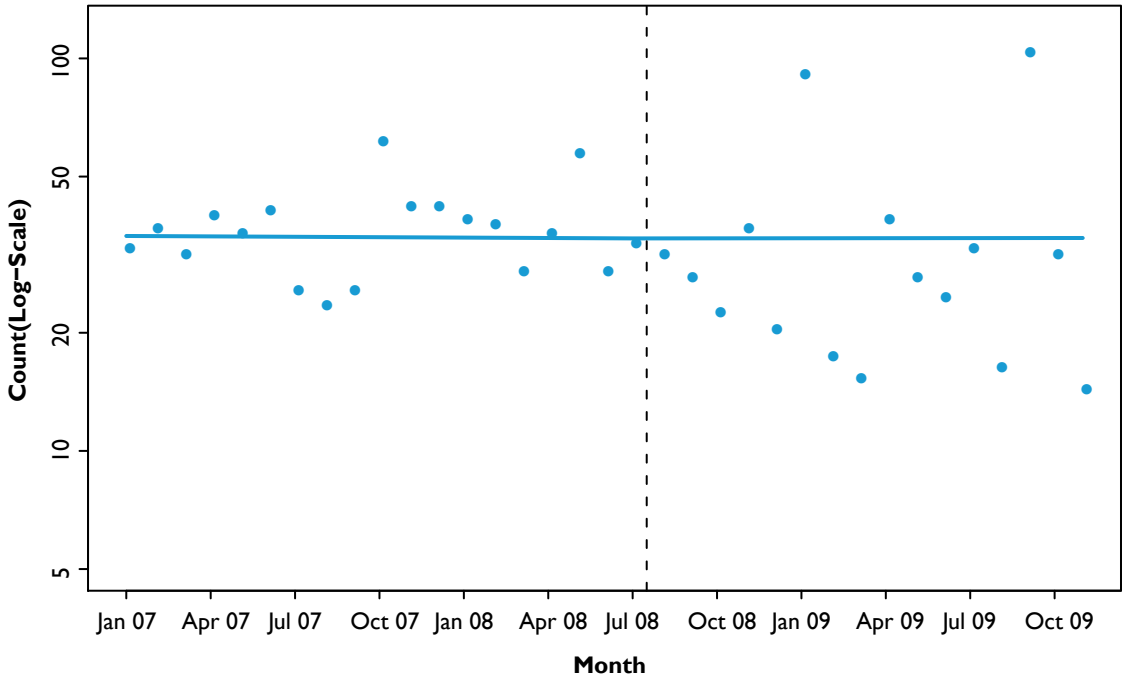
For Ayrshire and Arran using the piecewise linear model the decrease in rates of first clinical isolates of MRSA was greater post the intervention of universal screening, however this reduction in rate was not statistically significant ($p=0.067$). In the pathfinder hospitals there was a decrease of 0.007 per month before August 2008. From August 2008 onwards the log MRSA cases have decreased at a rate of 0.041.

Figure 12-12: Comparison of MRSA first new clinical isolates in Ayrshire and Arran Pathfinder hospitals from January 2007 to November 2009 the change point (or date that universal screening was implemented) was July 2008 (Presented on a logarithmic scale).



For Grampian using the piecewise linear model the decrease in rates of first clinical isolates of MRSA were the same post the intervention of universal screening, therefore the rate did not change (p=0.979). In the pathfinder hospitals there was a decrease of 0.001 per month before August 2008. From August 2008 onwards the log MRSA cases have not changed.

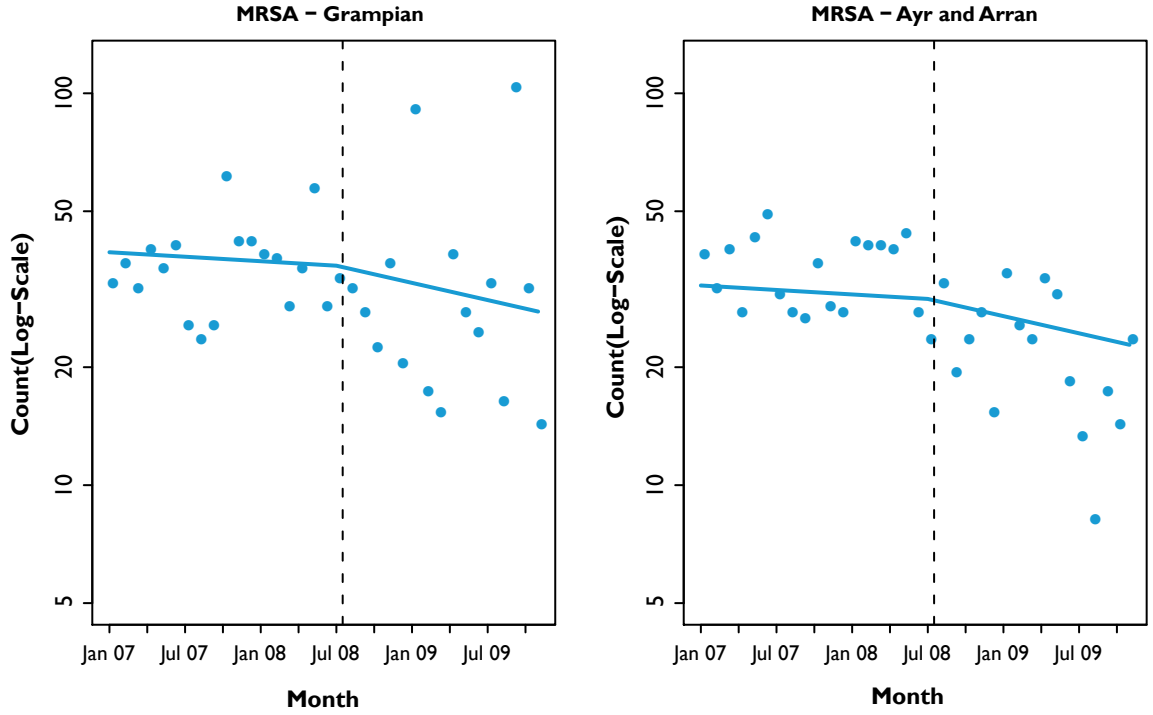
Figure 12-13: Comparison of MRSA first new clinical isolates in Grampian Pathfinder hospitals from January 2007 to November 2009 the change point (or date that universal screening was implemented) was July 2008 (Presented on a logarithmic scale).



In this analysis the data from Ayrshire and Arran were combined with those from Grampian and a factor used to differentiate between them. There was no statistical evidence that any of the trends in the piecewise linear model varied between Grampian and Ayrshire and Arran (F= 2.483 on 4, 64 degrees of freedom, p=0.092, within the quasi Poisson model) and so it was reasonable to pool the data over the two boards to display the trends.

For the combined data using the piecewise linear model the decrease in rates of first clinical isolates of MRSA was greater post the intervention of universal screening, however this reduction in rate was not statistically significant (p=0.575). There was a decrease of 0.004 per month before August 2008. From August 2008 onwards the log MRSA cases have decreased at a rate of 0.016.

Figure 12-14: Comparison of MRSA first new clinical isolates from combined Ayrshire and Arran and Grampian Pathfinder hospitals from January 2007 to November 2009 the change point (or date that universal screening was implemented) was July 2008 (Presented on a logarithmic scale).



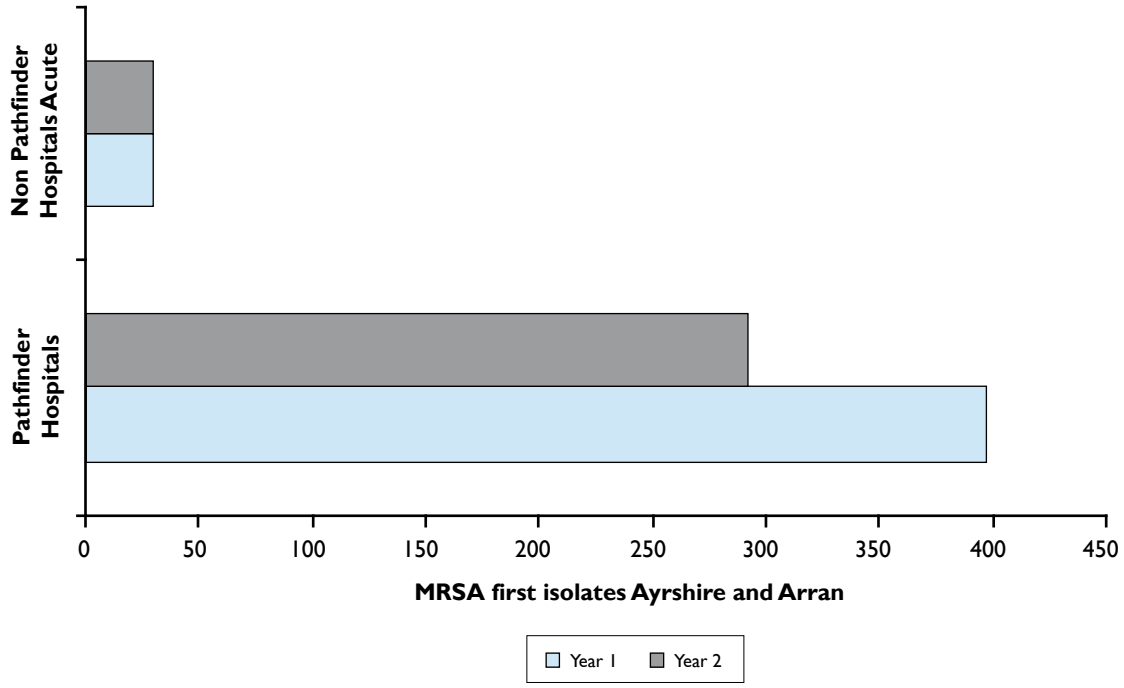
Non-pathfinder comparator

Within these analyses the comparator hospitals were the small acute hospitals within the pathfinder health board areas, but were not part of the Pathfinder studies, i.e. did not have universal MRSA screening implemented.

Poisson regression analyses are used to assess the relationship between the year and the pathfinder or non pathfinder acute hospitals within each health board (Figure 12-15 and Figure 12-16)

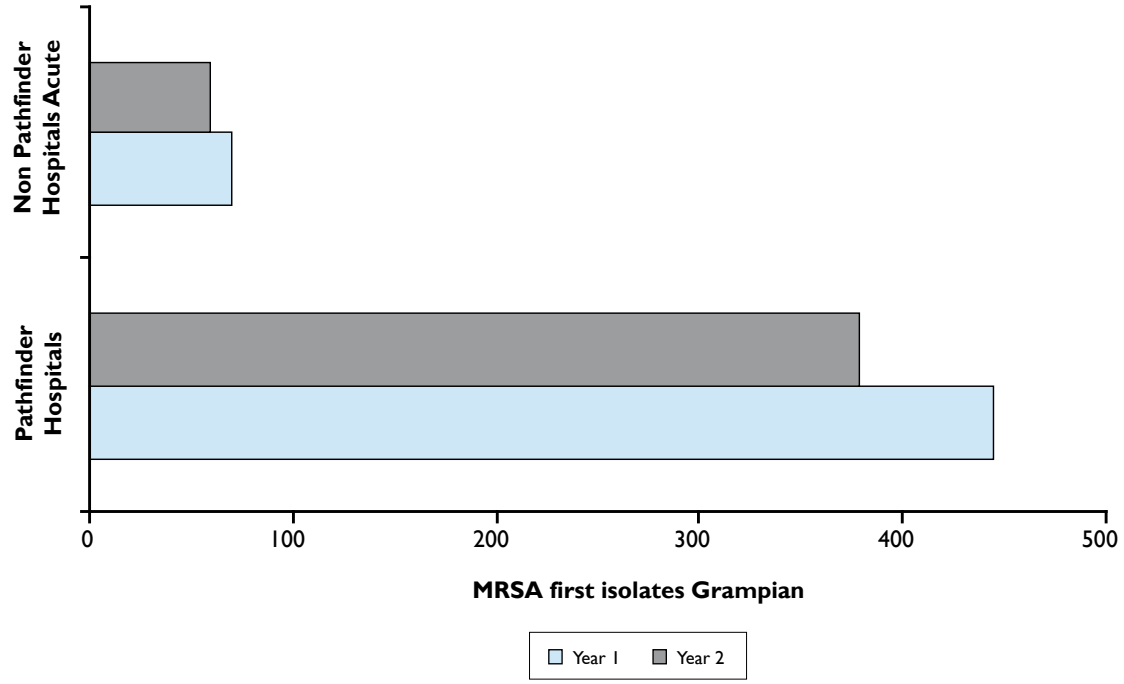
For Ayrshire and Arran, the reduction in volume of first clinical isolates was greater in pathfinder hospitals, however there was no significant differences in the percentage change of MRSA cases from year one to year two between the pathfinder and non pathfinder hospitals. The produced p-value is not significant (0.262).

Figure 12-15: Poisson regression of MRSA first new clinical isolates before and after implementation of Pathfinder study Ayrshire and Arran Pathfinder and non Pathfinder hospitals



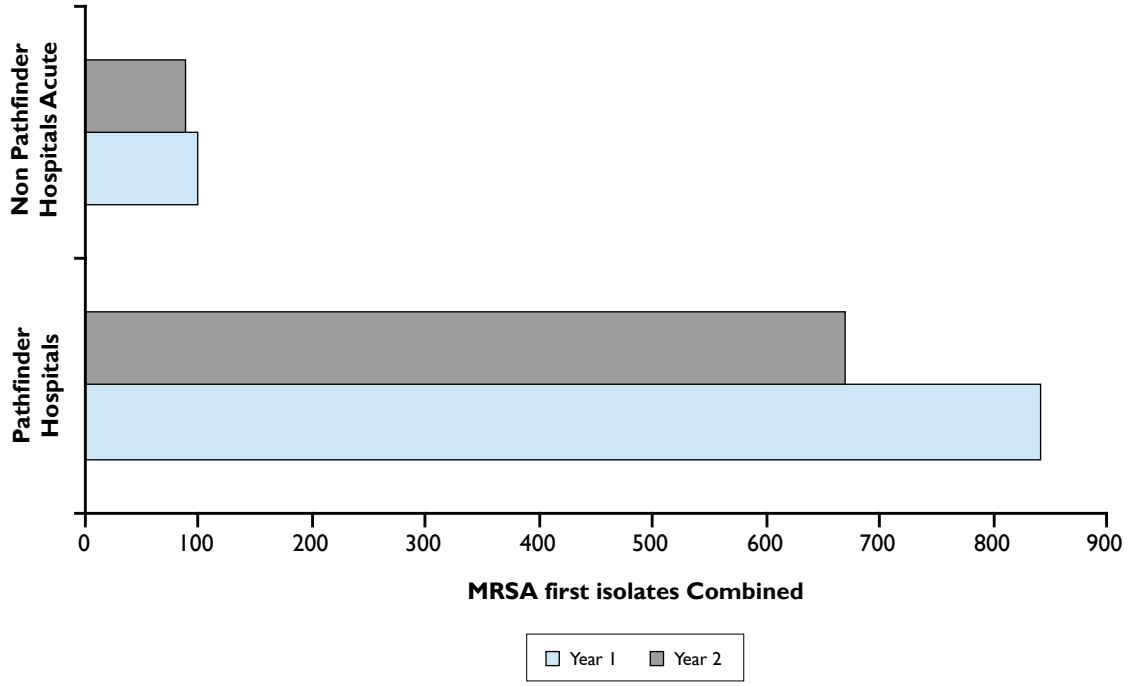
For Grampian, the reduction in volume of first clinical isolates was greater in pathfinder hospitals, however there was no significant differences in the percentage change of MRSA cases from year one to year two between the pathfinder and non pathfinder hospitals (0.962).

Figure 12-16: Poisson regression of MRSA first new clinical isolates before and after implementation of Pathfinder study Grampian Pathfinder and non Pathfinder hospitals



When the combined data from both boards were examined (Figure 12-17) , there is no significant difference in the percentage change of MRSA cases from year one to year two between the pathfinder and non pathfinder hospitals (P=0.431).

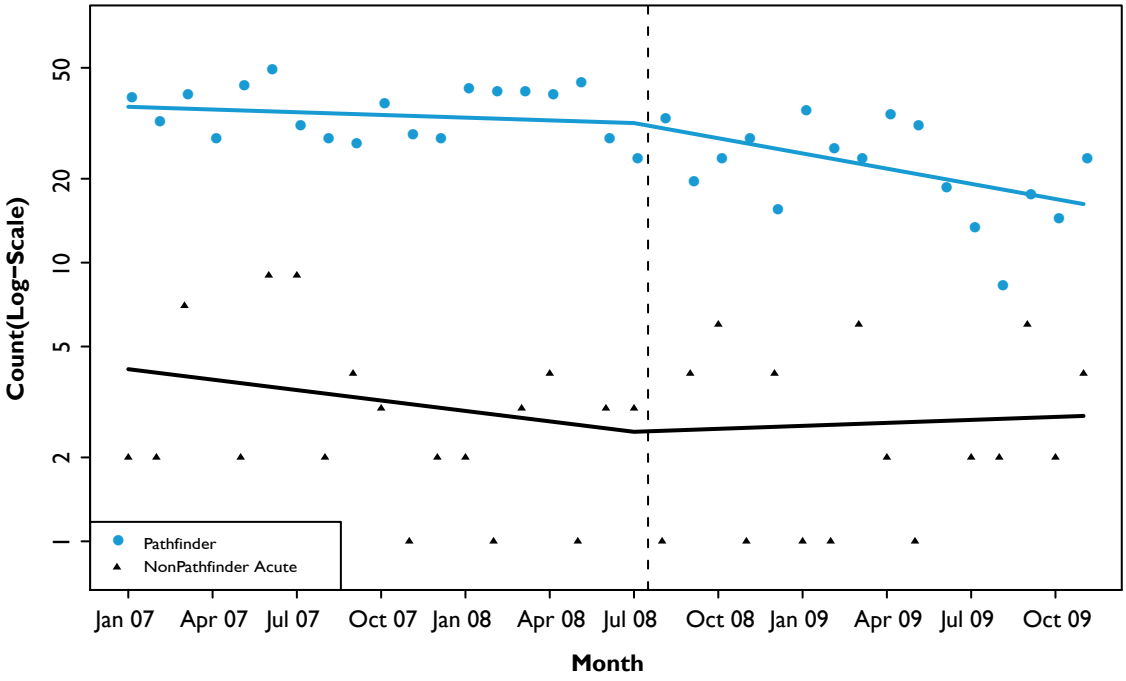
Figure 12-17: Poisson regression of MRSA first new clinical isolates before and after implementation of Pathfinder study combined Ayrshire and Arran and Grampian Pathfinder and non Pathfinder hospitals



In addition to comparing the year before with the year after screening was implemented it was possible to analyse these data using a piecewise linear model to look at the trends in the numbers of MRSA clinical isolates month by month before and after screening was implemented in July 2009 and between pathfinder and non pathfinder hospitals.

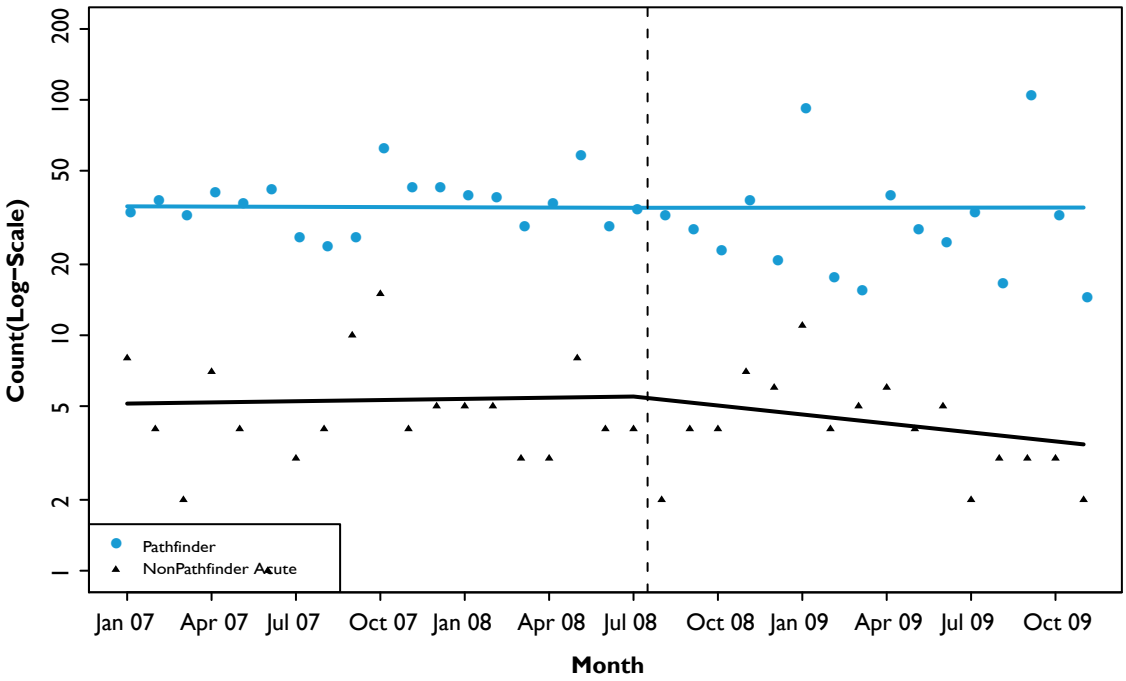
Before the intervention of universal screening in pathfinder hospitals in Ayrshire and Arran, the non pathfinder acute hospitals log MRSA cases decreased at a rate of 0.029 per month while in the pathfinder hospitals there was a decrease of 0.007 per month. From August 2008 onwards the log MRSA cases increased in non pathfinder acute hospitals at a rate of 0.008 per year. In pathfinder hospitals post implementation of universal MRSA screening from August 2008 there was a decrease in the log MRSA rates of 0.042 per month. Whilst a reduction was seen in pathfinder hospitals and not in non pathfinder hospitals, this did not reach statistical significance (p= 0.208) (Figure 12-18)

Figure 12-18: Comparison of MRSA first new clinical isolates in Ayrshire and Arran Pathfinder hospitals compared with Ayrshire and Arran non Pathfinder acute hospitals from January 2007 to November 2009 the change point (or date that universal screening was implemented) was July 2008 (Presented on a logarithmic scale).



Before the intervention of universal screening in pathfinder hospitals in Grampian, the non pathfinder acute hospitals log MRSA cases increased at a rate of 0.004 per month while in the pathfinder hospitals there was a decrease of 0.001 per month. From August 2008 onwards the log MRSA cases have decreased in non pathfinder acute hospitals at a rate of 0.029 per year. In pathfinder hospitals post implementation of universal MRSA screening from August 2008 there was no change in the log MRSA rates per month. There was no significant evidence that the trends from August 2008 onwards are not the same in pathfinder and non pathfinder hospitals (p= 0.669) (Figure 12-19)

Figure 12-19: Comparison of MRSA first new clinical isolates in Grampian Pathfinder hospitals compared with Grampian non Pathfinder acute hospitals from January 2007 to November 2009 the change point (or date that universal screening was implemented) was July 2008 (Presented on a logarithmic scale).



Overall *S. aureus* comparator

In order to examine the impact of the intervention of MRSA screening on outcome, the reduction in MRSA first new clinical isolates as a proportion of all *S. aureus* first new isolates was examined.

Pearson Chi-squared tests were conducted to test for association between the year and the proportion of all S.aureus which was MRSA for the recorded annual counts one year before and one year after August 2008. For both pathfinder hospitals there was a statistically significant reduction in the proportion of all *S. aureus* which was MRSA. This indicates that the percentage change in the MRSA count from year one to year two was significantly different to the percentage change in the all S.aureus count over the same years ($p<0.0001$ for Ayrshire and Arran and $p=0.014$ for Grampian respectively).

The same analyses were undertaken for non pathfinder hospitals and the results indicated no significant difference in the proportion of *S. aureus* which were MRSA in year one compared to year two (p= 0.682 for Ayrshire and Arran and p=0.462 for Grampian respectively).

12.4.4 Aim 1 Objective 4: To monitor the trends in mandatory surveillance data outputs undertaken by HPS examining the key indicators of HCAI (S. aureus bacteraemia, Surgical Site Infection (SSI))

Poisson regression analyses were carried out on two sets of national mandatory surveillance data held at HPS to investigate if the incidence of each of the type of infection in the pathfinder boards changed in a significantly different way to the incidence in the non pathfinder boards during year prior to the pathfinder study and the year of the pathfinder study.

The two sets of data were: Meticillin Sensitive *Staphylococcus aureus* (MSSA) bacteraemia (Figure 12-20) and surgical site infections (SSI) for hip arthroplasty (Figure 12-21).

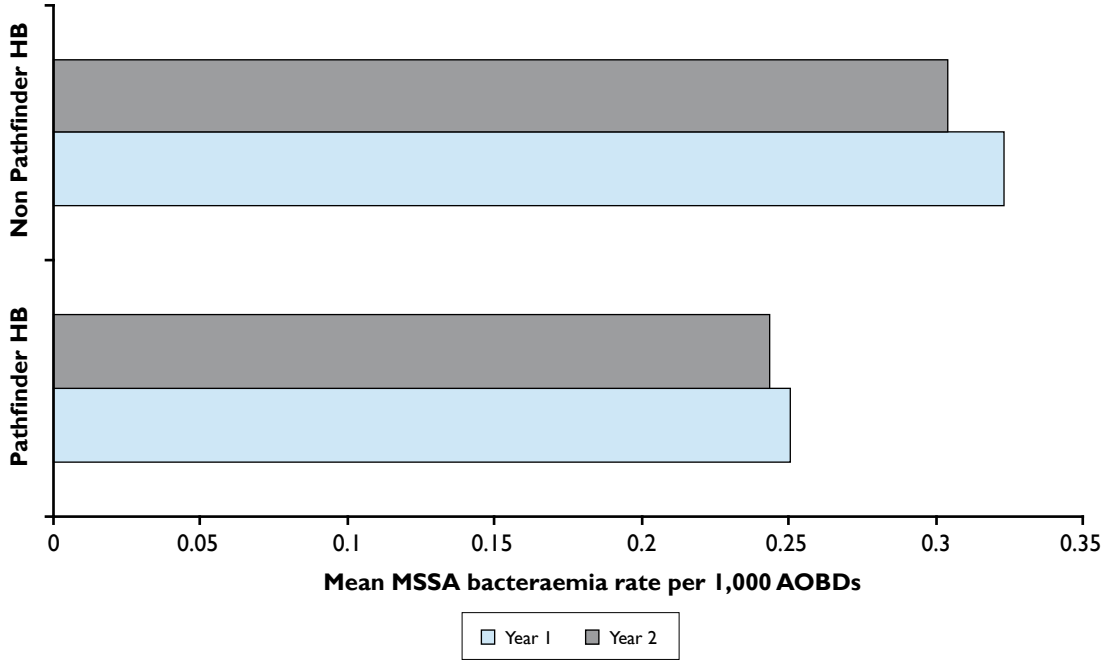
MSSA

In Meticillin sensitive *Staphylococcus aureus* (MSSA) bacteraemia (Figure 12-20) Poisson regression showed that the rate in the Pathfinder boards decreased by 15.2% from 0.107 per 1,000 Acute Occupied Bed Days (AOBDs) in the year ending July 2008 to 0.091 per 1,000 AOBDs in the year ending July 2009; this change was not statistically significant.

The MSSA bacteraemia rate in the non Pathfinder boards decreased by 21.1% from 0.158 per 1,000 AOBDs in the year ending July 2008 to 0.125 per 1,000 AOBDs in the year ending July 2009, this change was statistically significant ($P<0.001$) and was largely driven by the change in one large NHS board.

The interaction term in the Poisson regression tested if these percentage changes were statistically significantly different between the Pathfinder and non Pathfinder boards. It showed that the percentage changes in rates between the Pathfinder and non Pathfinder boards between the two years were not statistically significantly different.

Figure 12-20 Multiple bar charts of MSSA bacteraemia for pathfinder and non pathfinder NHS Boards



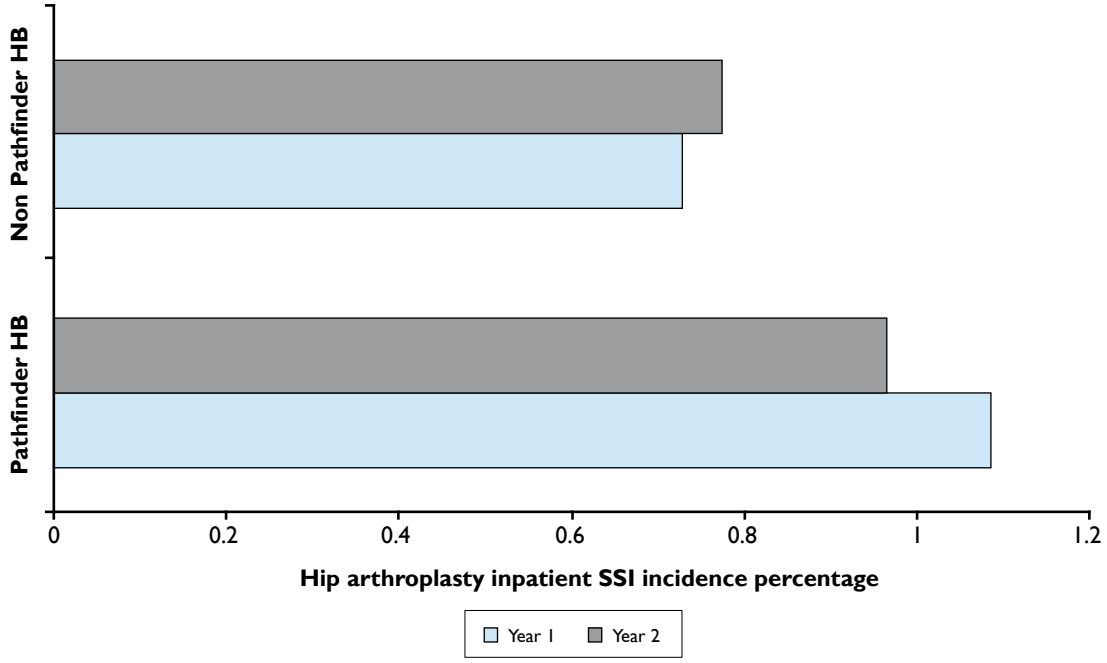
SSI

Surgical site infections following hip arthroplasty (Figure 12-21) were analysed using Poisson regression, which showed that the rate in the Pathfinder boards decreased by 11.2% from 1.09 per 100 operations in the year ending July 2008 to 0.965 per 100 operations in the year ending July 2009, this change was not statistically significant.

The rate in the non Pathfinder Boards increased by 6.29% from 0.728 per 100 operations in the year ending July 2008 to 0.774 per 100 operations in the year ending July 2009, this change was not statistically significant.

The interaction term in the Poisson regression tested if these percentage changes were statistically significantly different between the Pathfinder and non Pathfinder boards. It showed that the percentage changes in rates between the Pathfinder and non Pathfinder boards between the two years were not statistically significantly different. It should be noted that the statistical power in theses analyses was affected as the incidence of SSI following arthroplasty was low.

Figure 12-21: Multiple bar charts for surgical site infections following hip arthroplasty operations by pathfinder and non pathfinder NHS Boards



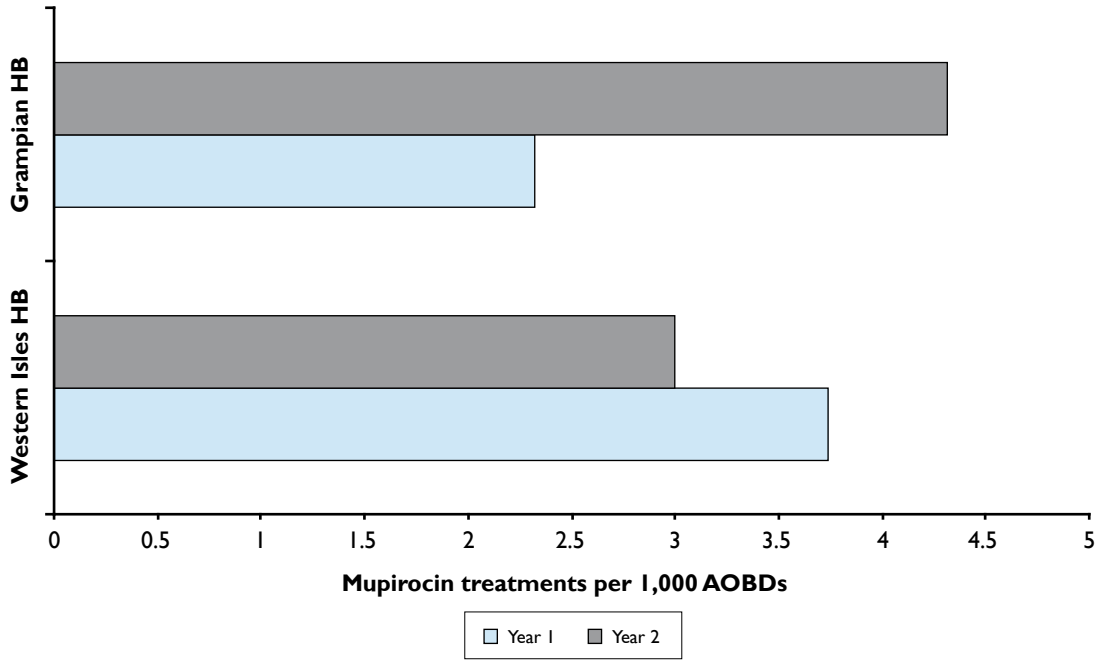
12.4.5 Aim 1 Objective 5: To monitor mupirocin antibiotic usage over the study period.

Poisson regression on pharmacy data from those pathfinder boards, (Grampian and the Western Isles), where these data were available, showed that the rate of mupirocin antibiotic usage in Grampian health board rose by 85.6% from 2.32 per 1,000 AOBDs in the year ending July 2008 to 4.31 per 1,000 AOBDs in the year ending July 2009; this change was statistically significant (P<0.001).

The mupirocin usage rate in the Western Isles Board decreased by 19.9% from 3.74 per 1,000 AOBDs in the year ending July 2008 to 2.99 per 1,000 AOBDs in the year ending July 2009, this change was not statistically significant.

The interaction term in the Poisson regression tested if these percentage changes were statistically significantly different between the Grampian and Western Isles boards. It showed that the percentage changes in rates between the Grampian and Western Isles boards between the two years were statistically significantly different (P<0.001) (Figure 12-20).

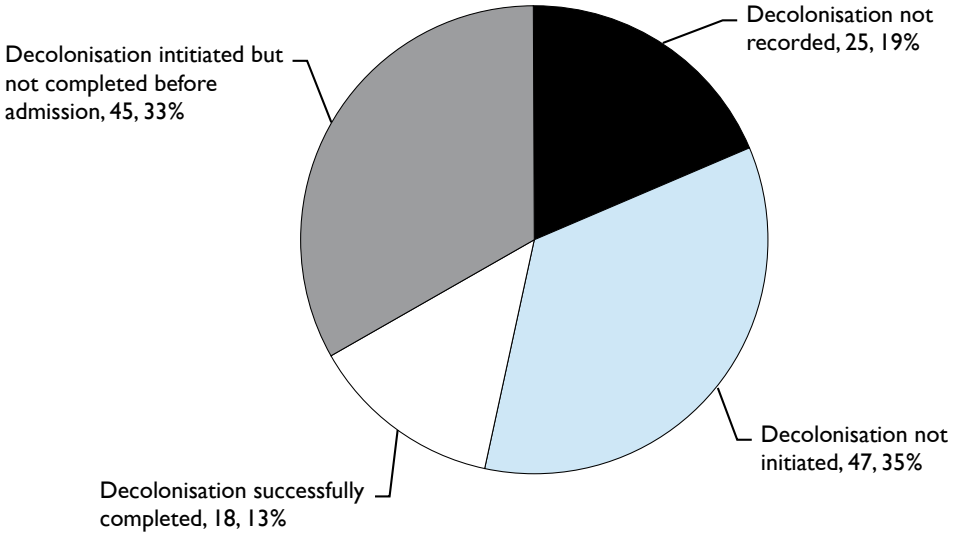
Figure 12-22: Multiple bar chart of mupirocin antibiotic usage by pathfinder NHS Boards



12.4.6 Aim 1 Objective 6: To evaluate the success of decolonisation.

Of all patient admissions screened at pre-admission clinics, 2.1% (135/6,411) were positive for MRSA (Figure 12-23). Of those who were positive 46% (63/135) were given decolonisation and 35% (47/135) were recorded as having received no treatment. For 19% (25/135) treatment status was unknown. Only 18 (13% of all positive admissions identified by pre-admission screen, but 2.1% of all preadmission patients screened) were successfully decolonised.

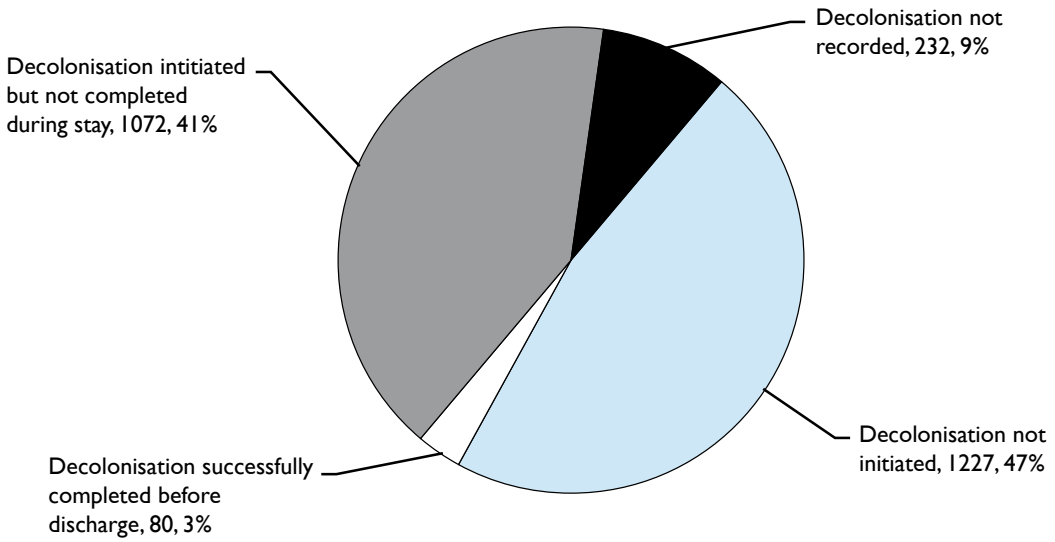
Figure 12-23: Pie chart shown decolonisation status of all pre-admission positive admissions N=135



Most of the patients who were screened at pre-admission clinic were not re-screened on admission 94.8% (6,081/6,411).

Of the 2,611 admissions, (elective and emergency presentation), who had a positive admission screen result, 1,152 (44%) received treatment (Figure 12-24). Of the 1,152 receiving treatment 80 (6.9%) of those admissions who received treatment received three consecutive screens prior to discharge.

Figure 12-24: Pie chart shown decolonisation status of all admission screen positive admissions N=2,611



Admissions positive from admission screen, N= 2,611

12.4.7 Aim 1 Objective 7: To assess the validity of nasal swabs for universal screening

Within the pathfinder study the number of patients found positive for MRSA colonisation by nasal swab, colonisation by a swab taken from any other body site, from a colonised wound or device and infected sites were recorded.

During the study, specialties which routinely screened patients in sites other than nares were instructed to continue as per local protocol. For specialties which did not previously routinely screen patients, a minimum of a nasal swab was taken unless other sites were indicated due to presence of skin breaks, devices, wounds or there was a clinical reason to suspect MRSA infection. All screen sites which were found to be positive were recorded. These data include patients with indicators for possible colonisation or infection.

For inpatient screening, nasal screening identified 86% of all positive colonisations, the remainder of colonisations were detected only at other screening body sites, devices or wound sites.

12.4.8 Aim 1 Objective 8: To assess the validity of the testing strategy 2 from the HTA

Multivariable logistic regression, clustered by patient admissions, was carried out to investigate the prevalence on admission of known positive or screened positive on admission and burden positive among the study population. All 81,438 admissions were included in the regression. The outcome variable was burden positive. Variables included in the model were age at admission, gender, type of admission (elective/emergency), frequency of admission in the study year, hospital and specialty admitted to, and where the patient was admitted from (home or not). Interactions with age group, gender and type of admission were tested and found to be not significant. The significant variables are displayed in Table 12-15. In order of importance the variables that independently best predicted burden positive on admission were frequency of admission, age, whether or not admitted from home, specialty and type of admission.

Table 12-15 shows the number of admissions, percent of admissions, number of burden positive and percentage of burden positive for the variables which were found to be important independent predictors in the regression analyses.

Table 12-15: Logistic regression of factors associated with being known positive on Admission N=81,438

Variable	Subgroup	Regression Coefficient (standard error)		P Value	Odds Ratio (95% CI)
Frequency of Admission	1 admission (baseline)	0	-	-	1
	2 admissions	0.567	0.042	<0.0001	1.764 (1.624 , 1.92)
	3 admissions	0.928	0.059	<0.0001	2.53 (2.253 , 2.84)
	4+ admissions	1.317	0.068	<0.0001	3.731 (3.267 , 4.26)
Age Group	<= 49 yrs (baseline)	0	0	-	1
	50- 64 yrs	0.382	0.078	<0.0001	1.466 (1.258 , 1.71)
	65-79 yrs	0.795	0.07	<0.0001	2.214 (1.929 , 2.54)
	80+ yrs	1.3	0.069	<0.0001	3.669 (3.205 , 4.2)
Admitted from	Admitted from home (baseline)	0	-	-	1
	Not admitted from home	0.88	0.05	<0.0001	2.41 (2.185 , 2.66)
Speciality	Surgery (baseline)	0	-	-	1
	Accident and Emergency	-0.269	0.101	0.008	0.764 (0.627 , 0.93)
	Cardiology	-0.168	0.08	0.0368	0.845 (0.722 , 0.99)
	Care Of the Elderly	0.326	0.092	0.0004	1.385 (1.156 , 1.66)
	Anaesthesia/ ICU/ HDU	0.265	0.12	0.0267	1.304 (1.031 , 1.65)
	Medicine	0.29	0.046	<0.0001	1.337 (1.223 , 1.46)
	Oncology	-0.505	0.156	0.0012	0.603 (0.444 , 0.82)
	Orthopaedic	-0.254	0.065	0.0001	0.776 (0.682 , 0.88)
	Nephrology/Renal	0.444	0.086	<0.0001	1.558 (1.317 , 1.84)
Type of Admission	Elective (baseline)	0	-	-	1
	Emergency	0.274	0.041	<0.0001	1.315 (1.213 , 1.43)
	constant	-4.275	0.089		
Log Likelihood: -20165.20		Degrees of Freedom:17			AIC: 40364.40

12.4.9 Aim 1 Objective 9: To identify new epidemiology

Figure 12-25 shows European Centre for Disease Prevention and Control (ECDC) reporting of prevalence of helahtcare associated (nosocomial) infection taken from national or multicentre prevalence surveys. This shows *S. aureus* (including MRSA and MSSA) to be the second most prevalent causative organism for nosocomial infection in Europe.

Figure 12-25 Relative frequency of micro organism isolated in Nosocomial infections (all types) in six European national or multicentre prevalence surveys [8].

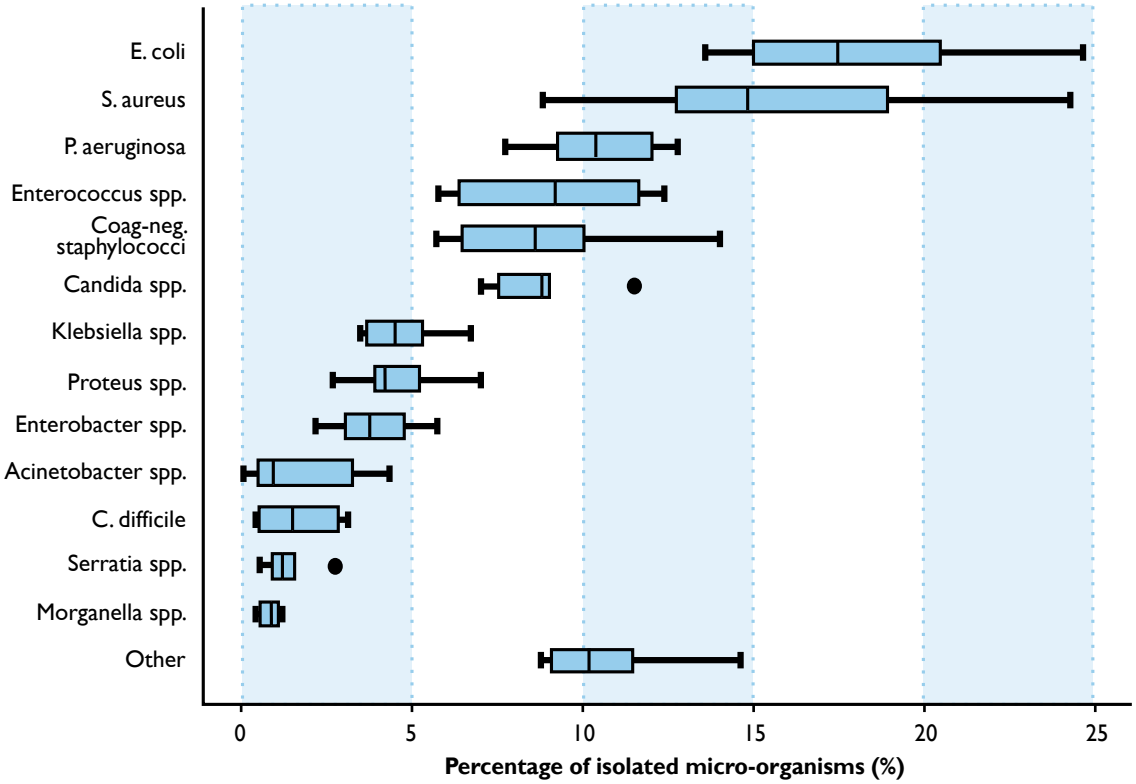
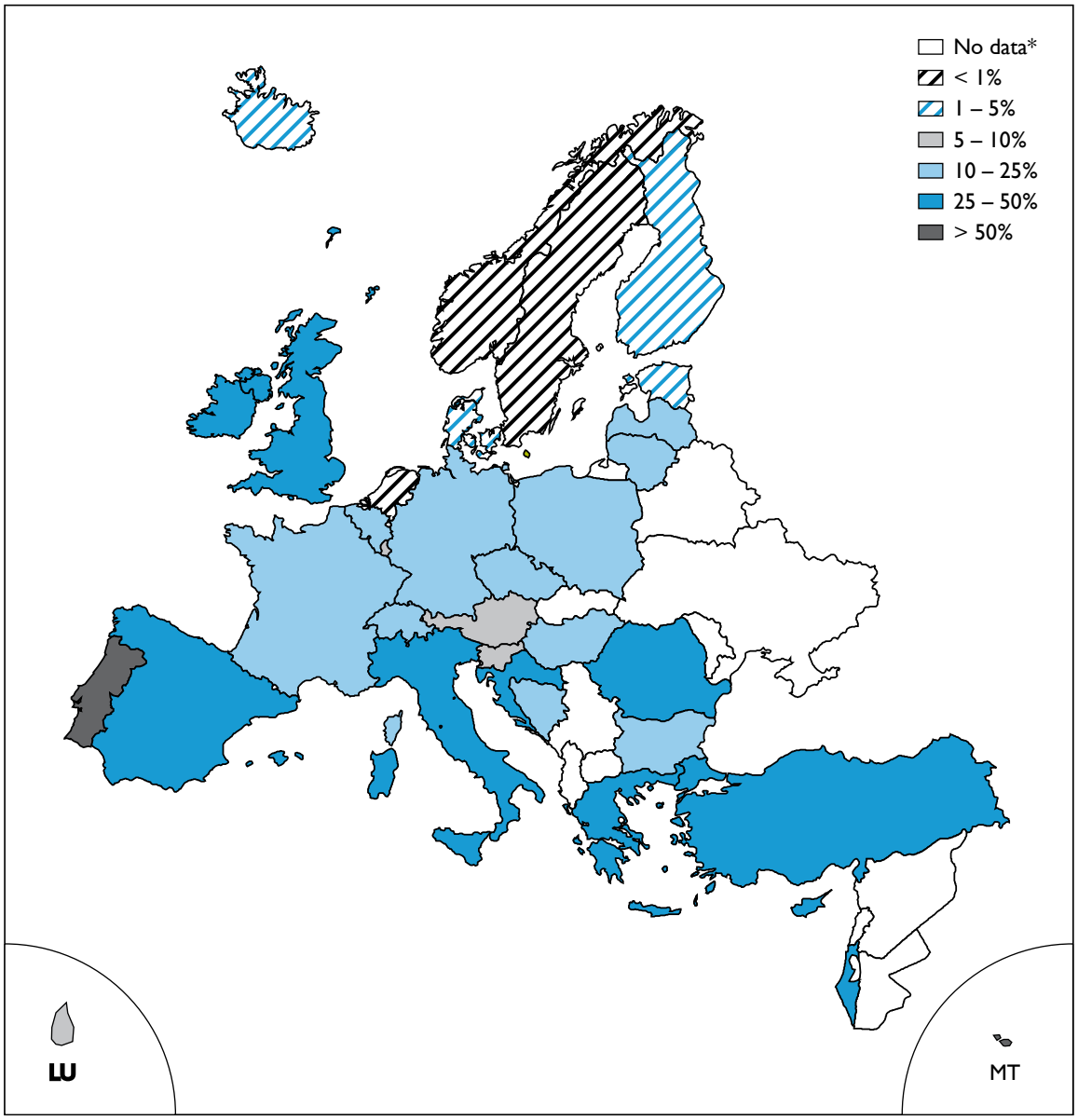


Figure 12-26 shows the European Antimicrobial Resistance Surveillance System (EARSS) summary of the proportion of *S. aureus* isolates resistant to meticillin in 2008. The UK report that 30.7% of isolated *S. aureus* is resistant to meticillin.

Figure 12-26: Staphylococcus aureus proportion of invasive isolated resistant to meticillin (MRSA) in 2008. These countries do not report any data or reported less than 10 isolates [9].



12.4.10 Aim 1 Objective 10: To evaluate other emerging issues from the published literature relating to the screening programme

Table 12-16:Table of issues relating to MRSA screening identified from the published literature.

Issue	Reference	Summary of Evidence
Laboratory	[35;52-56]	There has been much discussion in the literature regarding various areas such as; which body sites give the best results, what sampling technique should be used and also which tests should be used. It has been shown in the literature that some anatomical sample sites have higher sensitivities than others and that combinations of sample site can increase the sensitivity further. The use of rapid tests has been shown in the literature to reduce the turn around time of results and therefore decrease the length of time a patient with unknown status is in isolation; however their use has not been shown to consistently reduce MRSA infections. In addition the additional costs of this type of test merit further investigation into there potential benefits. A number of organisational issues have been highlighted in relation to the laboratory management as a result of universal screening for instance; additional staff; the potential for change to existing working patterns to deal with the increased numbers of swabs and potential increases in the number of consumables (e.g. agar plates, identification tests) as well as their potential impact associated with additional storage / waste produced by these. Point of care testing has potential benefits in admission screening. Laboratory automation to reduce the number of staff required has also been identified as a more efficient way of working with high volumes of samples in screening studies.
Ward facilities	[35;52;54;57]	There will be increased demand for isolation facilities by adoption of universal screening due to the number of both isolation and side rooms used for MRSA positive patients. As a result this may put increase pressure on bed management when considering the number of other infections in healthcare settings. This may therefore require the degree of active surveillance to be judged based on the number of isolation rooms available. Little evidence has been produced on cohorting as an intervention to reduce risk.

Issue	Reference	Summary of Evidence
Staff	[35;57]	There are a number of potential issues for staff managing MRSA positive patients. Firstly there is the possibility of increased nursing time required for isolated patients as a result of nurses needing to go between patients rooms to check them, each time needing to follow the appropriate infection control precautions for entering that patient's room (e.g. contact precautions) and subsequently this may mean that more nurses will be required for an increase in isolated patients. As well as this other tasks associated to screening such as taking swabs, patient transfers, assisting with terminal cleaning and management of decolonisation regimes will also add to the workload of healthcare staff. In addition there may be an impact on prescribing and postponed procedures due to MRSA positive status causing delays.
Infection control	[35;54;56-58]	There are number of specific infection control issues related to screening such as additional gathering of surveillance and audit data and dissemination of this to appropriate healthcare staff, increased management of patients positive for MRSA and any other patients possibly affected and the potential effects of contact precautions such as less HCW contact, less contentment with care and a potential higher rate of depression and anxiety.
Microbiologists	[35]	There may be increased workload caused by universal screening may affect the management of outbreaks and other serious infections.
Counselling and ethics	[35;52;59;60]	Another aspect of universal screening is the management of positive patients and their relatives through appropriate guidance given by HCWs. In addition the appropriate management of staff colonised with MRSA is a topical issue that requires further study. Ethical frameworks for MRSA screening have been called for
Support and ancillary staff	[35]	An number of additional services will need to adapt to the increased identification of MRSA positive patients resulting in; possible increase in ward consumables; increased need for portering staff to deliver screening swabs at the required time; increased need for domestic staff for terminal cleaning at all times of the day and additional linen storage and impact on laundry facilities

12.4.11 Aim 1 Objective 11: To evaluate if the public health principles of introducing a screening programme were met

Table 12-17: Summary of the public health principles in relation to universal MRSA screening

Public Health Principles	Criteria	Met before Pathfinder Project	Met by Pathfinder project	Comments
The Condition	All cost effective primary prevention interventions should have been implemented as far as practicable	X	X	This is outwith the scope of the Pathfinder project. While MRSA rates are decreasing, there is little evidence available for optimal implementation of interventions or for the associated costs.
The Test	The test should be acceptable to the population	X	✓	Clear evidence now of high acceptability ratings from patients (See Volume 3) Remains unknown whether associated interventions are acceptable in those who are screened positive
	There should be a simple, safe, precise and validated test	✓	✓	Timeliness of obtaining test results remains a critical factor, though not a formal part of this criterion.
	There should be an agreed policy on the further diagnostic investigation of individuals with a positive test result and on the choices available to those individuals	✓	✓	Criterion is met within hospital setting – further discussion and research required on actions (if any) required after discharge
The Treatment	There should be an effective treatment or intervention for patients identified through early detection with evidence of early treatment leading to better outcomes than late treatment	✓	✓	Infection incidence reduction observed in those who had decolonisation

Key: ✓ = Fully met (✓) = Partially met X = Not met

Public Health Principles	Criteria	Met before Pathfinder Project	Met by Pathfinder project	Comments
	There should be agreed evidence based policies covering which individual should be offered treatment and the appropriate treatment to be offered	X	✓	Criteria for offer of treatment were established as part of the Pathfinder protocol. The HTA indicated decolonising high risk only, however the pathfinder evidence indicates all positives should be considered for this intervention – further discussion and research required on actions (if any) required after discharge [36].
	Clinical management of the condition and patient outcomes should be optimised in all health care providers prior to participation in a screening programme	X	(✓)	Clear Pathfinder protocols for management of colonised patients and for decolonisation have been developed. Evidence in pathfinder indicates that healthcare redesign is required to further optimise managment
The Screening Programme	There should be evidence from Randomised Controlled Trials (RCTs) that the screening programme is effective in reducing mortality or morbidity	X	X	Initial findings from the Pathfinder study are promising, but longer study will be required to establish efficacy. Formal RCT approach is unlikely.
	There should be evidence that the complete screening programme (test, diagnostic procedures, treatment and intervention) is clinically, socially and ethically acceptable to health professionals and the public	X	(✓)	Results from patient and staff survey indicate high acceptability of the test and diagonstic proceedures. (See Volume three of the report) There is limited evidence for acceptability of the treatment and intervention amongst those found positive – requires further study

Key: ✓ = Fully met (✓) = Partially met X = Not met

Public Health Principles	Criteria	Met before Pathfinder Project	Met by Pathfinder project	Comments
	The benefit from the screening programme should outweigh the physical and psychological harm (caused by the test, diagnostic procedures and treatment)	X	✓	Very low refusal rate and deferral of treatment rate; high acceptability of the test; isolation issues outweighed by privacy and dignity criteria in terms of national single rooms policy. Short term monitoring in the pathfinder boards (one year) indicates no unintended consequences but this requires longer term monitoring
	The opportunity cost of the screening programme (including testing, diagnosis and treatment, administration, training and quality assurance) should be economically balanced in relation to expenditure on medical care as a whole (i.e. value for money)	X	(✓)	The likely costs of a national universal screening programme (initially £14.5m per year) are balanced against the HCAI Point Prevalence study [14] estimates for total HCAI costs of £183m per year; MRSA accounted for 17% of confirmed infections, giving a crude estimate of £31.5m annual costs due to MRSA infections. (See Volume two of the report)
	There should be a plan for managing and monitoring the screening programme and an agreed set of quality assurance standards	X	✓	These key performance indicators are under active development
	Adequate staffing and facilities for testing, diagnosis, treatment, and programme management should be available prior to the commencement of the screening programme	X	(✓)	Funding and preparatory programme for national rollout is underway. NHS boards have developed project initiation documents and financial plans. Laboratory capability issues identified.

Key: ✓ = Fully met (✓) = Partially met X = Not met

Public Health Principles	Criteria	Met before Pathfinder Project	Met by Pathfinder project	Comments
	All other options for managing the condition have been considered: e.g. improving treatment, providing other services, to ensure that no more cost effective intervention could be introduced or current interventions increased within the resources available	X	X	This is outwith the scope of the Pathfinder project. While MRSA rates are decreasing, there is little evidence for optimal implementation of interventions or for the associated costs.
	Evidence based information explaining the consequences of testing, investigation and treatment should be made available to potential participants to assist them in making an informed choice	X	✓	Patient information and consent materials have been developed for the Pathfinder programme, and a suite of materials for national rollout is being prepared.
	Public pressure for widening the eligibility criteria, for reducing the screening interval, and for increasing the sensitivity of the testing process should be anticipated. Decisions about these parameters should be scientifically justifiable to the public	X	✓	High acceptability indicates public pressure will be to resist limiting screening. Harnessing appropriate new technology to improve sensitivity and specificity of testing, and to reduce turnaround times (in relation to cost) is under continuing review, and the use of clinical risk assessment to target patients for screening is being formally tested. Staff screening extention has been considered. Other specialties to be reviewed e.g. paediatrics, obstetrics, etc.

Key: ✓ = Fully met (✓) = Partially met X = Not met

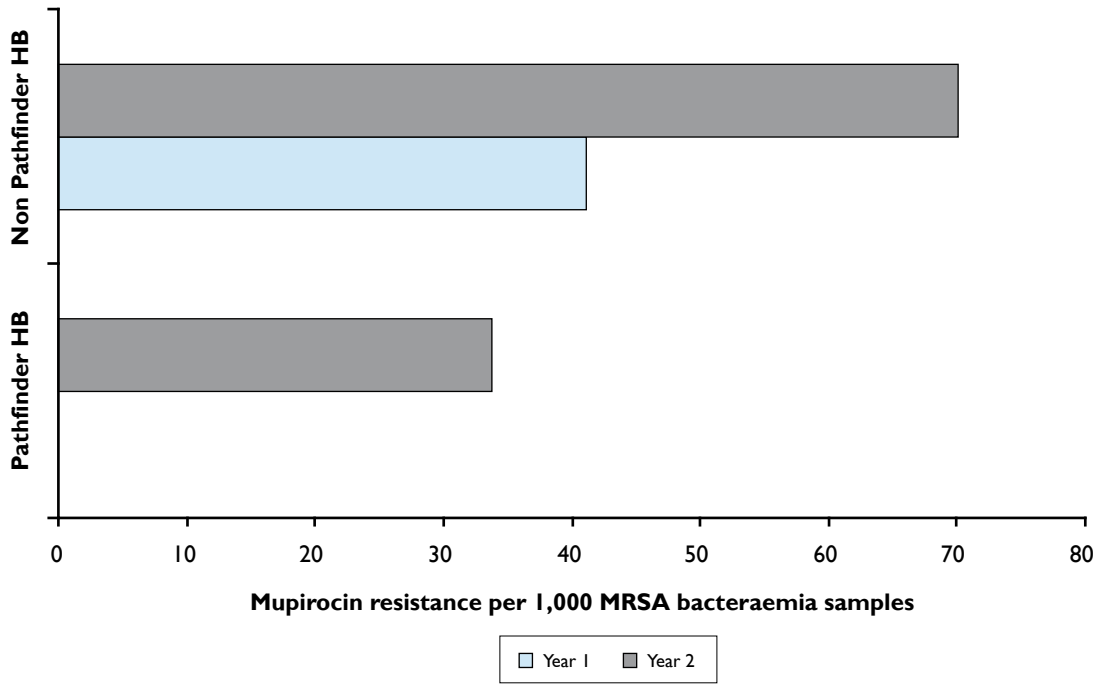
12.4.12 Aim 1 Objective 12: To monitor any change in mupirocin resistance

Poisson regression analyses carried out on the Scottish MRSA reference laboratory data and showed that the rate of mupirocin resistance in the Pathfinder boards increased from 0 per 1,000 MRSA bacteraemia (0/96) in the year ending July 2008 to 33.7 per 1,000 MRSA samples in the year ending July 2009 (3/89), this change was not statistically significant (p=0.998).

The rate in the Non Pathfinder Boards increased by 70.5% from 41.1 per 1,000 MRSA samples (0.041) in the year ending July 2008 to 70 per 1,000 MRSA samples (0.07) in the year ending July 2009, this change was statistically significant (p=0.038).

The interaction term in the Poisson regression tested if these percentage changes were statistically significantly different between the Pathfinder and non Pathfinder boards. It showed that the percentage changes in rates between the Pathfinder and Non Pathfinder boards between the two years were not statistically significantly different (p=0.998) (Figure 12-27).

Figure 12-27: Multiple bar chart of mupirocin resistance as a proportion of all MRSA bacteraemia by pathfinder and non pathfinder sites pre and post implementation of pathfinder project

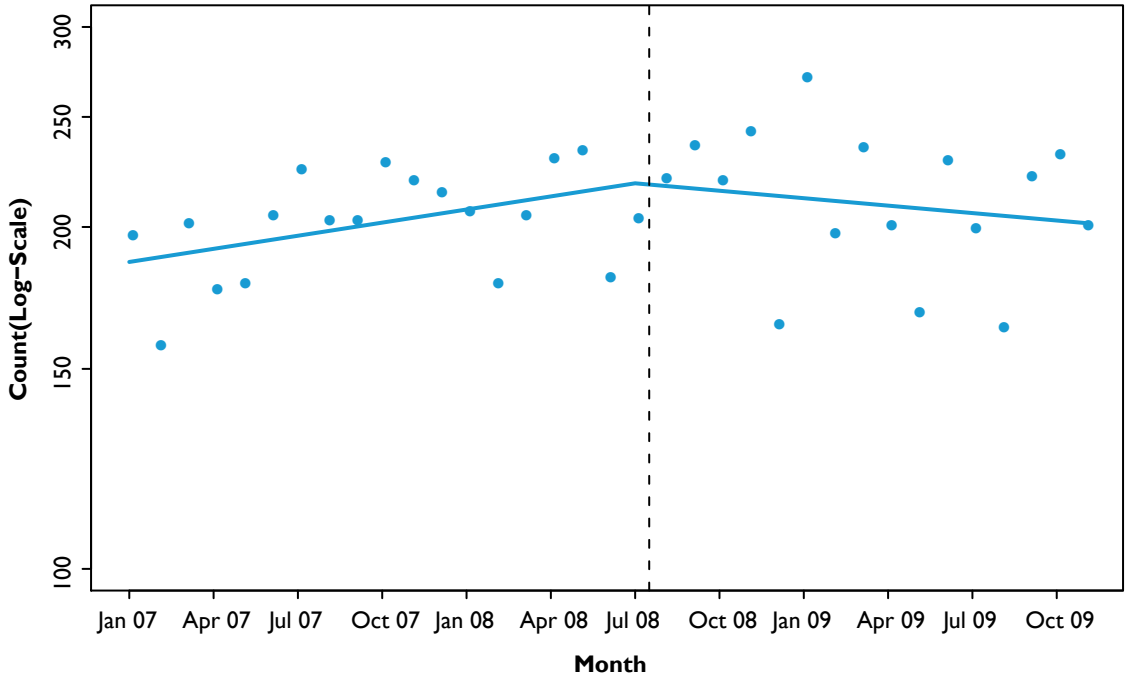


12.4.13 Aim 1 Objective 13: To assess the impact on selected hospital epidemiology of introducing MRSA screening of patients.

12.4.13.1 Historical comparator

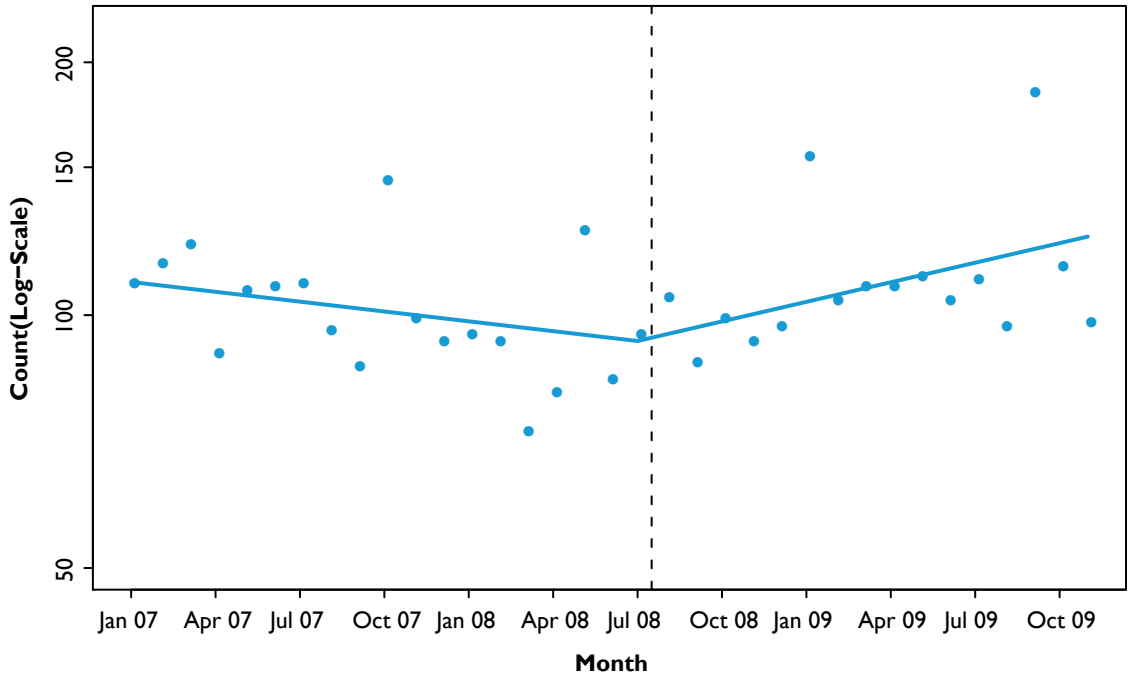
In Ayrshire and Arran there was an increase of 0.009 per month before August 2008. From August 2008 onwards the log MSSA cases decreased in pathfinder hospitals at a rate of 0.005. Using the piecewise linear model there was no evidence that the trend in the rates in pathfinder hospitals before and after August 2008 were significantly different (p=0.092).

Figure 12-28: Comparison of MSSA first new clinical isolates in Ayrshire and Arran Pathfinder hospitals from January 2007 to November 2009 the change point (or date that universal screening was implemented) was July 2008 (Presented on a logarithmic scale).



In Grampian in the pathfinder hospitals there was a decrease of 0.009 per month before August 2008. From August 2008 onwards the log MSSA cases increased in pathfinder hospitals at a rate of 0.018 per month. Using the piecewise linear model there was evidence that the trend in the rates in pathfinder hospitals before and after August 2008 were significantly different (p=0.040).

Figure 12-29: Comparison of MSSA first new clinical isolates in Grampian Pathfinder hospitals from January 2007 to November 2009 the change point (or date that universal screening was implemented) was July 2008 (Presented on a logarithmic scale).



In this analysis the data from Ayrshire and Arran were combined with those from Grampian and a factor used to differentiate between them. There was statistical evidence that the trends in the piecewise linear model varied between Grampian and Ayrshire and Arran and so it was not reasonable to pool the data over the two boards to display the trends.

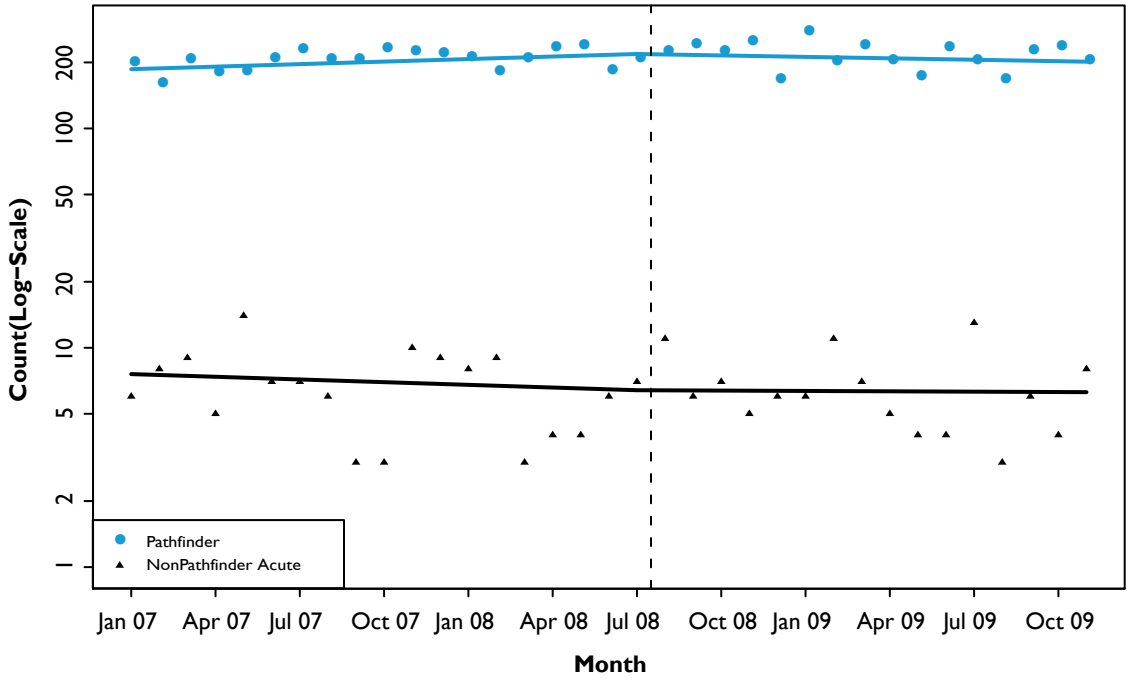
12.4.13.2Non-pathfinder comparator

Within these analyses the comparator hospitals were the small acute hospitals within the pathfinder health board areas, but were not part of the Pathfinder studies, i.e. did not have universal MRSA screening implemented.

Poisson regression analyses were used to assess the relationship between the year and the pathfinder or non pathfinder acute hospitals within each health board (Figure 12-30)

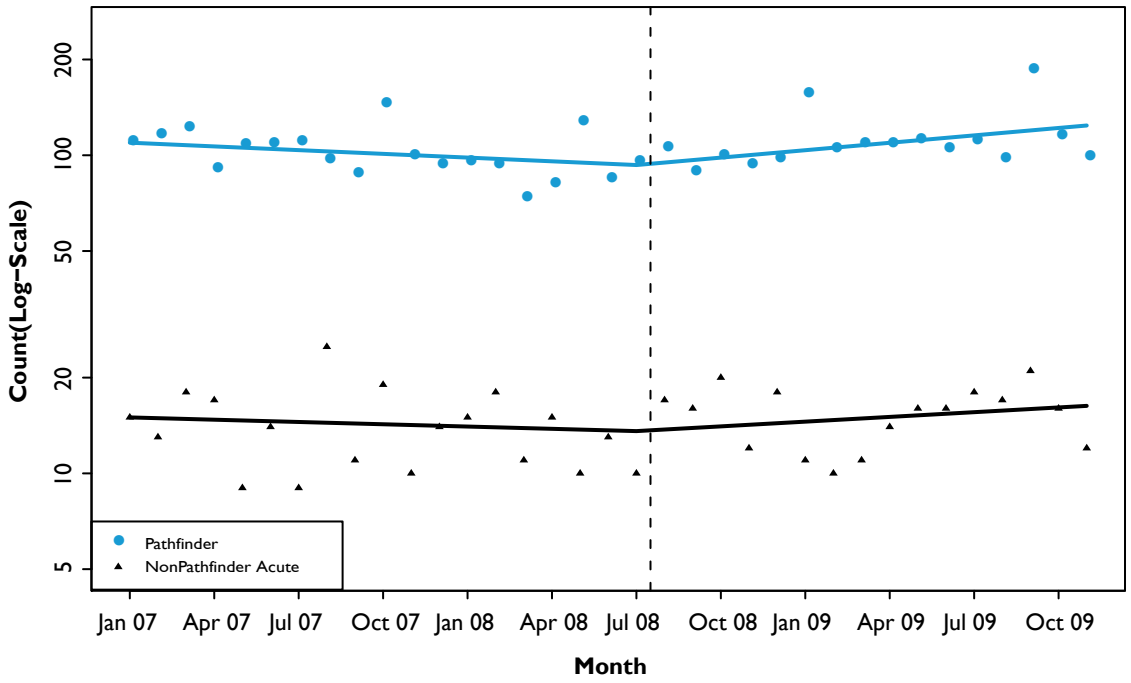
In Ayrshire and Arran there was no significant difference in the trends in first clinical isolates of MRSA before (p= 0.350) or after (p= 0.565) August 2008 in pathfinder and non pathfinder hospitals.

Figure 12-30: Comparison of MSSA first new clinical isolates in Ayrshire and Arran Pathfinder hospitals compared with Ayrshire and Arran non Pathfinder acute hospitals from January 2007 to November 2009 the change point (or date that universal screening was implemented) was July 2008 (Presented on a logarithmic scale).



In Grampian there was no significant difference in the trends in first new clinical isolates of MRSA from before (p=0.817) or after (p= 0.729) August 2008 in pathfinder and non pathfinder hospitals (See Figure 12-31).

Figure 12-31: Comparison of MSSA first new clinical isolates in Grampian Pathfinder hospitals compared with Grampian non Pathfinder acute hospitals from January 2007 to November 2009 the change point (or date that universal screening was implemented) was July 2008 (Presented on a logarithmic scale).



12.4.14 Aim 1 Objective 14: To monitor the trends in pathfinder board laboratory confirmed infection data on organisms other than MRSA pre and post MRSA screening intervention.

The recorded annual counts of six key selected organism bacteraemias were examined in the analysis, chosen because these have been identified by EARSS as the ones most closely related to emerging resistance and posing a heavy burden on healthcare. Over this period not all laboratories were reporting through the ECOSS electronic reporting system, thus it is important that this data is not over interpreted. Pearson Chisquared tests were conducted to test for association between the year pre and post the implementation of universal screening, and the pathfinder and non pathfinder health boards. No significant difference was found. The percentage change in the pathfinder health boards from year one to year two was not significantly different to the percentage change in the non pathfinder boards over the same years.

Table 12-18: Causative organism of bacteraemia by Pathfinder year one and two and non pathfinder year one and two showing P values from Pearson Chi-squared test

Organism	Pathfinder Cases Year one	Pathfinder Cases Year two	Non Pathfinder Cases Year one	Non Pathfinder Cases Year two	P-value
Enterococcus faecalis	42	65	234	423	0.468
Enterococcus faecium	36	45	198	248	0.993
Escherichia coli	208	416	1636	2779	0.071
Klebsiella pneumoniae	47	86	318	554	0.801
Pseudomonas aeruginosa	14	25	153	159	0.121
Streptococcus pneumoniae	67	88	460	516	0.365

13 Discussion

13.1 Introduction to discussion

MRSA is a common hospital pathogen and accounts for a third of all *S. aureus* bacteraemia within NHSScotland [13]. It continues to be an international cause for concern in healthcare and is viewed by world authorities as a public health threat [61]. Infections caused by MRSA are damaging and distressing to patients, and are difficult to treat, and consequently have considerable attributable morbidity and mortality.

These results, from a pathfinder project within three NHS boards, inclusive of six acute hospitals in NHSScotland and 81,438 admissions (one third elective and two thirds emergency), indicated an overall MRSA colonisation prevalence of 3.9% and an infection incidence of 7.5 per 1000 bed days.

Prevention and control of MRSA infection is an important health protection intervention. MRSA screening and the associated interventions have potential benefits to the patient in terms of minimising the risk of infection whilst in hospital, and benefits to the whole hospital population in terms of reducing the burden of colonisation and therefore risk of transmission of MRSA from patient to patient. Risk factors for colonisation and infection are well described in the literature and have been overviewed in this report as were the multifaceted interventions associated with minimising the risk. The added value of MRSA screening in the prevention and control of MRSA remains a controversial topic in the literature [33;62].

This report on MRSA screening within NHSScotland addresses four aims:

1. To investigate the clinical effectiveness of MRSA screening as an intervention on outcomes (colonisation / infection / bacteraemia rates) in pathfinder boards.
2. To test the estimates of the NHS QIS HTA economic model assumptions in pathfinder boards.
3. To determine the acceptability of screening for MRSA all acute in-patient admissions in pathfinder boards to patients and staff.
4. To evaluate the feasibility and potential for rollout of the MRSA screening programme in the non pathfinder boards.

The aims and associated objectives are discussed as a summative evaluation, encompassing one year long monitoring of system wide effects in the three pathfinder project NHS boards.

This report has drawn upon a variety of data sources including: document review, observation, audit, interviews and surveys at the pathfinder boards, and indicators from routine surveillance, pharmacy and laboratory systems. The findings from the pathfinder project, together with the other intelligence gathered, are discussed in relation to the NHS QIS HTA and broader literature published in the field of MRSA screening. Limitations of the work to date are addressed and conclusions and recommendations are also included.

13.2 Clinical Effectiveness

The first aim of this study was to investigate the clinical effectiveness of MRSA screening as an intervention in the pathfinder boards addressing the objectives identified in Section 6.2.1. Each of these will be discussed in turn.

13.2.1 Aim 1. Objective 1: To identify the prevalence on admission of MRSA colonisation amongst the patients admitted by age, sex and specialty

The prevalence of MRSA colonisation in all admissions at time of admission to the acute hospitals during the pathfinder study was found to be 3.9%. Prevalence of MRSA colonisation is defined in different ways in the published literature, such as community burden, burden at the point of admission or during the stay in hospital [15;33;63]. International studies published on MRSA colonisation prevalence summarised in Appendix 1 [33;34;63-68] have indicated an observed acute hospital admission MRSA colonisation prevalence ranging from: 0.5% in Netherlands to 8.6% in the UK, resulting from hospital wide MRSA universal screening. Different definitions, laboratory tests, patient groups and settings may account for any differences when compared with the findings within this study. Nonetheless studies from countries with high endemic proportions of MRSA, do indicate an overall higher level of MRSA colonisation prevalence on admission to hospital.

The prevalence of MRSA colonisation from pre-admission screened in patients attending pre-assessment clinics was 2.1%, but this accounts for 25% of all elective patient admissions and only 8% of all hospital admissions included in this study. Although the percentage of patients confirmed as colonised due to a nasal screen carried out at admission was 3.9%, this value does not represent all the presumed known positive cases at admission, who subsequently test negative when screened on admission. Many patients were presumed to be positive at the point of admission and therefore isolated or cohorted for the first 48 hours, before a confirmation of MRSA status by laboratory test. This practice happens as a result of the long turnaround time of the test and a requirement to manage risk within the period before confirmation of results. The percentage of admissions that were presumed known MRSA positive (through pre elective screening, documented evidence or previous admissions intelligence) was 7.7%. More than a third (36%) of all MRSA colonisations, were detected in-patients with repeat admissions during the year of the study and the prevalence of colonisation in patients with 3 or more admissions was 6.4% compared with 2.8% for first time admissions. Jointly, these aforementioned values represent the burden of patients being managed as presumed or confirmed MRSA colonised, overall.

Not all presumed positive cases were confirmed positive by laboratory test, therefore the critical value for patient management, to control and prevent onward transmission of MRSA, is the confirmed prevalence during the hospital stay, in this case 3.9%. For the remainder of the discussion, an MRSA colonisation prevalence value of 3.9% will be referred to unless otherwise indicated. It should however be noted that there is a presumed burden of 6.1% at the point of admission, until laboratory tests are confirmed, and this has an impact on bed

management. The consequences of this for the health service in terms of implementing a universal screening programme for MRSA using chromogenic agar, as recommended by the HTA model, are addressed later in the report.

Risk factors for MRSA colonisation on admission to hospital within this study included those who were over 65 years, admission from a care home or another hospital, multiple admissions to hospital within a year, specialty and emergency admission status. These findings are supported by the literature [34;63-66].

Age was an important predictor of colonisation on admission to hospital. The risk was incremental with age: those over 65 years were twice as likely to be colonised as those under 50; and those over 80 almost 4 times more likely to be colonised than those under 50. Age is a ubiquitous risk factor in studies of this nature [34;63-66] and the wider healthcare associated infection literature [8;14].

Previous residence in care homes or other healthcare settings has been associated with higher risk of colonisation with MRSA [69;70]. The pathfinder study found those coming from other hospitals and care homes to be three times more likely to be colonised on admission than those coming from home. It should be noted that transfers from care homes or other hospitals represented a small but nonetheless at risk proportion (around two percent) of all admissions.

Over forty percent of all the admissions (a quarter of all patients) were readmissions within the year of the study. Many patients had multiple admissions during the year. Colonisation prevalence clearly increased with the number of readmissions and those patients with 3 or more admissions in a year were twice as likely to be colonised compared with those only admitted once. This cohort of patients with known potential for readmission represented 36% of all confirmed MRSA colonisation and could be considered important for continuation of decolonisation regimes post discharge, in order to minimise the risk of colonisation on readmission. There is no UK or international guidance currently with respect to this practice. The first step in developing this would be to examine the possibility of predicting those colonised, likely to be readmitted. This could link to the work undertaken over the last few years in Scotland for the SPARRA (Scottish Patients At Risk of Readmission and Admission) project.

Specialty differences were of note with regard to prevalence of MRSA colonisation on admission. Those in high risk specialties (as defined by the HTA [15] did not have a higher MRSA colonisation prevalence than those in low risk specialties. The individual specialties, rather than the aggregated high and low risk classified by the HTA, accounted for variation in risk of colonisation on admission. Specialty is probably a marker for the intrinsic risks of the patient population presenting to that specialty and the patient care interventions (extrinsic risks) associated with that speciality. The specialties with the highest prevalence (6-9%) were: care of the elderly, dermatology and vascular surgery, high dependency, respiratory medicine, rheumatology and gastroenterology. However when other factors such as age and number of previous admissions were accounted for the specialties identified with the highest MRSA colonisation prevalence were: care of the elderly, medical and ITU. Emergency admissions were also more likely to be colonised than those who were electively admitted. The specialties currently targeted for screening all admissions in the existing national screening programme in Scotland feature in the top ten specialties with respect to proportion of admissions colonised with MRSA.

The intelligence gained from the study on risk factors for colonisation prevalence on admission to hospital, adds to the evidence base on clinical risk assessment, which the NHS QIS HTA suggested together with screening, was the most clinically effective approach to reducing MRSA. The number of presumed positive MRSA cases on admission, patient movement within the hospital in that period, and the turnaround time of the test being on average 48 hours means that the role of clinical risk assessment for that period is critical.

Prevalence of a condition also has particular importance with regards to decision making about the effectiveness of a screening programme. The positive and negative predictive values of a screening test are important parameters for decision making in public health screening programmes. The number of expected false negative (patients who are actually positive but the screening does not detect this), and false positive (patients who are actually negative but the screening gives a positive result), determine the efficacy of a screening test. The HTA defined the sensitivity of the test for MRSA screening (Chromogenic agar) as 98% and the specificity as 99.8%.

False negative results present an increased risk of infection to the patient in terms of not receiving appropriate interventions to minimise the risk of infection whilst in hospital, but also an increased risk to other patients who are being nursed alongside those patients who are undiagnosed, but colonised with MRSA. Although there are concerns regarding the non detection of positive cases, of equal or arguably greater concern for patient care is the likelihood of false positive detections since these patients could be subjected to unnecessary treatment and isolation.

At the HTA quoted sensitivity and specificity and applying a pathfinder prevalence of 3.9% for a large hospital of 50,000 admissions per year an estimated 39 MRSA colonisations would go undetected and 96 false positive MRSA detections would be made. Sensitivity and specificity are not solely governed by a single laboratory detection method however. Other intrinsic factors are likely to influence these estimates such as swabbing technique, body sites screened and swabbing material used. The true sensitivity may indeed be considerably lower than that quoted for individual laboratory testing methods. Conversely overall specificity will be influenced by the additional confirmatory testing undertaken prior to diagnosis and the false positive results are likely to be far lower than the numbers applicable to a single diagnostic test.

MRSA test results which are false pose a challenge for any screening programme. False positive tests may result in a patient receiving an intervention unnecessarily. In the case of MRSA, this may mean prescribing unnecessary antibiotic treatment, which has consequences for patients with the risk of side effects, and for the wider public health issues around antimicrobial resistance rising through overuse of these. Isolation can also have negative consequences for patients, such as sensory deprivation.

False negative results present an increased risk of infection to the patient in terms of not receiving appropriate interventions to minimise the risk of infection whilst in hospital, but also an increased risk to other patients who are being nursed alongside those patients who are undiagnosed, but colonised with MRSA.

Key summary point

There was an overall laboratory confirmed MRSA colonisation prevalence of 3.9%. Factors influencing the prevalence of colonisation included: the number of admissions per patient, specialty of admission, age and source of admission (home, other hospital or care home). The programme identified a two percent colonisation prevalence in patients with no prior history of MRSA infection or colonisation.

13.2.2 Aim 1. Objective 2: To describe the proportion of patients by specialty and colonisation status who develop MRSA infection.

The incidence of MRSA infection during the year of data collection was 7.5 per 1,000 patient days (422 infections in 384 patients). Of these MRSA infections around half (n=219) were HA-MRSA (Hospital associated MRSA infection) and half (n=209) were CO-MRSA (Community onset MRSA infection). This compares favourably with data in recent published literature from the UK [33].

Skin and soft tissue infections were the most common type of infection, followed by surgical site infections. These two infection types, together with urinary tract, lower respiratory tract and blood stream infections, accounted for 85% of all the MRSA infections detected during the year of the study. Ten percent of HA MRSA were bloodstream infections. It should be noted that the infection incidence is likely to be an underestimate of all infections as those infections presenting after discharge from hospital are not within the scope of the study. Post discharge infections are likely to occur as the median length of stay for all patient admissions was only three to four days.

Risk factors for HA MRSA identified using univariate analyses in this study included: MRSA colonisation on admission, age over 64 years, readmissions and specialty. These findings are supported by the literature [5;71]. Age is a ubiquitous risk factor in studies of this nature [62], [34;63-66] and the wider healthcare associated infection literature.

Patients in ICU, cardiac surgery, thoracic surgery, vascular surgery, diabetes medicine and dermatology specialties were more likely to develop infection. These specialties are ones where the patient case mix and healthcare interventions are associated with increased risk of MRSA infections. Other studies have indicated that factors such as diabetes, renal failure, cancer or dementia [71] put these patients at risk of MRSA infection. Specialty is also an indicator for extrinsic risk factors predisposing infection identified in other studies as invasive devices, surgery or immunosuppressive therapy [62;71]. Infection incidence was higher in surgical specialities whereas colonisation prevalence was high in predominantly medical specialties.

The largest burden of infection, in terms of absolute numbers of cases, was in general medicine and general surgery; however this does not equate to a high infection incidence when throughput of patients is accounted for. Vascular surgery and dermatology specialties featured in the top 5 for highest colonisation prevalence and infection incidence.

MRSA colonisation on admission was such an important predictor of HA MRSA, that in the multivariate model it was the only significant risk factor. Those who were colonised were fifteen times more likely to develop infection than those were not colonised on admission. This could suggest that decolonisation is not sufficiently rapid during stay (which is addressed later in this discussion) or that recolonisation due to cross transmission occurs in hospital, or there might be intrinsic factors which predispose to subsequent recolonisation or infection. Nonetheless, the incidence of infection was significantly lower in those who received decolonisation treatment. Those who commenced decolonisation treatment had an HAI infection incidence of 2.7 per 1,000 patient days which was a significantly lower rate of infection than those who did not receive decolonisation (4.2 per 1,000 patient days). This indicates that even a day of decolonisation may have a protective effect. This indicates that even one day of decolonisation as an itervention may have a protective effect. There is limited evidence to support this theory from the literature and this is an area requiring further research.

HA-MRSA infection incidence was 3.2 per 1,000 patient days for those who were colonised on admission, compared with 0.2 per 1,000 patient days for those screened negative on admission. Around half of the infections identified were in those who were colonised, which indicates that the remainder may be undetected colonisation or cross transmission of colonisation or associated in some other way with interventions during patient care. This emphasises the importance of the role of standard infection control precautions in reducing risk of MRSA infection in patients during a hospital stay.

Community onset infections were defined as those occurring within the first 48 hours of admission to hospital. However it is recognised, with 44% of the hospital admission population being readmissions, that many of these infections were potentially hospital associated. They might not have been acquired on that admission, but could be associated with a previous admission, particularly if that admission was recent. A third of the infections defined as community onset were in patients who had been in hospital within the last 30 days prior to the admission in which the infection was detected. There is also the potential for many of these infections to be classified as healthcare associated rather than true community cases if the patient has had a healthcare intervention in a non hospital setting prior to the admission period that the infection presents within. The burden of infection overall during the stay is that which must be managed from an infection control perspective thus all of these infections whether defined as hospital or community onset have healthcare service provision implications.

Key summary point

There was an overall MRSA infection incidence of 7.5 per 1,000 patient days. Patients in ICU, cardiac surgery, thoracic surgery, vascular surgery, diabetes medicine and dermatology specialties were more likely to develop infection The single independent risk factor for infection was colonisation on admission to hospital; those who were colonised on admission were 15 times more likely to develop infection during their stay. In addition to the MRSA infections classed as hospital associated, a number of the 'community onset' cases may have been associated with colonisation as a result of previous healthcare interventions- a third of these infections were in patients who had been in hospital within the previous 30 days.

13.2.3 Aim 1. Objective 3: To evaluate the impact on outcome (MRSA colonisation/ infection/bacteraemia) of the screening programme.

MRSA colonisation

The focus of the intervention of MRSA screening is to identify colonised patients and manage them to reduce the risk of MRSA transmission to others as well as minimising the risk of self infection. The expected outcome in terms of colonisation, is to reduce the burden of colonisation during the patient stay so as to minimise the risk of infection.

The MRSA colonisation prevalence of 3.9% on admission to hospital found in this study is within the range of values published in the literature, as indicated previously within the discussion. The MRSA colonisation prevalence significantly decreased over time during the pathfinder study. In month two this was 5.5% reducing to 3.5 % in month twelve. This finding is supported by existing literature in single hospitals post implementation of universal screening [63] and was the expectation of introducing screening [15]. This pathfinder study demonstrates this finding across all of the pathfinder hospitals (n=6).

Interestingly the number of previously known positive MRSA cases remained relatively constant over the year of the study (5.7% in month two compared to 5.8% in month 12) and therefore did not increase over time as expected in the HTA model [15]. This may be due to the fact that the HTA worked on the assumption that the starting point for implementing screening was that no existing screening practice was in place. However screening practice was in place in selected patient groups in the pathfinder hospitals, like most other hospitals before universal screening was implemented. This meant that there were already known positive cases in the system and there were processes in place for monitoring and flagging these patients when they were readmitted. Nonetheless the change in confirmed MRSA colonisation prevalence during the pathfinder study may be associated with the introduction of universal screening.

MRSA infection

Patients with MRSA infections during the year of the study had an incidence of 7.5 per 1000 bed days. A decreasing trend in the incidence of these infections during the study was observed, and this was statistically significant. This trend reduced at the same rate as colonisation reduced and is consistent with that found in other studies [34;63]. This indicates a potential association between the intervention of screening and subsequent infection incidence. It should be noted that these data do not demonstrate causality. These data were not routinely collected in a consistent manner within all the pathfinder boards prior to the pathfinder project. Therefore other routine laboratory data measures, pre and post the intervention of MRSA screening, were examined to evaluate the impact on outcome and are discussed herein.

First clinical (non screening) isolates of MRSA in hospital clinical samples (used as an indicator of infection) from the laboratories in Ayrshire and Arran and Grampian, demonstrated a decrease in MRSA clinical isolates and a consistent decreasing trend over the year of the intervention when compared to the previous year. The decrease did not reach statistical significance. This indicates that more time may be needed to see an impact at an individual board level and indeed the NHS QIS HTA suggested a significant difference may be seen at 3 years post implementation. However this associated reduction in historical comparator data is further supported by control hospital comparator data. Those acute hospitals within the NHS pathfinder boards, but not taking part in the universal screening study, did not demonstrate a reducing trend in MRSA clinical isolates over the same period that the intervention hospitals did. The difference between the two groups of hospitals was not significant although this should be interpreted with caution as the numbers were small in non intervention hospitals, and the intervention hospitals drive the MRSA in the non intervention hospitals within the board. In order to further examine any potential impact of screening on outcome, the proportion of all *S. aureus* which were MRSA was examined pre and post the intervention, and between pathfinder and non pathfinder hospitals. The results indicated a stastically significant reduction in both pathfinder hospitals which was not observed in non pathfinder hospitals.

Establishing association, of any reduction seen with the implimentation of MRSA screening assumes that within a single board the infection prevention and control measures and interventions would be the same across all hospitals for the duration of the intervention and the only difference is the additional screening intervention. This assumption has been tested in part with the audit of infection control practice carried out at two points during the study by the independent auditor (See Volume 4 for further details). The results indicated that practice was consistent over time with respect to standard infection control precautions and use of isolation facilities. The limitations of the control comparator hospitals should be noted and are addressed more fully in the limitations section of this report.

The temporal association between the initiation of the universal screening and the decline in MRSA infection does not prove that screening caused the reduction. However the reduction persisted during the period after the introduction of the screening and no statistically significant accompanying reduction in MSSA occurred. Further, the patients had similar baseline characteristics during the time of the study and the observed reduction was not seen in the comparator control hospitals within the pathfinder NHS boards. This

is consistent with other smaller studies published to date and adds to the evidence base around the added value of universal screening in endemic settings [34] although it is not conclusive.

MRSA bacteraemia

MRSA bacteraemia rates in NHSScotland decreased, within and outwith the pathfinder boards, over the period of the screening intervention. This decreasing trend commenced prior to the introduction of screening and therefore cannot be attributed to the screening and associated interventions. The event of bacteraemia is too infrequent to be a useful measure of outcome over a year. The individual boards had a range by board of: 0, 3 and 59 MRSA bacteraemias, during the year. Therefore these data are best used for examining NHS board wide and national trends and burden, and not as a sensitive indicator for outcome within a hospital over a year.

Clinical isolates have been proposed as a marker for all *S. aureus* bacteraemia as they trend closely and the isolates are a more sensitive indicator of outcome than bacteraemias alone. A recent study of universal screening in three hospitals in the USA [72] tested this and observed a reduction in MRSA isolates which followed the trend of bacteraemia isolates and reached statistical significance in year three of universal screening. A decrease in isolates does not equate to a decrease in disease, but within the pathfinder study the CDC defined infections, collected during the year of implementation, indicate an overall reducing trend and this is a marker of reduced disease.

Key summary point

MRSA colonisation prevalence significantly reduced during the year of the study from 5.5% to 3.5%. MRSA infection incidence significantly reduced at the same rate within the year across the pathfinder boards. Early indications are apparent of a temporal association between the initiation of the universal screening and a decline in MRSA infections as defined by the number of first clinical isolates from hospital-based laboratory confirmed cases during the study. The reduction in the proportion of *S. aureus* which was MRSA reached statistical significance within all pathfinder hospitals data, although this does not prove that the screening caused the reduction. However, the decreasing trend persisted during the period after the introduction of the screening and the decreasing trend was not seen in the comparator control hospitals in the same period.

13.2.4 Aim 1. Objective 4: To monitor the trends in mandatory surveillance data outputs undertaken by HPS examining the key indicators of HCAI. This will include S. aureus bacteraemia, and Surgical Site Infection (SSI)

National trends in the mandatory HCAI surveillance programmes run by HPS indicate a significant reduction in MRSA bacteraemia rates over the last year in NHSScotland, including the period of the pathfinder project. MSSA bacteraemia data also appear to be reducing, but not significantly, in the same time period. The impact of implementing MRSA screening in the pathfinder boards would be seen in the MRSA bacteraemia data only; thus, examining MSSA data provides a good comparator for the MRSA data previously described in this discussion. For the last reporting period (to July 2009), which covers the period of the pathfinder programme, there was a continuing significant reduction in MRSA bacteraemia, but not MSSA bacteraemia, within NHSScotland. This reduction had been observed prior to the initiation of the pathfinder study in August 2008.

A reduction in MRSA bacteraemia was also seen in the pathfinder boards when compared with the same time period in the previous year. The reduction in MRSA bacteraemia in pathfinder boards is not significantly different to that in non pathfinder boards. A similar pattern of trend is seen for MSSA in both pathfinder and non pathfinder boards. Nationally available bacteraemia data for MRSA and MSSA do not provide evidence that universal screening in one year has an impact on outcome.

Surgical site infections are also a useful indicator for monitoring HCAI. Approximately 14% of all HCAIs manifest as surgical site infections. Although the organisms which are responsible for surgical site infections vary with operation type and site, an estimated 49% of SSIs are attributable to staphylococci. Of these, 81% are attributable to *S. aureus* of which 61% are MRSA [73]. SSI caused by MRSA has a 3.4 times higher risk of mortality and 2 times greater median hospital cost than those with MSSA [74].

Hip arthroplasty procedures are continuously monitored, as part of mandatory SSI surveillance, by all NHS boards and reported by HPS. The results here indicate that, as with *S. aureus* bacteraemia rates, there is an overall decreasing trend in the percentage of in-patient hip arthroplasty procedures for all NHSScotland since monitoring began in 2002. A continuing decrease in the trend in these SSI rates was seen nationally over the year of the pathfinder study. In both Ayrshire and Arran and Grampian the rate of SSIs for hip arthroplasty procedures decreased, but not significantly, when compared with the same reporting period in 2007.

The reduction in SSI following hip arthroplasty may be associated with screening; however any current difference cannot, at this stage, be associated with screening practice change in the pathfinder hospitals as screening practice in non pathfinder hospitals across Scotland targets this group of patients also. Caution is required in interpreting these data however, as they are based on small numbers.

Key summary point

No significant difference was noted in the routine outputs of MRSA bacteraemia and surgical site infection data for pathfinder boards or non pathfinder boards during the study. These indicators might not be sensitive enough to detect changes within this timeframe at individual board level.

13.2.5 Aim 1. Objective 5: To monitor mupirocin antibiotic usage over the study period.

Universal screening for MRSA results in the detection of previously unknown cases of colonisation and therefore more usage of mupirocin for nasal decolonisation of MRSA. Mupirocin (pseudomonic acid A) has been widely available for use as a topical antimicrobial agent for many years [75]. The nasal formulation of this agent was used in all the pathfinder hospitals as part of the pathfinder protocol, and is used in most hospitals in Scotland for this purpose. Mupirocin is given over a five day course to patients in order to reduce the burden of decolonisation during the stay in hospital.

Using antibiotics to suppress MRSA colonisation is promoted by UK guidance [36] as a strategy for preventing infection and transmission, on the basis that carriage is a major risk factor for subsequent infection. As indicated previously within the pathfinder study, MRSA colonisation on admission was found to be a major risk factor for subsequent infection, thus it would seem logical to focus intervention on reducing the risk in this way. However the efficacy of mupirocin as an infection prevention strategy is of concern due to the limited evidence available from the literature [75]. The HTA [15] systematically reviewed all the published evidence on efficacy of decolonisation regimes and concluded that a pooled efficacy of 53% was a good assumption to populate their economic model on MRSA screening. Even with this low efficacy the model found the strategy of universal screening, with the associated interventions of isolating and decolonising those found to be MRSA positive to be the most clinically and cost effective. Whilst efficacy of treatment was not an objective of the pathfinder study (this would require a randomised controlled trial), success of decolonisation as an intervention was monitored and the findings are addressed in the discussion on objective 6.

Mupirocin antibiotic usage was monitored during the pathfinder study to assess the volume of use compared to previous use within the pathfinder hospitals as a result of implementing universal screening. The results indicated significant increase in usage in Grampian. There was a decrease in the Western Isles but this was not significant and the results are confounded by the new approach to testing introduced at the start of the pathfinder programme which may have had an impact on the sensitivity and specificity of test results within this board.

Increasing antibiotic consumption is a concern when considering the mass usage which would be introduced as part of a national MRSA screening programme. Increases in mupirocin resistance might be fuelled by this widespread use and monitoring is critical in this regard.

The SGHD HAI task force has commissioned the Scottish Antimicrobial Prescribing Group (SAPG) to develop guidance and policy for the prudent prescribing of antimicrobials in Scotland in recognition of the public health threat of antimicrobial resistance. This group might usefully consider best practice for prescribing with respect to mupirocin and the longer term implications for universal screening for MRSA if this treatment of choice became no longer available for use. Monitoring of mupirocin resistance is addressed later in the discussion under objective 12.

Key summary point

The results indicated a significant increase in mupirocin usage in Grampian (the data were unavailable for Ayrshire and Arran). There was a decrease in the Western Isles but this was not significant and the results are confounded by the new approach to testing introduced at the start of the pathfinder programme .Monitoring of mupirocin use is an important within an MRSA screening programme.

13.2.6 Aim 1. Objective 6: To evaluate the success of decolonisation.

Success of decolonisation relies on those patients who are MRSA positive receiving the treatment at a point in time, whereby the risk of infection is minimised. The decolonisation, for patients found to be positive with MRSA, includes treatment with topical antibiotics and antiseptic body washes for five days.

Within the pathfinder study, following completion of decolonisation patients were re-screened at 48 hours and then at least 48 hour intervals on two further occasions, to confirm a negative result. This represents a minimum time period of 15 days for one decolonisation regime and maximum of 30 days for two decolonisations end to end. Only 48% of all admissions found MRSA positive had decolonisation initiated.

Factors which described whether a patient received decolonisation were: length of stay, hospital, and being seen at a preadmission clinic. This practice is most likely to have been affected by the short length of stay for most of the admissions. Those patients who were in hospital for two days or more were 8 times more likely to be decolonised, and overall 67% of these patients were offered decolonisation.

For those patients where repeat screen results were available, only 3% of admissions who were given decolonisation therapy were found to be negative for MRSA following 3 post treatment screens during their stay. A small proportion (13%) of those screened pre-admission and found colonised were successfully decolonised prior to admission; this result was affected by the timing of pre-admission clinics.

These results do not evaluate the success of decolonisation as such; this evaluation would require a randomised controlled trial to be conclusive and there is a need for studies of this kind as a matter of priority. Nonetheless of those who were given decolonisation therapy,

the infection incidence was less than those who did not receive it. Decolonisation therapy serves to suppress MRSA organisms colonising the patient and may reduce the burden even if the course is not completed.

The burden of cross transmission of MRSA colonisation during the hospital stay is not well described in the literature and is an important piece of intelligence in understanding the role of decolonisation within the context of a screening programme. Further intelligence will be gathered on cross transmission of MRSA colonisation as part of a special research study associated with the pathfinder project to be published in 2010.

Key summary point

Only 48% of all admissions found MRSA positive had decolonisation initiated. Factors which described whether a patient received decolonisation were: length of stay, hospital, and being seen at a preadmission clinic. Those patients who were in hospital for two days or more were 8 times more likely to be decolonised, and overall 67% of these patients were offered decolonisation. Only 3% of admissions who were given decolonisation therapy were found to be negative for MRSA following 3 post treatment screens during their stay. A small proportion (13%) of those screened pre-admission and found colonised were successfully decolonised prior to admission. Those patients who received decolonisation (even if it was less than the complete course) had a significantly lower infection rate than those who did not.

13.2.7 Aim 1. Objective 7: To assess the validity of nasal swabs for universal screening.

Identifying colonised patients is a key component of reducing the spread of MRSA. Nasal screening is promoted for use in universal MRSA screening programmes because the anterior nares are the most common site of *S. aureus* carriage [76]. Nasal screening is also suggested to be simple and clinically and cost effective [15]. However the optimal combination of body sites to screen in order to maximise clinical effectiveness remains unknown, as does the patient acceptability of screening these body sites. Some literature indicates that nasal screening is optimised if supplemented by screening of wounds and invasive devices as these can be a source of colonisation [77]and therefore the pathfinder project included samples from these sites.

The findings indicated that the majority (86%) of those positive at other body sites, wounds or devices were also colonised in the nares. Overall nasal screening alone potentially fails to identify 14% of cases, although these data are biased towards the screening protocol adopted within the study which did not include multiple body site screening of all patients.

The literature indicates that nasal screening will detect the majority of cases (74% [78]-93% [79]) of MRSA colonisation and is the most important single body site to include for universal screening. The results within the pathfinder study are within the range described

in the published literature. A variety of other body sites (axilla, groin, perineum, rectum and throat) are suggested in the literature as having added value in terms of diagnostic yield for MRSA colonisation [34;35;80-84]. These studies are however small, limited in design, carried out in specific specialties or at risk patient groups, and are not directly applicable to universal screening. In the latest critical review of the evidence published in the BMJ this year [62], the added value of adding other body sites to nasal screening was called into question.

A balance of diagnostic yield, acceptability from a patient perspective and cost (inclusive of staff time to perform screening and laboratory costs) needs to be struck in guidance making, with regard to which body sites are included. Whilst the uptake of nasal screening within the pathfinder project was high with less than 0.04% of patient refusals, it remains unknown how acceptable more intrusive body site screening, such as perineal or rectal screening, would be to patients in the context of universal screening. Much of the published literature is limited in assessing all of the above noted criteria and the added value of including axilla, groin, perineum remains unknown. As such a research study is being undertaken as part of the MRSA screening pathfinder programme, in order to develop an evidence base for body sites to include in universal screening decision making in NHSScotland.

Key summary point

The majority (86%) of colonised patients were identified by nasal screening alone. More research is needed on the optimal body sites for universal screening colonisation detection. A balance of diagnostic yield, acceptability from a patient perspective and cost (inclusive of staff time to perform screening and laboratory costs) needs to be struck in guidance making, with regard to which body sites are included.

13.2.8 Aim 1. Objective 8: To assess the validity of the testing strategy described by NHS QIS HTA.

The NHS QIS HTA strategy 2 suggested that it was clinically and cost effective to screen all patients on admission to hospital. This strategy was formed on the basis of a theoretical model which used estimates from the literature to populate the parameters in the model.

The estimates used by the HTA included an assumption that MRSA screening could be universally implemented by testing all patients on admission and holding them within the receiving ward until the result was known (around 24 hours after admission). At that point the patient with MRSA could be managed, from an infection control perspective, before sending them onto their specialty ward for management of their condition. The testing strategy recommended within the HTA was that no clinical risk assessment would be carried out at the point of admission, as this was not as cost effective as the laboratory test screening alone.

The pathfinder study found that this model of care was significantly different to what happens in practice. The findings in the pathfinder project indicated that patients were admitted to specialties before their results were known and that on average the turnaround time was 48 hours for confirmation of result though negatives were usually available within 24 hours. The role of clinical risk assessment was therefore critical in managing these patients and the risk of cross transmission of colonisation and infection before the result was known.

Risk factors in those presumed MRSA positive on admission, in order of importance for the multivariate analysis, were: frequency of admission, age, whether or not admitted from home, specialty and type of admission. These risk factors are therefore critical in clinical risk assessment to manage risk at the point of admission to hospital before laboratory test results are known.

The potential importance of the role of clinical risk assessment has been highlighted in recent literature [52;69;85]. Knowledge of the variables that identify patients at higher risk of MRSA colonisation or infection on admission to hospital; assists clinicians in targeting preventive measures. This pathfinder study has highlighted the importance of continuing the role of risk assessment in preventing and controlling MRSA infection, in a healthcare environment with a median length of stay for patients of three days and a two days average turnaround time for confirming positive results of tests for MRSA screening.

The intelligence gained on pre emptive isolation further emphasises the importance of the role of clinical risk assessment. Almost three quarters of those patient admissions previously known as positive; assessed as high risk and pre emptively isolated, were found to be positive by nasal screening results thereafter (See Volume 2). This result varied by pathfinder board and this variation may be as a result in the variation in clinical risk assessment tools used. As there is no validated clinical risk assessment tool in practice, the role of clinical risk assessment in MRSA prevention and control is the subject of another research study within the MRSA screening programme, the results of which will be presented in 2010.

Clinical risk assessment as currently applied in the pathfinder boards did however seem to work well in allocating isolation facilities appropriate to those patients who required them on admission. This is an important finding as the NHS QIS HTA did suggest that clinical risk assessment and laboratory testing of those at risk was the most clinically effective strategy for MRSA screening.

Key summary point

The pathfinder study found that the HTA strategy model of care was significantly different to what happened in practice. The findings in the pathfinder project indicated that patients were admitted to specialties before their results were known and that on average the turnaround time was 48 hours for confirmation of positive results. The role of clinical risk assessment was therefore critical in managing these patients and the risk of cross transmission of colonisation and infection before the result was known. Further research is needed to optimise the process of clinical risk assessment.

13.2.9 Aim 1. Objective 9: To identify new epidemiology.

The emergence of more virulent microorganisms and antimicrobial resistance, the development of more aggressive therapeutic procedures and a population of hospitalised patients with more frequent impaired immunity due to age, illness and treatments all add to the continuing threat of HCAI in healthcare. The risk associated with a focus on organism specific interventions, such as MRSA screening, is that there may be unintended consequences, due to the natural process of organism evolution.

ECDC data published this year indicate that the epidemiology of healthcare associated infections in Europe and internationally continues as a cause for concern. There are an estimated 4 million HCAI in the EU each year and 37000 attributable deaths a year [8]. The prevalence of HCAI varies from country to country and in some part the variation can be attributed to differing approaches to data collection and definitions. Nonetheless a prevalence of HCAI ranging from 3.5% to 10.5% indicates that HCAI are a continuing public health threat.

The organisms causing these infections across Europe were presented in the results section of this report (See section 12.4.9). *S. aureus* remains a frequently isolated organism from healthcare associated infections. Overall, *E.coli* and *S. aureus* are the most frequently involved followed by: *P.aeruginosa*, *Enterococcus spp.,* Coagulase-negative staphylococci, *Candida*, and Enterbacteriaceae such as *Klebsiella spp*. and *Enterobacter spp*.

S. aureus also remains the organism most commonly (14%) associated with outbreaks of HCAI although the emergence of *Clostridium difficile* in Europe in recent years has resulted in its prominence in outbreaks, inclusive of those in Scotland in the last year. Data from the national mandatory surveillance programmes indicate that there were 689 MRSA bacteraemia and 15,65 MSSA bacteraemia in NHS Scotland in 2008. MRSA bacteraemia rates are continuing to decrease year on year in NHS Scotland. The last national HCAI prevalence survey in Scotland indicated that MRSA represented 17% of all laboratory confirmed HCAI. Although MRSA is one of many organisms causing HCAI and does appear to be reducing over time, it remains a common cause of HCAI and continues to be of concern internationally.

European data on the burden of MRSA as a proportion of *S. aureus* bacteraemia in Europe, (see section 12.4.9), indicate that the UK and most of southern Europe have a continuing endemic problem (>25% of all *S. aureus*) with MRSA. An increasing trend has been seen in Portugal and Malta and they now have MRSA proportions of more than 50% of all *S. aureus*. The UK and France have seen a decreasing trend in the last couple of years. The ECDC view is that this is likely due to increased efforts on infection control (including screening), hand hygiene, and antibiotic policy in hospitals in these countries. Northern Europe continues to have low (<2% of all *S. aureus*) prevalence of MRSA. Although previous EARSS reports have indicated an increasing trend in countries with a historical low prevalence of MRSA this seems to have plateaued in the last year [9].

There are concerns raised in the recent published literature about emerging strains of MRSA circulating in the community and their potential to spread within healthcare facilities [86]. The interventions to control these infections are not well described in the literature and evidence from countries such as Denmark suggests more research is needed. Denmark had a low incidence of MRSA infections historically, due to the implementation of a universal screening policy and associated interventions, but recently have found a rising incidence, with the emergence of USA 300 clone [86]. Although the numbers are relatively small, the new clone does not appear to be controlled by existing policies. Emerging AMR is therefore of concern in terms of understanding the interventions required for prevention and control.

Antimicrobial resistance is still high and some types are increasing in most European countries, in particular for common Gram-negative bacteria such *Escherichia coli*, *Klebsiella pneumoniae,* and *Pseudomonas aeruginosa*. Antimicrobial-resistant microorganisms fail to respond to common therapy, therefore infections due these microorganisms result in: prolonged illness and stay in hospitals and greater associated mortality. The number of deaths in the EU directly attributable to five common multi-drug resistant bacteria often responsible for HCAI is estimated at 25,000 in the EU each year [8]. Additionally, there are emerging infections for which there is no rational choice of antibiotic therapy. ECDC have warned that this new trend is of concern as there are very few compounds in the research and development pipeline that would potentially have any benefit.

Hospital epidemiology will continue to evolve, particularly with antimicrobial use now being a focus for control through prudent prescribing. The Scottish Antimicrobial Prescribing Group (SAPG) is taking forward the Scottish Management of Antimicrobial Resistance Action Plan [27] for NHSScotland Emerging data from HPS within that work programme indicate there are other organisms of concern in healthcare and in broader public health threat terms. There is the potential for substitution of MRSA with other organisms when interventions focus on only reducing one organism. Monitoring of key selected AMR organisms is therefore critical to ensure there are no unintended consequences of introducing universal MRSA screening. These other resistant organisms may in time become candidates themselves for future screening programmes.

Key summary point

European data on the burden of MRSA as a proportion of *S. aureus* bacteraemia in Europe indicate that the UK and most of southern Europe have a continuing endemic problem (>25% of all *S. aureus*) with MRSA and it remains an organism of concern in healthcare settings. There are concerns raised in the recent published literature about emerging strains of MRSA circulating in the community and their potential to spread within healthcare facilities. Continued monitoring of these and other selected antimicrobial resistant organisms should be continued..

13.2.10 Aim 1. Objective 10: To evaluate other emerging issues from the published literature relating to the screening programme.

There has been continued interest and debate in the peer reviewed literature on universal screening and the associated interventions to control MRSA. A summary table of the key papers and issues arising from these was presented in the results section (see Table 12-16). The main issues being debated recently include: laboratory tests, ward facilities for managing patients, staffing and costs for interventions, the effectiveness of infection control interventions, and ethics.

With respect to outcome studies on universal screening, four papers have attracted much professional and media interest since the publication of the HTA in 2007. The first was by Harbarth *et al* in 2008 [33]. This prospective interventional cohort study, in surgical patients, concluded that universal rapid MRSA admission screening did not reduce MRSA infection. Whilst the study was well designed, it was only carried out in surgical wards, and as such, and despite the title, does not meet the definition of universal screening at a hospital population level.

A study by Robicsek *et al*[34], reported a decrease in the frequency of MRSA infections in three hospitals that universally screened all admissions. This study was a large observational cohort study in three hospitals and met the definition of universal screening at a hospital level. It should be noted however that the authors conclude a temporal association was established between the implementation of screening and a reduction in the number of MRSA infections; they, like many studies in the infection control literature, could not establish cause and effect. This is a challenge for the infection control literature as the theoretical framework for studies in this field is based on epidemiology approaches which usually demonstrate association rather than cause and effect.

The third study by Jeyaratnam *et al* [87] was similar to the Harbarth study, in that this work included only certain specialties and therefore did not meet the universal hospital screening definition. All new admissions to general medicine, general surgery, care of the elderly and oncology specialties were screened for MRSA. The study was a cluster randomised crossover trial and the outcome was comparable to the findings of the Harbarth *et al* study, i.e. screening of new admissions did not result in a reduction of MRSA acquisition. Editorials for all journals cautioned that the answer to reduced infection may not be in merely adopting a universal MRSA screening programme as a "one size fits all" solution. Further, the latest clinical review of current evidence in the 2009 February BMJ [62] suggests that the role of universal screening is still up for debate in countries with a high prevalence of MRSA.

In the latest study published of note (due to the large number of hospitals involved [67]), the authors examined universal screening in 33 acute hospitals in Germany (and included a comparator hospital in the Netherlands). A low prevalence of MRSA colonisation was noted in Germany (1.6%), and, as might be expected, lower still in the Netherlands (0.5%), which has a low endemic proportion of MRSA thought to be due to their national search and destroy policy. The study was carried out over a short time period and had the objective of identifying risk factors rather than looking at the impact on outcome. They concluded

that the MRSA colonisation prevalence was proportional to the MRSA bacteraemia rates within each country and the role of identifying and managing those colonised is important to prevent and control infection.

A 2009 review of the evidence for screening and isolation of MRSA cases for infection control [56],overviewed the gaps in the existing evidence for HCAI prevention and control and concluded that definitive recommendations for adoption of screening practice cannot be made due to the lack of evidence based clinical and cost effectiveness data.

Turnaround times for results and the role of emerging technologies in reducing these have remained a focus for much of the literature on MRSA screening published since the NHS QIS HTA [35;53;62;88;89;106]. An interesting study from Northern Ireland [53] on the role of PCR, compared PCR screening method with standard culture for MRSA detection in two hospital wards. They found that, although the PCR method significantly reduced the median turnaround time for results from 47 hours to 21 hours, this decrease had no impact on the MRSA incidence. This finding emphasises the importance of getting a sufficiently short turnaround time to limit the transmission of MRSA. The pathfinder project intelligence, together with this study from Northern Ireland are indicating that turnaround time is dependent upon more than just the time taken for testing within the laboratory, e.g. portering services from the ward to the laboratory and communication of the results from laboratory to the ward. There is also no clear view as yet of the threshold below which turnaround time makes a significant difference to risk in the hospital population. Although the latest well designed study [106] in this field indicated that in surgical units, with limited isolation facilities, PCR reduced the turnaround time for screening tests from 3.3 days to 0.9 days on average and this was associated with a significant reduction in MRSA aquisition durning stay.

Emerging technologies on near patient testing are an interesting new development, which may support the reduction of turnaround times to a point where cross transmission of MRSA can be prevented. However the sensitivity, specificity, positive predictive value and cost of these tests require further research before any commitment to implementation could be considered.

Literature on risk factors for MRSA colonisation and infection has generated few new previously unknown risk factors. A few papers have focussed on the role and approaches to clinical risk assessment as an alternate to universal screening tests of detection on MRSA [52;66;69;90-92]. These papers propose that applying clinical risk assessment at the point of admission and isolating or cohorting those at high risk pre emptively, may be a more effective MRSA control strategy than waiting for 2 days for a microbiology result. For this strategy to be effective more single rooms would be needed in NHSScotland. There is no gold standard clinical risk assessment tool [62;74] for this purpose and the cost effectiveness of this approach was questioned by the authors of the HTA. There is a need for more research in this area of clinical risk assessment for infection prevention and control, which one of the special studies arising from the pathfinder programme will address

Critical reviews of the existing evidence on strategies to prevent transmission of MRSA in acute hospitals continue to be published in the peer review literature [62;74]. However, very little new evidence is emerging in the literature on the modes of transmission of MRSA strains, the clinical epidemiology and outcome of the infections caused by the new clones, and the design and evaluation of infection control measures associated with screening for MRSA. This is an area which requires further research.

Key summary point:

There has been continued interest and debate in the peer reviewed literature on universal screening and the associated interventions to control MRSA. The main issues being debated recently include: laboratory tests, ward facilities for managing patients, staffing and costs for interventions, the effectiveness of infection control interventions, and ethics. There is no worldwide consensus on the added value of the role of universal MRSA screening.

13.2.11 Aim 1. Objective 11 To evaluate if the public health principles of introducing a screening programme are met.

Public Health Screening Programmes are formally approved by the UK National Screening Committee (NSC) prior to implementation within the NHS. MRSA screening does not meet their definition of a screening programme and as such does not require their approval. HPS considered it important however to develop the MRSA Screening Programme using public health principles and therefore used that framework.

Criteria for the condition, test, treatment and screening programme overall were examined, and a number of non-fulfilled criteria were identified within the Interim Report [44] as being priority areas for further evaluation. Information from the Pathfinder study has now enabled a reclassification of most of these criteria to being fulfilled.

The criteria met and unmet for MRSA screening in NHSScotland before and after the Pathfinder study are summarised in Table 12-17.

Criteria remaining unfulfilled

The criteria still outstanding as 'unmet' relate to:

The condition:

All cost effective primary prevention interventions should have been implemented as far as practicable;

The screening programme:

There should be evidence from Randomised Controlled Trials (RCTs) that the screening programme is effective in reducing mortality or morbidity;

All other options for managing the condition have been considered: e.g. improving treatment, providing other services, to ensure that no more cost effective intervention could be introduced or current interventions increased within the resources available.

The first and third of these bulleted points are essentially similar, predicated on ensuring optimal management of prevention and management before, or as an alternative to, initiation of a screening programme. It is outwith the remit of the Pathfinder programme to assess or measure other primary interventions or treatment in terms of full implementation, relative cost effectiveness or clinical effectiveness. There is evidence however that (for example) environmental cleaning performance and hand hygiene compliance have improved since mandatory reporting was implemented [93;94] and both show compliance by these measures in excess of 90%. There is very limited information on quality and consistency of infection control within clinical procedures (e.g. insertion of intravascular catheters), although device management is within the scope of being optimised through the implementation of the Scottish Patient Safety Programme (SPSP). These are, however, all generic issues which are relevant to prevention and control of many infections other than MRSA, and it is difficult to attribute what portion of the resources applied would accrue to MRSA prevention. Screening for MRSA on the other hand brings no clear contribution to the prevention of non-MRSA infections, but costs can be calculated and offset against the known burden of MRSA infection.

The second of the three issues is the requirement for RCT-level evidence of reducing mortality or morbidity through the screening intervention. As was observed in the Interim Report, much of our currently accepted infection control practice is based at best on large observational studies rather than formal RCTs. It looks very unlikely that a formal RCT on MRSA screening would be contemplated, given the time, resource and logistical issues an RCT would raise, also taking into consideration the public, political and professional pressures for action. The case for effectiveness of MRSA screening should in any case be made in practical terms through use of cohort and case-control analyses, which look promising as reported at the early stage of the current report (*Figure 12-9*).

Criteria now fulfilled

As shown in Table 12-17 a number of criteria which were not met at the outset can now be classified as being fulfilled on the basis of information accruing from the Pathfinder study. These criteria and the basis for their compliance are listed below.

The test:

The test should be acceptable to the population:

We now know from the patient acceptability study (See volume 3), that MRSA screening is very positively rated by patients and the public, and refusal rates when seeking consent for testing have been very low (0.04%)

The treatment:

There should be agreed evidence based policies covering which individual should be offered treatment and the appropriate treatment to be offered

Agreed guidance based on existing evidence for decisions on treatment of colonised patients are in existing UK guidance [36] has been developed as part of the Pathfinder programme.

Clinical management of the condition and patient outcomes should be optimised in all health care providers prior to participation in a screening programme

Optimisation of clinical management of MRSA colonisation will flow from having standardised procedures for screening and decolonisation. The degree to which clinical management of MRSA infection (rather than colonisation) is at an optimal level is unknown, but has been the subject of continually updated UK professional guidance [17;95].

The screening programme:

There should be evidence that the complete screening programme (test, diagnostic procedures, treatment and intervention) is clinically, socially and ethically acceptable to health professionals and the public

As above, screening has been shown to be highly acceptable with minimal adverse effects on care in terms of treatment deferrals.

The benefit from the screening programme should outweigh the physical and psychological harm (caused by the test, diagnostic procedures and treatment)

The patient survey showed a widespread perception of benefit rather than harm. The effects on deferred treatment are minimal, and the issue of managing the potentially negative effects of isolation in single rooms has to be set within the context of the SGHD national strategic decision to substantially increase the use of single rooms for routine clinical management of patients [96]

Evidence based information explaining the consequences of testing, investigation and treatment should be made available to potential participants to assist them in making an informed choice

Patient information and consent materials have been developed for the Pathfinder programme, and a suite of materials for national rollout is being prepared.

The opportunity cost of the screening programme (including testing, diagnosis and treatment, administration, training and quality assurance) should be economically balanced in relation to expenditure on medical care as a whole (i.e. value for money)

This is covered within the economic analyses presented within volume 2 of the report.

There should be a plan for managing and monitoring the screening programme and an agreed set of quality assurance standards

Key performance indicators to monitor uptake and critical variables are currently under active development. An overview of these is provided in Volume 4 of the report.

Adequate staffing and facilities for testing, diagnosis, treatment, and programme management should be available prior to the commencement of the screening programme.

A national exercise to determine resource requirements for each NHS Board and allocation of central funding for national rollout are now in place.

Public pressure for widening the eligibility criteria, for reducing the screening interval, and for increasing the sensitivity of the testing process should be anticipated. Decisions about these parameters should be scientifically justifiable to the public.

High acceptability indicates public pressure will probably be to resist any limiting of screening. Harnessing appropriate new technology to improve sensitivity and specificity of testing and to reduce turnaround times in relation to cost is under continuing review, and the use of clinical risk assessment to target patients for screening is being formally tested. The scientific basis for any change to approach within the programme would require to be carefully communicated to the public as well as to the service.

It is possible that there will be public pressure to expand the MRSA screening programme to include the routine screening of health care workers (HCWs). One of the key findings from the acceptability study conducted as part of the Pathfinder Programme (see volume three) was that there is strong support for the screening of NHS staff from patients, their visitors, the wider community, and NHS staff themselves. Similarly, in a recent survey of 260 UK doctors attending two national conferences, 63% of participants were in support of routine medical staff screening for MRSA [97]

Current UK guidelines [36] recommend the use of staff screening in certain situations e.g. to assist in outbreak investigation; and recommendations for targeted MRSA screening of HCWs have been made elsewhere [74;52;98;99;100]. With regard to the routine screening of healthcare workers, however, a recent literature review conducted by HPS found no published controlled studies examining the impact of routine staff screening as an intervention in the prevention and control of MRSA infections in the endemic setting [44]. The literature review concluded that further research is required to clarify the role of the colonised HCW in the transmission of MRSA and the effectiveness of staff screening as an infection control measure. Similar calls for further research have been made elsewhere [15;59].

A number of practical and ethical issues relevant to the implementation of routine staff screening have also been raised in the literature [98;100;101] [102] [59] [103] [36;104]; these include:

- The optimum timing and frequency of staff screening
- The optimum treatment regime for colonised staff
- Whether, and for how long, colonised staff should be excluded from work
- The potential impact of staff exclusions on staffing levels
- The financial costs of providing cover for excluded staff
- The potential psychological impact on colonised staff
- The potential stigmatisation of colonised staff
- The management of staff found to be persistently colonised despite treatment, and the occupational consequences for these staff
- Whether screening and decolonisation should be extended to the families of colonised staff to prevent re-colonisation
- The management of staff who refuse to be screened or treated

The issue of routine staff screening is a topic of much debate. There is evidence to suggest that routine staff screening is, in principal, acceptable to both patients and NHS staff. However, before any recommendation can be made to introduce routine screening across NHS Scotland, further research is required to determine its clinical and cost effectiveness as an infection control measure; and the related ethical and practical issues would need to be considered and addressed in full.

In general terms, virtually all criteria for a national screening programme have now been established as being met. The outstanding issue of optimising other interventions is a principle that underpins the continuing processes of improvement driven by the national HCAI programme under the lead of the SGHD HAI Task Force.

In terms of seeking RCT level evidence of effectiveness of screening; this would require a very large study, probably running for several years, to establish this level of evidence. Given the early indicative findings and the intuitively sound rationale of 'being best able to manage hazards when you know where they are', it would be ethically difficult to defer decisions on the screening programme for two or three years, or to leave half of eligible patients untested for a prolonged period. There does need to be some flexibility in revisiting strategic decisions on the national rollout based on emerging evidence from the continuing Pathfinder time series and inter-site comparison data.

Key summary point:

The majority of the criteria for a national screening programme have now been established as being met. The outstanding issue of optimising other interventions is a principle that underpins the continuing processes of improvement driven by the national HCAI programme under the lead of the SGHD HAI Task Force.

13.2.12 Aim 1. Objective 12: To monitor any increase of mupirocin resistance

The earlier discussion identified that the use of mupirocin to suppress carriage and shedding of MRSA is promoted by UK guidance [36] as a strategy for preventing infection and transmission. This is on the basis that carriage is a major risk factor for subsequent infection as indicated within this pathfinder study. The risk of such a strategy is the selection of mupirocin resistance. Selection pressure for resistance will increase if there is increased use of mupirocin as a consequence of a universal screening programme [75]. In recognition of the importance of AMR as an unintended consequence of the MRSA screening programme, the national MRSA reference laboratory monitored mupirocin resistance of isolates as part of the pathfinder study. The laboratory also provided historical and comparator data for non pathfinder hospitals from the routine and snapshot study samples submitted from NHS laboratories in Scotland for the year before and after the intervention of universal screening.

Selection of drug resistant strains of MRSA may arise as a result of usage of antibiotics for both prophylaxis and treatment. The time course for evolution and spread of an antibiotic-resistant strain is unpredictable. Prescribing of antibiotics needs to reflect local resistance patterns as captured through local surveillance whilst taking note of national trends [95]. The frequency of resistance at which an antimicrobial drug ceases to be the empirical choice in a patient group is debateable, but ten percent resistance has been used as a guide for seeking an alternative [95]. This level of resistance was not found during the pathfinder project and little change was seen during the study, despite the noted increased use of mupirocin. It should however be noted that the short time period over which the study has been conducted may not be long enough to detect any changes of resistance to mupirocin.

Other data from the reference laboratory indicates that resistance levels within NHSScotland remain low in NHSScotland, but an upward trend has been seen in the last few years. This trend varies between NHS boards and there is considerable local variation within boards.

International literature has noted the emergence of mupirocin resistance with unrestricted prescribing policies, although this has not been universally observed [75]. In some studies the use of a restrictive policy has resulted in mupirocin resistance levels decreasing or remaining low despite continuing use for decolonisation in the context of a single hospital with a universal screening programme [75]. If clinical use of mupirocin increases nationwide in the context of a national screening programme, it is the possible that prevalence of resistance will increase.

A strategy for the on going monitoring of the prevalence of mupirocin resistance within NHSScotland should therefore be developed by the MRSA reference laboratory and HPS as part of the national rollout of MRSA screening.

Research studies are required to quantify the efficacy, effectiveness and unintended consequences of mupirocin use as an MRSA infection prevention strategy.

Key summary point:

Selection pressure for resistance will increase if there is increased use of mupirocin as a consequence of a universal screening programme. In recognition of the importance of AMR as an unintended consequence of the MRSA screening programme, the national MRSA reference laboratory monitored mupirocin resistance of isolates as part of the pathfinder study. Whilst levels of resistance levels remain low at present, longer term monitoring is required.

13.2.13 Aim 1. Objective 13: To assess the impact on selected hospital epidemiology of introducing MRSA screening of patients

The results of the pathfinder study indicated that the introduction of MRSA screening had no impact on MSSA. Short term monitoring in the year before and after the study indicated little change in MSSA bacteraemia or clinical isolates from the laboratory. This is an early indication that reducing MRSA does not result in an increase of MSSA.

There was also no indication that the MSSA bacteraemia trend within pathfinder boards was any different to that in non pathfinder boards. This indicates that an overall reduction in *S. aureus* infection was seen as a result a reduction in MRSA (see section 13.2.3). This is not directly attributable to the implementation of screening, however, a paper on universal screening in three hospitals in the USA published this year did conclude that the overall reduction in *S. aureus* infection was attributable to screening [72]. Monitoring of these data longer term is required to ensure that there are no unintended consequences of focussing interventions on one organism, in this case replacement of MRSA with MSSA or other hospital associated pathogens.

If MRSA screening is effective and reduces the number of infections due to MRSA (without a concomitant increase in infections due to MSSA or other organisms) it is possible there will be a reduction in the use of vancomycin and teicoplanin (the glycopeptides). This in turn may result in the reduction of glycopeptide resistance in Enterococcus sp. Therefore there is the possibility that screening for MRSA can have a positive impact on reducing other organisms causing HCAI.

Key summary point:

There is no indication that the trend in MSSA clinical isolates or bacteraemias within pathfinder boards is any different to that in non pathfinder boards. This indicates that an overall reduction in *S. aureus* infection is seen as a result of a reduction in MRSA isolates. From the Pathfinder implementation study this may not be directly attributed to screening. Longer term monitoring is required.

13.2.14 Aim 1. Objective 14: To monitor the trends in pathfinder board laboratory confirmed infection data on organisms other than MRSA pre and post MRSA screening intervention

Inappropriate use of antimicrobials may result in the emergence of resistance reducing the value of these agents in containing MRSA. There is also the risk of linked resistance i.e. increased selection of mupirocin resistant strains may also select for resistance to other antimicrobial agents and disinfectants if they are closely linked genetically (plasmid or chromosome).

There is the potential that removal of one organism from body surfaces will create an opportunity for other organisms to colonise the site. In the hospital setting this may be other resistant organisms associated with the hospital environment such as *Enterococcus sp*., *Pseudomonas sp* etc.

Over this period not all laboratories were reporting through the ECOSS electronic reporting system, thus it is important that this data is not over interpreted. Short term monitoring of common bacteraemia isolates over a two year period indicated little change in within the data which are routinely available for the pathfinder and non pathfinder boards in NHS Scotland. These data are the subject of a HPS national surveillance programme which was commenced this year and routine outputs from this should be used in the future to examine changing trends in Antimicrobial Resistant (AMR) organisms in key healthcare associated pathogens. Continued monitoring will be undertaken by the Scottish Antimicrobial Prescribing Group within their annual reports. Within this limited data set, whilst there has not been a statistically different change in bacteraemia reports these data do not include a complete submission from all of NHS Scotland laboratories. From July 09 to June 2010, the first year that complete data is available, all laboratories in Scotland reported bacteraemia isolated via the ECOSS system.

Key summary point:

Continued monitoring these organisms, which are capable of causing significant morbidity and mortality, using 2009 - 2010 as the baseline, will be worthwhile to monitor any trends in the causation of bacteraemias within Scotland

14 Limitations

This pathfinder study has a few limitations which are addressed herein. The study was a prospective cohort design, which is recognised as the gold standard in epidemiology, but by the very nature of the study design established association rather than causation. The study adopted this design as it was an implementation project.

The three boards included in the study represent different geographical settings and acute care provision. Whilst they comprise a tertiary referral, district general and island board setting, these are not necessarily representative of all acute care settings in Scotland.

The study was undertaken over one year, but the effect of the screening programme would be expected to become apparent over a number of years. The NHS QIS model projected that a significant difference in colonisation prevalence would be seen at 3 years post implementation. As the colonisation prevalence was not known before the study commenced, within-year colonisation prevalence was monitored. Routine indicators (first clinical isolates and bacteraemia) for monitoring outcome pre- and post-implementation were used in order to provide a historical comparator to strengthen any association found within the study.

Control comparator hospitals used within the study were those hospitals within the pathfinder boards which were not implementing universal screening. This control comparator was chosen as it was considered that there would be relative consistency in local application of infection control policy within a board, whereas there would be variation between boards in local policy and implementation of national policy. This does however limit the control as these hospitals have different specialty distributions and patient populations. Further, there was patient transfer between the hospitals and the prevalence of MRSA colonisation and infection in the pathfinder hospitals may drive that in the other hospitals. In order to minimise any potential bias resulting from this, the statistical analyses techniques employed allowed for this limitation by comparing the magnitude of the step change in the time series between the pathfinder and the control, rather than making any direct comparisons between the hospitals.

It is acknowledged that other interventions to prevent and control HCAI continued during the pathfinder study as a result of local and national policy developments. These included hand hygiene campaigns and audits, mandatory surveillance, cleaning monitoring, antimicrobial prescribing and routine infection control team activities locally. There were no other interventions implemented which had a focus on MRSA specifically; however, it is acknowledged that all of these interventions would be expected to have an impact on overall incidence of HCAI.

15 Assessing the clinical effectiveness of MRSA screening: an overview

This report has addressed the first aim of the pathfinder study which was to investigate the clinical effectiveness of universal MRSA screening.

Clinical effectiveness is the extent to which specific clinical interventions do what they are intended to do, i.e. maintain and improve the health of patients securing the greatest possible health gain from the available resources.

HPS develops health protection programmes using the NHSQIS framework for clinical effectiveness [105] and therefore the MRSA screening programme has been considered within this framework to summarise this discussion section of this report. The framework has eight elements (health outcomes, programme aims, key impacts, inequalities, activities, performance indicators, implications and risks), described within it. Ensuring these elements are addressed in a health protection programme, such as MRSA screening, ensures that clinical effectiveness is maximised. Each of these will now be discussed in turn.

Health outcomes for universal MRSA screening are defined as reducing MRSA infection during the hospital stay. The public health benefit is therefore for those in the hospital population at risk of infection, having that risk minimised through the screening programme being implemented. The pathfinder study results have indicated that, within the first year of implementation, a significant reduction in MRSA infections has been demonstrated. This finding provides early indication that potential fulfilment of the programme vision is possible in the longer term, i.e. to make changes to hospital MRSA screening practices in order to reduce infection risk whilst in hospital. Longer term monitoring is required.

This programme vision had supplementary aims addressed by the pathfinder project and these have been addressed in Volumes 2-4 of this report. The repopulation of the NHS QIS HTA model with the pathfinder data projected that within 3-5 years, universal screening could result in low endemic proportions of colonised patients being admitted to hospital (See Volume 2). At this point the programme aims should be reviewed in the light of colonisation prevalence and infection incidence as these are the key impact areas of the programme. Colonisation prevalence during the hospital stay is not a health outcome per se, but the achievement of a low colonisation prevalence in hospital patients would lead to a lower infection incidence.

The pathfinder study indicated those who were at risk of being colonised with MRSA on admission were over 65, from care homes or other hospitals, or readmitted following previous admissions to hospital. It therefore becomes more important to consider universal rather than targeted screening based on clinical specialty, as inequalities in managing those risks arise from such screening. Further, patient movement between specialties during an admission would result in a reduced ability to manage risk; in some instances specialty-based targeted screening could result in patients within one ward having different and inequitable approaches to care in terms of the interventions associated with reducing risk of MRSA infection. The impact on outcome of targeted screening as an approach to reducing infection

risk is not yet understood and, further, the NHSQIS HTA indicated that this approach was the least clinically effective approach to MRSA screening. Universal risk assessment with follow up screen for those identified at risk [15] may be an effective approach but to date has been considered cost prohibitive.

The health protection activities associated with the screening are isolation and colonisation. Questions remain about the true level of effectiveness of these activities, and further research is needed. The pathfinder study found that only around half of the patients had these interventions while in hospital, due to short lengths of stay and slow turnaround time of tests. Service redesign would be required to address these issues in the context of the average length of stay in acute care, inclusive of diagnostic services, isolation facilities and patient pathways to admission and during their stay in hospital. These screening associated activities supplement the standard infection control precautions (SICPs) which should be in place at all times for all patients in hospital in order to minimise the risk of infection during their stay.

Compliance with SICPs is not routinely monitored, with the exception of hand hygiene. Compliance with hand hygiene in Scotland is monitored through observational audit of staff against the WHO guidance for hand hygiene opportunities. These data suggest that compliance is high (>90%) in NHSScotland, but very few performance indicators for infection control practice exist at a national level. Infection outcomes such as *S. aureus* bacteraemia are routinely monitored, but these are crude indicators of infection prevention and control practice. The added value of MRSA screening in this context requires to be monitored.

Performance indicators, to ensure the MRSA screening programme is clinically effective, can include: uptake or compliance with screening admissions; compliance with isolation and decolonisation of those positive for MRSA; colonisation prevalence; infection incidence (first clinical isolates); or bacteraemia. It is important that MRSA screening programme monitoring is built into the existing infrastructure in healthcare including: laboratory reporting; ward reporting (such as clinical quality indicators); and national reporting (such as mandatory surveillance outputs and national reference laboratory reporting).

The added value of screening for MRSA needs to be assessed in the context of other interventions to prevent and control HCAI. The risks of not employing universal screening or the consequent interventions are that more infections occur than is necessary. As these infections cause damage, distress and disability and in some instances death, the investment requires a cost consequence analysis to fully address the balance between clinical effectiveness and cost. This is addressed in volumes 2 and 4 of this report.

The data from this pathfinder project provide early indication of potential benefit, although some questions remain around the effectiveness of the interventions. There is a requirement for SGHD to consider healthcare service redesign in order to maximise the potential for these interventions to be given to the right person (confirmed colonised), in the right place (at home as well as in hospital) and at the right time (prior to admission and during hospital stay) to reduce risk of MRSA infection whilst in hospital. Patient movement between wards within a single stay is a *prima facie* risk for spreading colonisation and infection within a hospital, and again there is a need to examine critically the balance between cost efficiencies

in reducing bed numbers and the resulting increased opportunities for spreading healthcare associated infections, including MRSA.

In summary, to ensure that practice with respect to MRSA screening is safe, clinically effective and patient-focused [105]. NHSScotland should therefore have in place:

a) *A prioritised, approved, co-ordinated and supported programme which reflects the local delivery plan and the scope of services provided by the NHS Board.* HPS has facilitated national rollout with named coordinators in each board inclusive of a development plan and patients, the public, other stakeholders, including the staff and, where appropriate, independent sector contractors, are involved in its development.

b) *Systems to provide evidenced assurance of continuous improvement in patient care and outcomes. National and local targets should be in place to drive continuous improvement the screening programme*. There are indicators and metrics being developed to monitor improvement in care and clinical outcomes directly resulting from MRSA screening. There is support for clinicians to participate in regular clinical audit and reviews of the programme.

c) *Systems to provide evidenced assurance of continuous improvement in the health of the population.* There are targets to drive the contribution of screening to reducing the incidence and prevalence of HA MRSA infections [13]. There are indicators and metrics being developed to monitor improvement in these.

d) *A system to review, prioritise, implement and monitor national and local standards, guidance and policy*. National and local procedures need to be in place to disseminate and implement national standards, guidance and policies related to the programme. SGHD needs to be clear which organisation has the lead for ensuring implementation and compliance with national standards, guidance and policies, and which has responsibility for monitoring them.

e) *Formal and informal methods to seek information and feedback from patients, carers, public and staff to drive improvement.* Processes and mechanisms need to be in place to seek information and feedback from patients, the public and staff on the effectiveness and quality of screening. There may be means to measure and assess patient satisfaction and promote their active involvement via the patient experiance programme.

Potential national roll out in relation to implementation of these identified issues is further addressed in Volume 4 of this report.

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17 Appendix 1: Summary of MRSA screening studies

Table 17-1: Summary table of MRSA screening studies reporting prevalence on admission

Reference and Publication date	Country	Year of Survey	Inpatient population sampled	Test	Prevalence	Notes
Chaberny, I.F. *et al* [64]	Germany	2005	University Hospital1,330 beds (129 ICU beds)Extended admission screening protocol in ICU and surgical wards	Culture/ PCR / Spa typing	5.3% Patients (95% CI - 3.49 – 7.70)	MRSA point prevalencePrevalence rates higher for ICU (11.5%) and neurological wards (11.8%)
Eveillard, M. *et al* [65]	France	January to June 2003	Teaching Hospital 600 bedsICU all& risk factors for other wards	Culture	0.93%	Expected lower prevalence due to targeted screening This study method was as follows:Screening of all patients in ICU, screening of patients with risk factors in all wards, use of automatic alert system for previously identified patients
Gopal,Rao G. *et al* [63]	UK	2004 - 2005	University hospital500 bedsAdult emergency admissions	Culture (Broth)	6.7% patients8.6% admissions	MRSA colonisation rate fell during study (12.9 to 6.5%)
Harbarth, S. *et al* [33]	Switzerland	2004 -2006	University HospitalGeneva365 beds13280 admissions (2004)Surgical and Medical ICU Patients	PCR	5.1% patients4.7% admissions	Not universal screening

Reference and Publication date	Country	Year of Survey	Inpatient population sampled	Test	Prevalence	Notes
Harbarth, S. *et al* [66]	Switzerland	January to August 2003	University HospitalGeneva2220 beds	Culture	3.3% admissions	Figure shows overall on admission prevalenceSample taken within 24 hours of admission1.7% new cases
Kock,R. *et al* [67]	Germany / Holland	November 2006 (Germany)July to September 2007 (Holland)	33 acute care hospitals Germany1 acute care hospital (Holland)	Culture / PCR	1.6% patients Germany0.5% patients Holland	Low prevalence rate compared with studies from other countries
Robicsek *et al* [34]	USA	2003 - 2007	3 hospitals850 beds40000 admissions / year	PCR	2004 – 2005 active surveillance (ICU) – 8.3 %Aug 2005 – Apr 2007 active surveillance (universal) – 6.3%	Compliance to universal surveillance went from 75% to 90% by the end of the study.
Wernitz, M.H. *et al* [68]	Germany	September 1999 to March 2001	All "at risk patients"	Culture	0.55%	Not true universal screening as only patients defined as at risk screened

18 Acronyms

Acronym	Expanded Acronym
A & E	Accident and Emergency
AMR	Antimicrobial Resistance
AOBD	Acute occupied bed day
BMJ	British Medical Journal
CA-MRSA	Community associated Meticillin Resistant *Staphylococcus aureus*
CCU	Coronary Care Unit
CDC	Centre for Disease Control (US)
Chrom	Chromogenic Agar
CLO	Central Legal Office
CO	Community Onset
CO-MRSA	Community onset Meticillin Resistant *Staphylococcus aureus*
DDD	Daily Defined Doses
EARSS	European Antimicrobial Resistance Surveillance System
ECDC	European Centre for Disease Control
ECOSS	Electronic Communication of Surveillance in Scotland
ENT	Ear Nose and Throat
GP	General Practitioner
GUM	Genito-Urinary Medicine
HA	Hospital Associated
HAI	Health Associated Infection
HA-MRSA	Hospital Associated Meticillin Resistant *Staphylococcus aureus*
HCAI	HealthCare Associated Infection
HCW	HealthCare Workers
HDU	High Dependency Unit
HEAT	Health Improvement Efficiency Access and Treatment Target
HMUD	Hospital Medicines Utilisation Database
HPS	Health Protection Scotland
HTA	Health Technology Assessment
ICU	Intensive Care Unit
IQR	Inter Quartile Range
ISD	Information and Statistics Division
ITU	Intensive Therapy Unit
KPI	Key Performance Indicator
LIMS	Laboratory Information and Management System

Acronym	Expanded Acronym
LOS	Length of Stay
MIPS	Median Index of Public Sector Building Tender Prices (MIPS) Index
MRSA	Meticillin Resistant *Staphylococcus aureus*
MSSA	Meticillin Sensitive *Staphylococcus aureus*
NHS	National Health Service
NSC	National Screening Committee
PAS	Patient Administration Systems
PCR	Polymerase Chain Reaction
PFGE	Pulse Field Gel Electrophoresis
PVL	Panton-Valentine Leukocidin
QALY	Quality Adjusted Life Year
QIS	Quality Improvement Scotland
RCT	Randomised Controlled Trials
SAB	*Staphylococcus aureus* Bacteraemia
SAPG	Scottish Antimicrobial Prescribing Group
SCOTMARAP	Scottish Management of Antimicrobial Resistance Action Plan
SGHD	Scottish Government Health Department
SHEA	Society for Healthcare Epidemiology of America
SICP	Standard Infection Control Precautions
SIPC	Standard Infection Prevention and Control
SMRSARL	Scottish MRSA Reference Laboratory
SOP	Standard Operating Procedure
SPSP	Scottish Patient Safety Programme
SQL®	Structured Query Language
SSI	Surgical Site Infection
TAT	Turn Around Time

19 Glossary

Acute hospital: Hospitals in Scotland are classified as acute hospitals and non-acute hospitals. Acute hospitals were defined using the classification proposed by ISD. Acute hospitals provide a wide range of specialist care and treatment for patients. Typically, services offered in the NHS acute sector are diverse. They include: consultation with specialist clinicians (consultants, nurses, dieticians, physiotherapists and a wide range of other professionals); emergency treatment following accidents; routine, complex and life saving surgery; specialist diagnostic procedures; and close observation and short-term care of patients with worrying health symptoms.

Admission: Occurs when an inpatient occupies an available staffed bed in a hospital and remains overnight whatever the original intention. See Inpatient definition for more details.

Admission screen: Left and right nostrils using a single nasal swab, this will be undertaken by hospital staff on or as soon after admission as is possible according to local protocols.

Admission types – emergency or unplanned: For clinical reasons, a patient is admitted at the earliest possible time, usually immediately, after seeing a doctor - the patient will not necessarily be admitted via an accident and emergency department.

Admission types – routine, planned or elective: All admissions where the patient is admitted as planned are termed "routine". In most cases patients are admitted directly from their home for inpatient or day case treatment following a period on the waiting list.

Anterior: Situated before or towards the front.

Antibiotic: A substance that kills or inhibits the growth of bacteria. They are used to treat or prevent infection.

Antimicrobial: A general term that covers all medicines that kill or inhibit the growth of microorganisms such as bacteria, fungi or viruses.

Antiseptic: A substance that inhibits the growth and survival of microorganisms that is usually only applied externally.

Assessment: A scientific process of examining and reporting properties of a technology used in health care, such as safety, efficacy, feasibility and indications for use, cost and cost-effectiveness, as well as social, economic and ethical consequences.

Audit: The process of setting and adopting standards and measuring performance against those standards with the aim of identifying both good and bad practice.

Bias: In general, any factor that distorts the true nature of an event or observation. In clinical investigations, a bias is any systematic factor other than the intervention of interest that affects the magnitude of (i.e. tends to increase or decrease) an observed difference in the outcomes of a treatment group and a control group. Bias diminishes the accuracy (though not necessarily the precision) of an observation. Randomization is a technique used to decrease this form of bias. Bias also refers to a prejudiced or partial viewpoint that would affect someone's interpretation of a problem. Double blinding is a technique used to decrease this type of bias.

Boarder: A patient who is under the care of a specialty not usually attendant on the ward.

Body site: Area of the patients' body where a swab sample is taken from.

Capture rate: The proportion of patient admissions who are screened compared with the total number of admissions.

Clinical effectiveness: The extent to which a specific intervention, procedure, regimen, or service does what it is intended to do under ordinary circumstances, rather than controlled conditions. Or more specifically, the evaluation of benefit to risk of an intervention, in a standard clinical setting, using outcomes measuring issues of importance to patients (e.g. ability to do daily activities, longer life, etc.).

Clinical governance: Ensures that patients receive the highest quality of care possible, putting each patient at the centre of his or her care. This is achieved by making certain that those providing services work in an environment that supports them and places the safety and quality of care at the top of the organisation's agenda. Management of clinical risk at an organisational level is an important aspect of clinical governance. Clinical risk management recognises that risk can arise at many points in a patient's journey, and that aspects of how organisations are managed can systematically influence the degree of risk.

Clinical pathway: A multidisciplinary set of daily prescriptions and outcome targets for managing the overall care of a specific type of patient, e.g. from pre-admission to post-discharge for patients receiving inpatient care. Clinical pathways often are intended to maintain or improve quality of care and decrease costs for patients in particular diagnosis-related groups.

Cohorting: Patient is placed in a room and cared for by dedicated nursing staff along with other patients who are (in the context of this programme):

a. known to be MRSA colonisation positive due to admission test result.
b. known to be MRSA colonisation positive due to pre-assessment clinic test result.
c. known to be MRSA infection positive as a result of a laboratory confirmed infection.
d. known to be MRSA positive from a previous MRSA positive result (pre-emptive isolation until shown to be negative by appropriate screen result).

Cohorting can be undertaken for any other pathogen not just MRSA. Cohorting should be undertaken according to the HPS infection control Contact Precautions Policy and Procedure see http://www.hps.scot.nhs.uk/haiic/ic/guidelinedetail.aspx?id=37303.

Cohort study: An observational study in which outcomes in a group of patients that received an intervention are compared with outcomes in a similar group i.e. the cohort, either contemporary or historical, of patients that did not receive the intervention. In an adjusted- (or matched-) cohort study, investigators identify (or make statistical adjustments to provide) a cohort group that has characteristics (e.g. age, gender, disease severity) that are as similar as possible to the group that experienced the intervention.

Colonisation: MRSA is present on any body site without causing any infection or adverse effect to the individual.

Community acquired MRSA: Describes a number of strains of MRSA which are seen in individuals who would not normally be expected to acquire MRSA. These strains can both colonise and/or infect patients. These strains are found in patients who have not recently been in hospital, undergone surgical procedures or prolonged treatment with antibiotics. They are associated with individuals who have close living and physical contact with others. E.g. athletes involved in contact sports. Some countries have seen these strains with hospitals. Not all MRSA strains are clearly categorised in CA-MRSA and HA-MRSA.

Community associated MRSA infection: A laboratory confirmed MRSA positive clinical sample is taken <48 hours after admission and patient shows signs or symptoms according to CDC infection criteria. This will include all MRSA strains regardless of where it was acquired. The definition relates to the location where the infection became prevalent.

Consent: If a patient agrees to have a nasal swab taken in a pre-assessment clinic or on admission implied consent is given. Patients are free to decline consent. This must be recorded as an indicator of acceptability of the nasal screening process. If a patient is unable to give consent, pathfinder hospitals should follow local policy.

Contact precautions: Techniques used in infection prevention and control to prevent person to person contact and spread of pathogens.

Control (s):

1. [In a controlled trial:] A participant in the arm that acts as a comparator for one or more experimental interventions. Controls may receive placebo, no treatment, standard treatment, or an active intervention, such as a standard drug.
2. [In a case-control study:] A person in the group without the disease or outcome of interest.
3. [In statistics:] To adjust for, or take into account, extraneous influences or observations.

Cost-benefit analysis: A comparison of alternative interventions in which costs and outcomes are quantified in common monetary units.

Cost-consequence analysis: A form of cost-effectiveness analysis in which the components of incremental costs (of therapies, hospitalization, etc.) and consequences (health outcomes, adverse effects, etc.) of alternative interventions or programs are computed and displayed, without aggregating these results (e.g. into a cost-effectiveness ratio).

Cost effectiveness analysis: A comparison of alternative interventions in which costs are measured in monetary units and outcomes are measured in non-monetary units, e.g. reduced mortality or morbidity.

Critical appraisal: The process of assessing and interpreting evidence by systematically considering its validity, results and relevance.

Day case: A patient who makes a planned attendance to a specialty for clinical care sees a doctor or dentist or nurse (as the consultants' representative) and requires the use of a bed or trolley in lieu of a bed. The patient is not expected to, and *does not,* remain overnight. Many of these patients require anaesthesia. (These patients are excluded from the pathfinder project)

Decolonisation: Treatment designed to reduce the burden of MRSA colonisation on a patient known to be MRSA positive. This will be undertaken according to local protocols for decolonisation.

Deferred admission: Patients who, when first placed on a waiting list, were under either social or medical constraints which affected their ability to accept an admission date if offered. Examples specific to this programme are: Patients who are not medically ready for admission, due to a condition other than that requiring treatment, where the time taken to become medically fit would delay admission relative to the normal waiting time for that treatment, e.g. a hip replacement which is delayed because the patient is considerably overweight; an operation which is delayed because the patient is found to have a heart arrhythmia which needs treating by a Cardiologist or a patient for whom it is considered better to attempt decolonisation of MRSA carriage before their planned procedure is undertaken.

Deferred admission: Patients who, when first placed on a waiting list due to either MRSA screen or infection a decision has been made to delay their admission due to their MRSA status.

Discharge: An inpatient discharge marks the end of an inpatient episode of care and occurs when the patient:

- Is discharged to a location external to the NHS.
- Is transferred to another NHS hospital.
- Dies.

Hence inpatient discharges include deaths and inpatient transfers-out.

Economic evaluation: The comparative analysis of alternative courses of action, in terms of their costs and consequences.

Economic model: In healthcare, a mathematical model of the patient pathway that describes the essential choices and consequences for the interventions under study and can be used to extrapolate from intermediate outcomes to long-term outcomes of importance to patients.

Elective or planned admission: A patient who has been admitted at a pre-arranged time for a planned procedure. Elective patients attending a pre-assessment clinic should have had a swab taken at the clinic and undergone a decolonisation procedure before admission and MRSA status should be known on admission. Elective patients not attending a pre-assessment clinic should be screened on admission.

Emergency or unplanned admission: A patient who has been admitted without a pre-assessment appointment. These patients will include urgent GP referrals, accident and emergency patients, clinical referrals.

Empirical: Empirical results are based on experience (or observation) rather than on reasoning alone.

Endemic: Something peculiar to a particular people or locality, such as a disease which is always present in the population.

Endemic MRSA: Describes the strains of MRSA which is present within the population.

Epidemic MRSA (EMRSA): A level of MRSA in the population which is significantly greater then usually present over a short period of time.

Epidemiology: The study of the occurrence, distribution and control of infectious and non infectious diseases in populations. This is a key part of public health medicine.

Equilibrium colonisation rate: A rate of spread at which the overall level of colonisation in a population stays the same.

Evaluation research: Various research methods that are used to assess a program, agency, policy, etc., particularly with respect to elements such as organization, processes, outcomes and utility.

Formative evaluation: An ongoing review to describe and analyse how an activity is carried out and to interpret the outcomes. It is valuable in helping those directly involved in the activity to assess its strengths and weaknesses and the changes required to improve its effectiveness.

GROS General Register Office for Scotland: Part of the devolved Scottish Administration. It is responsible for the registration of births, marriages, civil partnerships, deaths, divorces, and adoptions. It runs the Census and uses Census and other data to publish information about population and households. It is the main source of family history records.

Guidelines: A systematically developed statement to assist practitioner and patient decisions about appropriate health care for one or more specific clinical circumstances. The development of clinical practice guidelines can be considered to be a particular type of HTA; or, it can be considered to be one of the types of policymaking that is informed or supported by HTA.

Hospital Associated MRSA infection: A laboratory confirmed MRSA clinical sample is taken >48 hours after admission and patient shows signs or symptoms according to the CDC Nosocomial infection definition criteria.

Healthcare Associated MRSA infection: An MRSA infection which is generally associated with healthcare, but not necessarily attributed to a particular hospital admission.

Health Protection Scotland (HPS): Health Protection Scotland (HPS) was established by the Scottish Government in 2005 to strengthen and co-ordinate health protection in Scotland. HPS plan and deliver effective and specialist national services which co-ordinate, strengthen and support activities aimed at protecting all the people of Scotland from infectious and environmental hazards. This is done by providing advice, support and information to health professionals, national and local government, the general public and a number of other bodies that play a part in protecting health. Website address: http://www.hps.scot.nhs.uk/

HEAT: Local Delivery Plans set out a delivery agreement between the Scottish Executive Health Department and each NHS area board, based on the key Ministerial targets. Local Delivery Plans reflect the HEAT Core Set - the key objectives, targets and measures that reflect Ministers' priorities for the Health portfolio. The key objectives are as follows:

- Health Improvement for the people of Scotland - improving life expectancy and healthy life expectancy;
- Efficiency and Governance Improvements - continually improve the efficiency and effectiveness of the NHS;

- Access to Services - recognising patients' need for quicker and easier use of NHS services; and
- Treatment Appropriate to Individuals - ensure patients receive high quality services that meet their needs.

High risk specialties: Specialties within which admitted patients are considered to be exposed to a high level of risk of contracting an MRSA infection or treat more vulnerable patients.

Incidence: The number of new cases of an illness in a defined population during any defined period.

Incremental cost effectiveness ratio: The additional cost of the more expensive intervention as compared with the less expensive intervention divided by the difference in effect or patient outcome between the interventions, e.g. additional cost per *QALY*.

Infection prevention and control measures: These include isolating, cohorting and decolonisation where appropriate, with the ultimate aim of minimising the risk of patients infecting themselves or infecting/colonising others as a result of their colonisation status.

Inpatient: Patients who are admitted to an acute speciality and who stay overnight. These patients would be included in ISD overnight returns.

Internal validity: The extent to which the findings of a study accurately represent the causal relationship between an intervention and an outcome in the particular circumstances of that study. The internal validity of a trial can be suspect when certain types of biases in the design or conduct of a trial could have affected outcomes, thereby obscuring the true direction, magnitude, or certainty of the treatment effect.

Invasive devices: Any device which temporarily is inserted into the body. These include: peripheral vascular catheters (PVCs); central vascular catheters (CVCs); urinary catheters; and ventilators.

Isolation: Patient is placed in a single room with hand washing facilities, ideally with en-suite toilet and shower where available. Isolation should be undertaken according to the HPS Infection Control Contact Precautions Policy and Procedure see http://www.hps.scot.nhs.uk/haiic/ic/guidelinedetail.aspx?id=37303.

Likelihood ratio:

1. Compares the chance of positive (or negative) test results in those with the disease to the chance in those without the disease. The likelihood ratio for a positive test result is sensitivity/(1 minus specificity). The likelihood ratio of a negative test result is (1 minus sensitivity)/specificity.
2. A statistical indicator comparing the adequacy of two related models to data, allowing hypothesis testing in a large number of situations.

Low risk specialties: Specialties within which admitted patients are considered to be exposed to a low level of risk of contracting an MRSA infection. (See table 7)

Mean: The average value, calculated as the sum of all observed values divided by the total number of observations.

Median: The middle observation when data have been arranged in order from lowest to highest value.

Meticillin: An antibiotic related to the penicillin class used in the identification of MRSA.

Meticillin Resistant Staphylococcus aureus (MRSA): Strain of the bacterium *Staphylococcus aureus* which is resistant to the antibiotic meticillin.

MRSA infections: Infection will be defined as an MRSA positive sample and associated signs or symptoms according to the Centre for Disease Control (CDC) (Horan *et al* 2008) criteria.

Meticillin sensitive Staphylococcus aureus (MSSA): Strain of the bacterium *Staphylococcus aureus* which is not resistant to the antibiotic meticillin.

Model: A simplified yet accurate representation of a program or intervention based on a set of assumptions.

Mupirocin: An antibiotic used in a nasal cream to decolonise patients colonised with microorganisms including MRSA from the nose.

Nares: Nostrils.

Negative predictive value: Is the proportion of patients with negative test results who are correctly diagnosed as negative.

NHS QIS: See NHS Quality Improvement Scotland.

NHS Quality Improvement Scotland (NHS QIS): NHS QIS was established in 2003 and leads the use of knowledge to promote improvement in the quality of healthcare for the people of Scotland. It performs four key functions: providing advice and guidance on effective clinical practice; setting standards; driving and supporting implementation of improvements in quality; and assessing the performance of the NHS, reporting and publishing the findings.

In addition, NHS QIS also has central responsibility for patient safety and clinical governance across NHS Scotland. Website address: http://www.nhshealthquality.org.

NHS board: There are 22 NHS boards of two types: 14 territorial boards responsible for healthcare in their areas and eight special health boards which offer support services nationally.

Nosocomial MRSA Infections or Healthcare Associated MRSA Infections: A laboratory confirmed MRSA clinical sample is taken >48 hours after admission and patient shows signs or symptoms.

Opportunity cost: The amount that could be spent on alternative healthcare strategies if the health technology in question was not used.

Outcomes: Components of patients' clinical and functional status after an intervention has been applied.

Patient care pathway: A plan of care that outlines key activities within specified times. The pathway follows the patients' journey of care.

Patient journey: The pathway through the health services taken by the person who is receiving treatment, and as viewed by that person.

Peer review: The process by which manuscripts submitted to health, biomedical, and other scientifically oriented journals and other publications are evaluated by experts in appropriate fields (usually anonymous to the authors) to determine if the manuscripts are of adequate quality for publication.

Personal protective equipment (PPE): Items as gloves, gowns, medical masks, or eye protection (such as a face shield, goggle, or visor).

Point Prevalence: The ratio of the total number of cases of an event in a population at a particular point in time compared with the total population at the same point in time.

Policy: The highest level statement of intent and objectives within an organisation. A policy can also be a required process or procedure within an organisation.

Polymerase chain reaction (PCR): A laboratory method for detecting the genetic material of an infectious disease agent in specimens from patients. This type of testing has become an essential tool for detecting infectious disease agents.

Population register: A data collection system in which characteristics of all or part of a population are recorded over time.

Positive predictive value: Or precision rate, or post-test probability of disease, is the proportion of patients with positive test results who are correctly diagnosed as positive. It is the most important measure of a diagnostic method as it reflects the probability that a positive test reflects the underlying condition being tested for. Its value does however depend on the prevalence of the disease, which may vary.

Post decolonisation test: MRSA screening for decolonisation should take place at least 2 days after the cessation of the decolonisation treatment. This requires 3 sets of nasal swabs taken with at least two days elapsing between each sample being taken.

Pre-admission clinic: Clinic attended by patients prior to admission where they are screened for MRSA. This will include pre-admission clinics and outpatient clinics.

Pre-admission screening: This will be undertaken before patients are admitted.

Pre-emptive isolation: Where patients are known to have been MRSA positive previously and are isolated on admission.

Probability distribution: Portrays the relative likelihood that a range of values is the true value of a treatment effect (or other outcome or result). This distribution may follow the form of a particular function, e.g., a normal, chi square, binomial, or Poisson distribution. An estimate of the most likely true value of the treatment effect is the value at the highest point of the distribution. The area under the curve between any two points along the range gives the probability that the true value of the treatment effect lies between those two points. Thus, a probability distribution can be used to determine an interval that has a designated probability (e.g. 95%) of including the true value of the treatment effect.

Prospective study:

1. In evaluations of the effects of healthcare interventions, a study in which people are divided into groups that are exposed or not exposed to the intervention(s) of interest before the outcomes have occurred. Randomized controlled trials are always prospective studies and case control studies never are. Concurrent cohort studies are prospective studies, whereas historical cohort studies are not (see cohort study), although in epidemiology a prospective study is sometimes used as a synonym for cohort study.
2. A study in which the investigators plan and manage the intervention of interest in selected groups of patients. As such, investigators do not know what the outcomes will be when they undertake the study.

Protocol: The plan or set of steps to be followed in a study. A protocol for a systematic review should describe the rationale for the review; the objectives; and the methods that will be used to locate, select and critically appraise studies, and to collect and analyse data from the included studies.

Quality assurance (QA): Activities intended to ensure that the best available knowledge concerning the use of health care to improve health outcomes is properly implemented. This involves the implementation of health care standards, including quality assessment and activities to correct, reduce variations in, or otherwise improve health care practices relative to these standards.

Randomised controlled trials (RCT): An experiment of two or more interventions in which eligible people are allocated to an intervention by randomization. The use of randomization then permits the valid use of a variety of statistical methods to compare outcomes of the interventions.

Retrospective study: A study in which investigators select groups of patients that have already been treated and analyze data from the events experienced by these patients. Retrospective studies are subject to selection bias because investigators can select groups of patients with known outcomes or exposures or that are otherwise not truly representative of the broader population of interest. Case control studies are always retrospective, cohort studies sometimes are, randomized controlled trials never are.

Review: A review article in the medical literature which summarises a number of different studies and may draw conclusions about a particular intervention. Review articles are often not systematic. Review articles are also sometimes called overviews.

Risk: The risk is the ratio of people with an event in a group to the total in the group.

Risk assessment: The qualitative or quantitative estimation of the likelihood of adverse effects that may result from exposure to specified health hazards or from the absence of beneficial influences.

Risk factor: An aspect of a person's condition, lifestyle or environment that increases the probability of occurrence of a disease. For example, cigarette smoking is a risk factor for lung cancer.

Risk management: A systematic approach to the management of risk, staff and patient/client/user safety, to reducing loss of life, financial loss, loss of staff availability, loss of availability of buildings or equipment, or loss of reputation. Risk management involves identifying, assessing, controlling, monitoring, reviewing and auditing risk.

Screening: A public health service in which members of a defined population, who do not necessarily perceive they are at risk of a disease or its complications, are asked a question or offered a test, to identify those individuals who are more likely to be helped than harmed by further tests or treatment.

Selection: The non-random survival and reproduction of an organism which alters the frequency of occurrence of a particular gene and therefore trait in that organism.

Sensitivity: The ability of a test to detect a disease when it is present.

Sensitivity analysis: A means to determine the robustness of a mathematical model or analysis (such as a cost-effectiveness analysis or decision analysis) that tests a plausible range of estimates of key independent variables (e.g. costs, outcomes, probabilities of events) to determine if such variations make meaningful changes the results of the analysis. Sensitivity analysis also can be performed for other types of study; e.g. clinical trials analysis (to see if inclusion/exclusion of certain data changes results) and meta-analysis (to see if inclusion/exclusion of certain studies changes results) (INAHTA).

Separated: Patients who have the same MRSA status i.e. are:

a. known to be MRSA colonisation positive due to admission test result
b. known to be MRSA colonisation positive due to pre-assessment clinic test result
c. known to be MRSA infection positive as a result of a laboratory confirmed infection
d. known to be MRSA positive from a previous MRSA positive result (pre-emptive isolation)

Are housed within the same room as patients who are not MRSA positive but are separated by at least 3 feet from any adjacent persons by use of: cubicles or use of closed bed curtains. This is considered to be a step down from full cohorting. These patients do not have separate nursing staff.

Specificity: The ability of a test to indicate non-disease when no disease is present.

Standard operating procedure: Detailed, written instructions to achieve uniformity of the performance of a specific function.

Standard precautions: A group of infection prevention practices that apply to all patients, regardless of suspected or confirmed diagnosis or presumed infection status. Standard Precautions are a combination and expansion of Universal Precautions and Body Substance Isolation. Standard Precautions are based on the principle that all blood, body fluids, secretions, excretions (except sweat), non-intact skin, and mucous membranes may contain transmissible infectious agents. Standard Precautions include hand hygiene, and depending on the anticipated exposure, the use of gloves, gown, mask, eye protection, or face shield. Also, equipment or items in the patient environment likely to have been contaminated with infectious fluids must be handled in a manner to prevent transmission of infectious agents (e.g. wear gloves for handling, contain heavily soiled equipment, and properly clean and disinfect or sterilize reusable equipment before use on another patient).

Stochastic model: A model or equation that incorporates a random variable.

Summative evaluation: A review designed to judge the effectiveness of an activity in terms of its outcomes and impact. The focus may be on measuring outcomes and quantifying costs and benefits. It is often carried out at the end of a process.

Surveillance: The ongoing, systematic collection, analysis and interpretation of health data essential to the planning, implementation, and evaluation of public health practice, closely integrated with the timely dissemination of these data to those who need to know.

Systematic review: A review of a clearly formulated question that uses systematic and explicit methods to identify, select, and critically appraise relevant research, and to collect and analyse data from the studies that are included in the review.

Turnaround time: The time interval between taking the nasal swab until the result is reported on the laboratory system for action by the ward.

Universal screening: Every eligible patient admitted to the hospital in question is screened either before admission or on admission.

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10a. Abstract : [Maximum 200 words]

The MRSA Screening Pathfinder Project implemented Universal Screening within three Pathfinder Health boards from August 2008 to July 2009. This project reports the clinical effectiveness of implementation of MRSA Screening. The two interventions following screening for MRSA are (i) decolonisation (suppression) of confirmed positive cases, and (ii) isolation of those at high risk of, or confirmed as being, colonised. This large prospective cohort study (pathfinder study) of MRSA screened all admissions in three NHS boards, including six acute hospitals in NHSScotland and 81,438 admissions (one third elective and two thirds emergency), indicated an overall MRSA colonisation prevalence of 3.9%. The starting colonisation prevalence of 5.5% reduced to 3.5% by month twelve of the study. Factors influencing the prevalence of colonisation included: number of admissions per patient, specialty of admission, age and source of admission. Patients who were colonised on admission were 15 times more likely to develop hospital associated MRSA infection. The majority of the public health principles which should underpin a national screening programme have been largely met.

Authorisation *(complete as applicable)*

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