Reduction of the nosocomial meticillin-resistant *Staphylococcus aureus* incidence density by a region-wide search and follow-strategy in forty German hospitals of the EUREGIO, 2009 to 2011

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Meticillin-resistant *Staphylococcus aureus* (MRSA) disseminates between hospitals serving one patient catchment area. Successful prevention and control requires concerted efforts and regional surveillance. Forty hospitals located in the German EUREGIO have established a network for combating MRSA. In 2007 they agreed upon a synchronised strategy for screening of risk patients and a standard for transmission-based precautions (search and follow). The same year, the hospitals started synchronised MRSA prevention and annually reporting MRSA-data to the public health authorities. The median rate of screening cultures per 100 patients admitted increased from 4.38 in 2007 to 34.4 in 2011 (p<0.0001). Between 2007 and 2011, the overall incidence density of MRSA (0.87 MRSA cases/1,000 patient days vs 1.54; p<0.0001) increased significantly. In contrast, both the incidence density of nosocomial MRSA cases (0.13 nosocomial MRSA cases/1,000 patient days in 2009 vs 0.08 in 2011; p=0.0084) and the MRSA-days-associated nosocomial MRSA rate (5.51 nosocomial MRSA cases/1,000 MRSA days in 2009 vs 3.80 in 2011; p=0.0437) decreased significantly after the second year of the project. We documented adherence to the regional screening strategy resulting in improved detection of MRSA carriers at admission. Subsequently, after two years the nosocomial MRSA-incidence density was reduced. Regional surveillance data, annually provided as benchmarking to the regional hospitals and public health authorities, indicated successful prevention.

Introduction

Meticillin-resistant *Staphylococcus aureus* (MRSA) globally belongs to the most frequent causes of healthcare-associated infections [1]. In addition, the severity of MRSA infections is documented by studies estimating that patients with MRSA bloodstream infection (BSI) have a higher 30-day mortality compared to those with BSI due to meticillin-susceptible *S. aureus* (MSSA) [2].

In 2007, the annual burden of MRSA infections in European Union (EU) Member States, Iceland and Norway was estimated to comprise 171,200 cases including 12% BSI [3]. However, MRSA rates in Europe show remarkable differences: In 2010, Sweden reported the lowest proportion of invasive isolates resistant to meticillin (0.5% of all *S. aureus*) and Portugal the highest (52.2%) [4]. Such discrepancies were even reported when comparing directly neighbouring countries. In the German federal state of North Rhine-Westphalia (NRW), 57.6 MRSA bacteraemia episodes per 1,000,000 inhabitants were reported to public health authorities in 2010, whereas only a few kilometres across the Dutch–German border the rate of bacteraemia episodes was estimated to be 1.8 per 1,000,000 inhabitants in the Netherlands [5,6]. Hence, the prevalence of MRSA differs nationally and regionally. Moreover, it was found that there are substantial regional differences regarding the molecular subtypes of MRSA circulating in Europe [7] and that compared with other continents, which observed a shift of the major MRSA burden from healthcare institutions into the community, healthcare-associated (HA-) MRSA are still predominant in Europe [8].

The molecular epidemiology of MRSA in Europe indicates that the dissemination of MRSA is mainly governed either by direct transfer of patients between hospitals, nursing homes and other healthcare facilities or by indirect exchange of patients admitted consecutively to several facilities in one same catchment area [7]. Indeed, of 354 MRSA carriers identified at admission to German hospitals, 32 were directly transferred from other hospitals, 173 had been hospitalised for > 24 h in the previous six months and 58 were

residents of long-term care facilities [9]. Other studies have shown that patients once identified as MRSA carriers had a 44% probability of being re-admitted to the same or other regional hospitals whilst still carrying MRSA [10] and that of 1,032 known patients with previous MRSA carriage attending the Hannover Medical School hospital, 39% were re-admitted more than once during a 46-month period, 59% of which remained MRSA positive during all admissions [11]. Simulating the importance of inter-facility patient movements, it has been shown that especially small long-term care facilities with low patient turnover rates are most susceptible to sustaining high MRSA prevalence, especially when cooperating with large, high-prevalence hospitals [12]. A model based on patient-flow characteristics of 29 acute care hospitals cooperating in Orange County, California, revealed that in case of an outbreak (increase of MRSA prevalence to 15%) in a single hospital within the county, most other regional hospitals also experienced an increase of the MRSA prevalence (median increase of MRSA prevalence 1.8%). In this model, even outbreaks in single intensive care units affected the overall prevalence of MRSA in regional acute care hospitals [13].

In consequence, the referral of patients between regional hospitals might contribute to MRSA spread. Thus preventive standards for MRSA control implemented only locally in single hospitals may be not effective to reduce MRSA. The implementation of harmonised preventive standards in the regional healthcare cluster, where the nosocomial pathogen spreads predominantly is more likely to be successful. The hospitals of the Dutch–German border region EUREGIO have been confirmed to represent such a regional healthcare cluster using mathematical modelling [14]. Therefore, the governments of the 16 German *Bundesländer* (i.e. federal states) have recommended to address the problem of antimicrobial resistance in regional networks of hospitals and other institutions involved in patient care [15], and to apply regional approaches and concerted regional action to solve the MRSA problem [15,16]. In addition, the implementation of preventive interventions including screening of defined risk patients, single or cohort room isolation and the use of transmission-based precautions (gloves, gowns) when caring for MRSA colonised or infected patients [17,18] has been recommended for all German acute care hospitals. However, despite the availability of guidance [19], it was shown that for German hospitals it is challenging to implement preventive bundles sufficiently and in a standardised manner on a local and regional level [20]. To reinforce regional cooperation and overcome the problem of limited local implementation, all 40 hospitals in the Münsterland region in NRW are cooperating in the EU-funded Dutch–German EUREGIO MRSA-net (www.mrsa-net.eu) and EurSafety Health-Net (www.eursafety.eu) projects since 2005. Since these 40 hospitals form a connected healthcare cluster [14], and contain all hospitals in the region, they can be considered to form a single patient catchment area.

In 2007, hospitals agreed upon and started the implementation of a concerted strategy for identification of MRSA carriers by (pre)admission MRSA screening of risk patients, isolation of carriers, continued care and decolonisation even after transfer to another hospital or after discharge and collection of basic MRSA surveillance data for centralised analysis and benchmarking [9,15]. In this report, we analyse surveillance data collected between 2007 and 2011 resulting from the network with respect to changes in the implementation of MRSA screening and the number and incidences of imported and nosocomial MRSA cases.

Methods
The German part of the project region geographically comprises six German districts (codes DEA33, DEA34, DEA35, DEA37, DEA38 and DE94B, level3, according to the Nomenclature of Territorial Units for Statistics) [21] and is inhabited by 1.7 million people. In 2007, 40 hospitals were located in the region, treating about 360,000 patient cases during 2,500,000 inpatient days per year. Of 40 hospitals, 36 were acute care hospitals, while one was a rehabilitation clinic and three hospitals were specialised in psychiatry.

During a prevalence screening of all admissions and risk factor assessment in November 2006, 35.6% of patients admitted to the hospital had at least one MRSA risk factor [9]. In 2007, all hospitals started to systematically screen defined patients associated with any one of the known risk factors described previously [9], prior to or at admission to hospital. In 2008, the risk factors were slightly adapted according to a new German national recommendation [18]. In the project there was no harmonised microbiological protocol for performing the MRSA screening. Mostly a culture-based approach using chromogenic MRSA media was used. Positive screening was followed in all hospitals by the implementation of single or cohort room isolation, transmission-based precautions and decolonisation therapies as recommended in Germany [17]. Adherence to the recommendations was checked exemplarily by the local public health authorities during annual inspections.

Since 2007 standardised MRSA-related data were collected, based on a surveillance protocol adapted from that of the national German Nosocomial Infections Surveillance System to ensure comparability [22]. We analysed and reported all surveillance results and reported once a year to the participating hospitals in an anonymised feedback data set via the responsible public health offices.

Data collection
The collected surveillance data included the numbers of MRSA cases (colonisation and infection) classified as imported or nosocomial cases, the overall number of patient cases treated and the overall number of patient days as well as patient days of MRSA cases and the number of nasal swabs performed at admission. The

findings of at least each MRSA-detection based on the first positive isolates of all MRSA-inpatient cases were inserted in a database (Epi-MRSA®, Ridom GmbH, Münster, Germany or Excel®, Microsoft Inc., Redmond, USA). For each case, information on every first MRSA isolate was included in an annual report to the public health authorities with one exception: if a patient developed a MRSA bacteraemia during the hospital stay, this detection of MRSA-bacteraemia based on the positive MRSA blood culture isolate was included in the report. Each MRSA-detection (colonisation or infection) of isolates sampled more than three days after admission was classified as nosocomial unless the patient was a known MRSA carrier. A day, which an MRSA patient spent in hospital, was classified as MRSA-in-hospital day. In most hospitals, the MRSA-in-hospital days could be specified by counting the isolation days of MRSA cases.

Data analysis

We analysed the surveillance data of five years (2007–2011) and calculated the following parameters: (i) number of MRSA cases, classified as imported or nosocomial cases, (ii) screening rate (number of screening cultures/100 admissions), (iii) MRSA incidence at admission (imported MRSA cases/100 admitted cases), (iv) MRSA incidence density (MRSA cases/1,000 patient days), (v) nosocomial MRSA incidence density (nosocomial MRSA-cases/1,000 patient days), (vi) the mean daily MRSA-burden (MRSA-in-hospital days/100 patient days), (vii) MRSA-days-associated nosocomial MRSA rate (nosocomial MRSA-cases/1,000 MRSA days).

Time trends of MRSA parameters were analysed by Friedmann test ($p < 0.05$ was considered significant). The percentage of nosocomial MRSA cases on all MRSA cases was assessed by Cochran Armitage test of linear trend ($p < 0.05$). The correlation of MRSA parameters was done calculating the Spearman rank correlation coefficient ($p < 0.05$). All statistical analyses were done using SAS 9.2 software (SAS Institute Inc., Cary, USA). Results of significance tests were discarded if the programme displayed an alert due to more than 10% of missing values in the respective dataset.

Results

In this study, we collected MRSA-related data of regional hospitals in the EUREGIO during a five-year period. While in 2007 and 2008, 38/40 hospitals (95%) participated in surveillance, the participation rate was 100% in 2009 (40/40 hospitals), 2010 (38/38 hospitals) and 2011 (37/37 hospitals). The number of participating hospitals changed from 40 to 37 because of acute care hospital fusions.

Overall, the implementation of the screening strategy as monitored by analysis of the median screening rate increased significantly ($p < 0.001$) over time from 4.38/100 patients (interquartile range (IQR): 2.15–11.8)

admitted in 2007 to 34.4/100 patients (IQR: 27.4–51.6) in 2011 (Table 1, Figure 1).

Table 2 shows the numbers of documented regional MRSA cases. In 2007, the total number of cases was 2,351. For 1,864 of these cases stratification into imported (1,481) and nosocomial (383) cases was possible (Table 2). Between 2007 and 2011, the overall number of cases increased significantly ($p < 0.0001$). According to Cochran Armitage trend test, the percentages of imported cases on all MRSA cases increased significantly ($p < 0.0001$) between 2007 and 2011, while the percentage of nosocomial cases on all MRSA cases decreased significantly ($p < 0.0001$) (Table 2).

From 2007 to 2011, the MRSA admission incidence (0.51 vs 1.09 MRSA cases/100 patients admitted), the MRSA-incidence density (0.87 vs 1.54 MRSA cases/1,000 patient days) as well as the mean daily MRSA-burden (1.30 vs 1.82 MRSA-in-hospital days/100 patient days) increased significantly ($p < 0.0001$) (Table 1). These overall increases were due to increases in the years from 2007 to 2009. From 2009 to 2011, the MRSA admission incidence ($p = 0.5796$), the MRSA incidence density ($p = 0.6729$) and the mean daily MRSA-burden ($p = 0.7327$) remained stable.

The incidence density of nosocomial cases decreased from 0.14 nosocomial MRSA cases per 1,000 patient days in 2007 to 0.08 per 1,000 patient days in 2011

FIGURE 1

Distribution of increasing screening rate at admission to identify meticillin-resistant *Staphylococcus aureus* (MRSA) carriers in German regional hospitals of the EUREGIO, 2007–2011 (n=40)
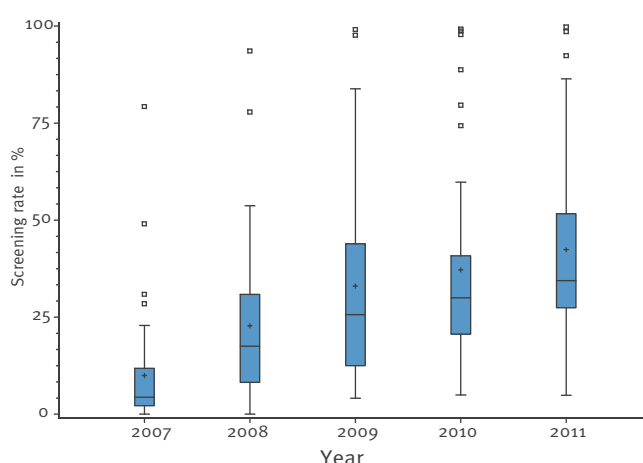
IQR: interquartile range.

Distribution of nasopharyngeal admission screening cultures per 100 patients admitted to the 40 German hospitals of the EUREGIO taking part in a concerted strategy for identification of MRSA carriers. For each year the number of screenings per 100 patients is shown in the boxplot with whiskers as minimum and maximum and outliers as squares below 1.5*IQR*25th percentile or above 1.5*IQR*75th percentile and far outliers above 3*IQR*75th percentile. 50% of hospitals reported a screening rate indicated in the rectangle with the mean (plus) and the median (band).

(Table 1). The MRSA-days-associated nosocomial MRSA rate decreased from 9.52 nosocomial MRSA cases per 1,000 MRSA days in 2007 to 8.14 in 2008 and to 5.51 in 2009. It subsequently increased to 7.77 in 2010 followed by a decrease to 3.80 in 2011 (Table 1).

The data quality allowed for specifying the significance of trend for these parameters from 2009 to 2011 only; other time periods were statistically excluded for lack of more than 10% of the data. From 2009 to 2011, the MRSA-admission incidence remained stable (p=0.5796) whereas the nosocomial MRSA-incidence density (p=0.0084) as well as the MRSA-days-associated nosocomial MRSA rate (p=0.0437) decreased significantly.

There was a moderate positive correlation between the mean daily MRSA-burden and the screening rate (Spearman rank correlation coefficient r=0.32710; p<0.0001) (Figure 2). Furthermore, there was a low negative correlation between the MRSA-days-associated nosocomial MRSA rate and the screening rate (Spearman rank correlation coefficient r=-0.23829; p=0.0017) (Figure 3). In Figures 2 and 3, the median and the IQR are plotted. In this way, hospitals beyond the 50% range may be graphically detected, stimulating inspection and, if necessary, intervention measures.

Discussion

According to the antimicrobial resistance surveillance in Europe in 2010, MRSA is the most important cause of antibiotic resistant healthcare-associated infections worldwide. In 11 of 28 European countries, the percentage MRSA-isolates per *S. aureus*-isolates in blood cultures is higher than in Germany. The *S. aureus* resistance to meticillin in Germany in 2010 is still reported as increasing [4].

Due to an active search and destroy policy in Dutch hospitals, the incidence of hospital-associated cases and the rate of nosocomial transmission have been kept at a low level since decades [23]. Within the framework of two Dutch–German preventive network projects (EUREGIO MRSA-net and EurSafety Health-net), we aimed to establish an adapted 'search and follow' strategy in hospitals in the German part of the Dutch–German border area [24]. This includes active search by region-wide screening for MRSA carriage at admission following the standardised implementation

Table 1

Admission screening rates and meticillin-resistant *Staphylococcus aureus* related rates in 40 hospitals in the EUREGIO, 2007–2011

Parameter	2007 Median (IQR)	2008 Median (IQR)	2009 Median (IQR)	2010 Median (IQR)	2011 Median (IQR)
Screening rate (MRSA/100 patients admitted)	4.38 (2.15–11.8)	17.5 (8.19–30.9)	25.6 (12.5–43.9)	30.0 (20.6–40.9)	34.4 (27.4–51.6)
MRSA admission incidence (MRSA cases/100 patients admitted)	0.51 (0.39–0.79)	0.94 (0.60–1.24)	0.86 (0.60–1.34)	1.12 (0.75–1.39)	1.09 (0.70-1.35)
MRSA incidence density (MRSA cases/1,000 patient days)	0.87 (0.56–1.21)	1.37 (0.93–1.89)	1.62 (1.01–2.20)	1.63 (1.19–2.35)	1.54 (0.92–2.27)
Nosocomial MRSA incidence density (nosocomial MRSA cases/1,000 patient days)	0.14 (0.06–0.24)	0.15 (0.10–0.21)	0.13 (0.04–0.25)	0.13 (0.06–0.23)	0.08 (0.03–0.15)
Mean daily MRSA burden (MRSA-in-hospital days/100 patient days)	1.30 (0.86–1.95)	1.98 (1.53–2.67)	2.01 (1.39–2.62)	1.80 (1.58–3.24)	1.82 (1.27–2.96)
MRSA-days-associated nosocomial MRSA rate (nosocomial MRSA-cases/1,000 MRSA days)	9.52 (2.97–17.4)	8.14 (4.53–11.7)	5.51 (3.31–12.5)	7.77 (3.62–10.7)	3.80 (2.04–7.97)

IQR: interquartile range; MRSA: meticillin-resistant *Staphylococcus aureus*.

Table 2

Numbers of meticillin-resistant *Staphylococcus aureus* cases documented in 40 German hospitals in the EUREGIO, 2007–2011

Numbers of MRSA cases	2007 n (%)	2008 n (%)	2009 n (%)	2010 n (%)	2011 n (%)
MRSA (total)	2,351 (100)	3,522 (100)	4,206 (100)	4,276 (100)	4,512 (100)
MRSA (stratified)[a]	1,864 (100)	3,263 (100)	3,759 (100)	4,150 (100)	4,347 (100)
Imported MRSA cases	1,481 (79)	2,807 (86)	3,262 (87)	3,641 (88)	3,992 (92)
Nosocomial MRSA cases	383 (21)	456 (14)	497 (13)	509 (12)	355 (8)

MRSA: meticillin-resistant *Staphylococcus aureus*.
[a] Number of MRSA cases with available information allowing stratification as imported or nosocomial.

of transmission-based precautions (hand hygiene, isolation and contact precaution) and decolonisation of MRSA carrier.

Here we present surveillance data obtained from this regional network aiming to prevent inter-institutional MRSA spread. We demonstrate that the network structures enabled the implementation of a risk-based admission screening approach. This was documented by a significant increase of nasopharyngeal MRSA screenings performed in the network hospitals after agreement upon a minimum standard for a screening regime. The aim of the network was to establish a screening of patients at a higher risk of MRSA carriage as defined by national German recommendations [17,18]. In 2011, the regional hospitals achieved a median screening rate of about 30%, which argues for successful implementation of the screening-policy. The latter is supported by the study in which the same hospitals have assessed risk factors for MRSA carriage

among all patients admitted during a one-month period in 2006. A total of 35.6% of the patients exhibited at least one risk factor at admission. The observed admission MRSA prevalence was 1.6/100 patients [9].

The effect of the improved admission screening was demonstrated by an overall 92% increase of MRSA cases detected in the participating hospitals. Moreover, the MRSA admission-incidence nearly doubled (0.51 MRSA/100 patients in 2007 vs 1.09 MRSA/100 patients in 2011). This increase was not surprising as it is known that 69 to 85% of all MRSA cases are not detected if microbiological cultures are only performed for clinical reasons and screening is not implemented [25].

We assume that the risk-based screening strategy implemented in the participating hospitals still does not detect all MRSA cases, but, according to our data at least 68%, due to the observed admission-incidence after full implementation (1.09/100 patients) which is

FIGURE 2

Moderate positive correlation between the mean daily meticillin-resistant *Staphylococcus aureus* burden and the screening rate, stratified by screening extent, of 40 German regional hospitals, EUREGIO, 2007–2011
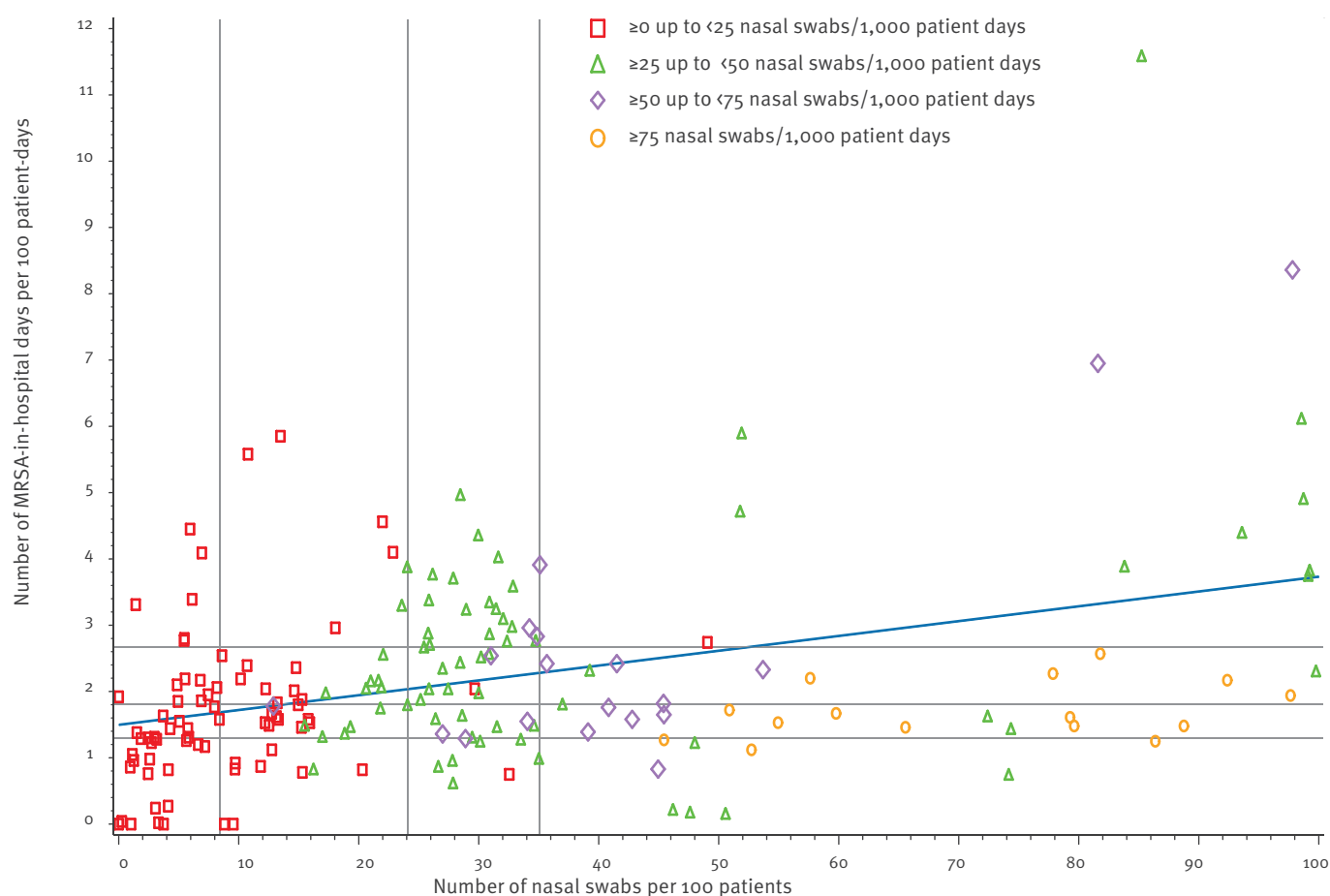
MRSA: meticillin-resistant *Staphylococcus aureus*.

Moderate positive correlation between mean daily MRSA burden (MRSA-in-hospital days/100 patient days) and screening rate (admission screenings/100 patients). Each sign represents a network hospital once a year from 2007 to 2011, with the respective colour and shape reflecting the degree of screening implementation in nasal swabs per 1,000 patient days. The grey lines represent the respective medians and interquartile ranges (IQR) of the MRSA-in-hospital days per 100 patient days and the nasal swabs per 100 patients.

lower than the admission burden found when screening all regional patients at admission (1.6 MRSA cases/100 patients) [9].

Furthermore in 2011, the MRSA admission incidence was higher compared to the median incidence of 0.83 MRSA/100 patients described in 302 of 2,041 German hospitals participating in a German nationwide surveillance programme [22,26]. Since data from admission prevalence screening studies do not indicate that MRSA was more endemic in the EUREGIO compared to other parts of Germany [27], this difference is most likely due to the fact that the median screening rate was 34.4/100 patients in the EUREGIO-hospitals, but much lower (9.39/100 patients) in hospitals taking part in the national surveillance programme. However, from 2009 to 2011, we observed a stabilisation of the MRSA-incidence and the mean daily MRSA burden, which indicates a saturation of excess MRSA detection due to enhanced screening.

The improved detection of MRSA at admission also led to a decrease in the proportion of nosocomial MRSA-cases within all MRSA cases. This is similar to results reported by other authors for 26 hospitals involved in the German nationwide MRSA surveillance from 2004 to 2006 [28], but has so far not been shown in a region-wide surveillance. From 2004 to 2009, the 111 hospitals, taking continuously part in the German national MRSA surveillance, reported a stable nosocomial MRSA incidence density of about 0.25 nosocomial MRSA cases per 1,000 patient days. A decrease was only observed in intensive care units [29]. The EUREGIO hospitals reported from 2007 to 2009 about 0.14 nosocomial MRSA cases per 1,000 patient days and even a significant reduction from 2009 to 2011.

The time-delayed reduction of nosocomial MRSA incidence density may be because the improved screening leads stepwise to better detection of MRSA cases in general, increasingly allowing better containment

FIGURE 3

Low negative correlation between the meticillin-resistant *Staphylococcus aureus* (MRSA)-days-associated nosocomial MRSA-rate and the screening rate, stratified by screening extent, of 40 German regional hospitals, EUREGIO, 2008–2011
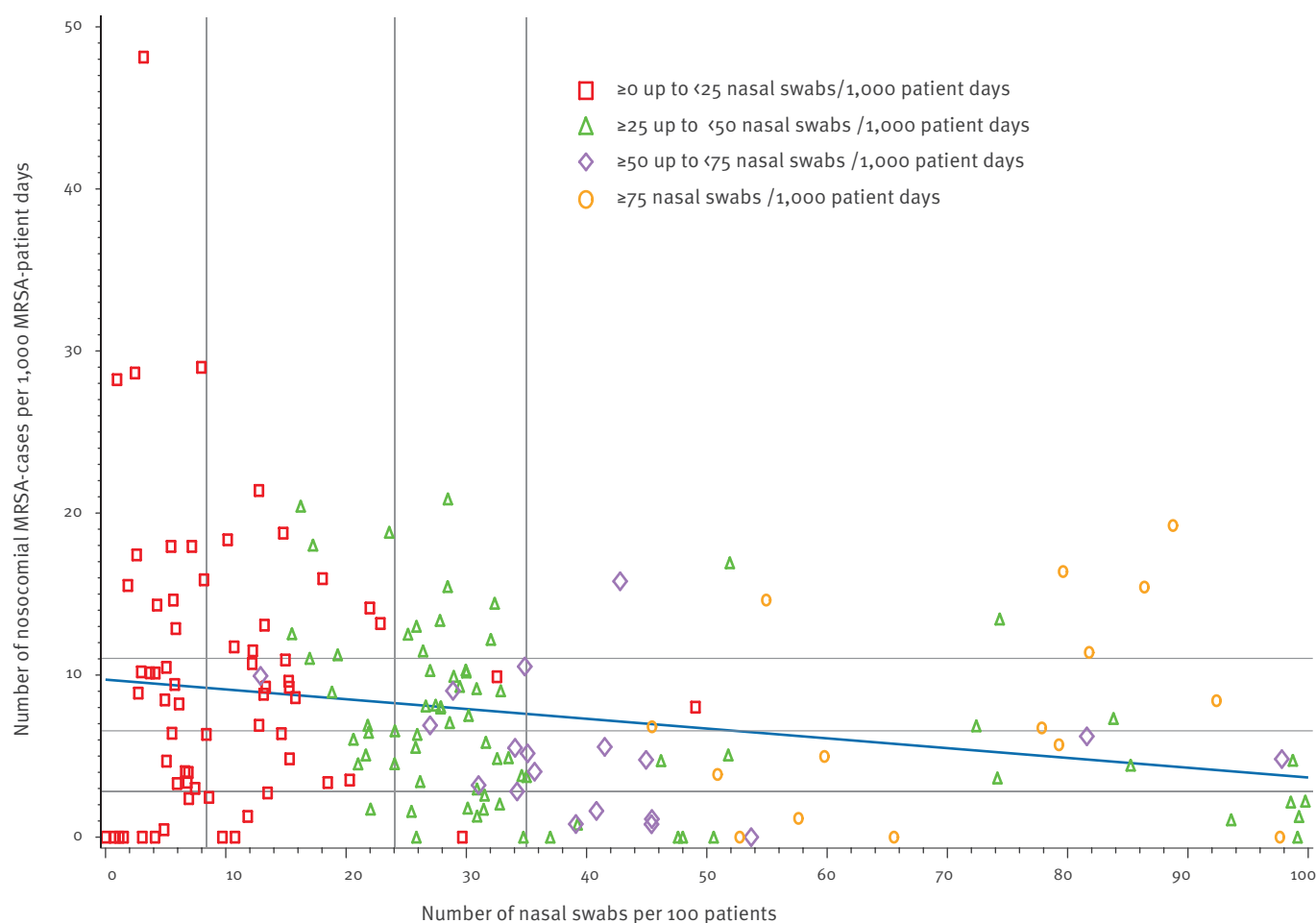
Low negative correlation between the MRSA-days-associated nosocomial MRSA-rate (number of nosocomial MRSA-cases/1,000 MRSA-patient-days) and screening rate (admission screenings/100 patients). Each sign represents a network hospital once a year from 2007 to 2011, with colour and shape reflecting the degree of screening implementation in nasal swabs per 1,000 patient days. The grey lines represent the respective median and interquartile ranges (IQR) of the nosocomial MRSA-cases per 1,000 MRSA days and nasal swabs per 100 patients.

of the bacteria and more limiting spread in the hospital by MRSA-management measures like for example hand hygiene, contact precautions, and decolonisation efforts. The introduction of screening at admission and the increased awareness for MRSA in the hospitals might have led to more detection of nosocomial MRSA-cases as well as to fewer MRSA cases not classifiable as imported or nosocomial (21% in 2007 vs 4% in 2011). On the other hand, there might be less 'false' nosocomial MRSA-cases (imported MRSA-cases detected via an isolate sampled from an inpatient after three days of hospital stay). Additionally, it may be that the hospitals improved the quality of the submitted data at least from 2009 to 2011, after two years of participation in the surveillance system. Furthermore the nosocomial MRSA incidence density was low (about 0.14 MRSA cases/1,000 patient days) in the 40 EUREGIO-hospitals compared to 111 hospitals, which took part in the German national surveillance system (0.25 MRSA cases/1,000 patient days, stable from 2004 to 2009). The low number MRSA cases per 1,000 patient days in our hospitals reduced the probability for a (significant) decrease, which we could nevertheless demonstrate from 2009 to 2011.

For infection control staff, the advantage of improved MRSA detection at admission is that detection of nosocomial cases more reliably reflects cases of MRSA infection or colonisation which are caused by intra-institutional transmission of the pathogen. This is important because a high number of nosocomial MRSA cases per 1,000 patient days (i.e. a nosocomial MRSA-incidence in the range of the upper quartile of all hospitals taking part in a surveillance system) might be an indicator for deficits in infection control and/or for selection pressure due to use of antibiotics, which should be checked for possible improvements [30]. Locally, the knowledge of nosocomial MRSA cases enables more targeted reactions with respect to elucidating the transmission pathways and implementing measures appropriate to forestall further transmission.

Admission screening for MRSA carriage has been shown to be (cost-) effective in reducing both nosocomial infections and MRSA transmission on the wards, because it enables timely implementation of transmission-based precautions, isolation and decolonisation therapies [31,32]. Although, we did not assess to what extent isolation measures or decolonisation therapies were performed for the MRSA patients detected, applying a standardised panel of MRSA infection control measures in all participating hospitals was part of the network's quality goals and the implementation of these measures was controlled exemplarily by the regional public health authorities. Since nosocomial transmission is more probable in a hospital with a high mean daily MRSA burden than in a hospital with a low mean daily MRSA burden, the MRSA-days-associated nosocomial MRSA rate is used to compare hospitals as this rate takes into account the institutional mean daily MRSA-burden and thereby reflects the degree

of transmission on the ward more reliably [33]. In this study, we observed a negative correlation between the slightly decreasing MRSA-days-associated nosocomial MRSA rate and the increasing screening rate. This also suggests that in those hospitals where screening was performed consistently it was followed by adequate hand hygiene, contact precautions, isolation of MRSA-carriers and subsequently led to a reduction of nosocomial transmissions.

Another important question related to the implementation of preventive strategies is whether they are effective in reducing the number of nosocomial MRSA cases. Many authors have investigated this issue with divergent results [31,34-36]. In this context, we found that from 2009 to 2011 the nosocomial incidence density decreased significantly from 0.13/1,000 patient days to 0.08/1,000 patient days. This indicates that after an implementation period, when MRSA carriers were detected at an early stage, the rate of nosocomial cross-transmission was reduced.

Besides screening, hand hygiene, isolation of MRSA-carriers and contact precautions the 'search and follow'-strategy in the EUREGIO implies a post-discharge MRSA-case management outside the hospital [15]. In this way after a reduction of the nosocomial burden, the overall burden of MRSA-carriage in the region may be reduced.

This study also has some limitations. Analysis of MRSA-surveillance data of all hospitals in a regional network cannot adjust for all existing differences between the hospitals including different specialities, difference in the presence of infection control staff, different patient populations and case-mixes. Especially in 2007 and 2008, there were missing data concerning MRSA days or classification of MRSA cases as imported or nosocomial. We addressed the latter by not calculating statistical differences in the absolute numbers of nosocomial cases, in the MRSA-admission incidence, in the nosocomial MRSA incidence density and in the MRSA-days-associated nosocomial MRSA rate assessed between 2007 and 2008. However, during the course of the study, the quality of data collection was enhanced and the statistical tests indicated robust performance. Furthermore, we cannot adjust for differences in further hygiene measures implemented in the participating hospitals (e.g. different participation in the German version of the World Health Organization (WHO) campaign 'Clean Care is Safer Care' [37]). In the future, the network will have to focus on a structured assessment of nosocomial MRSA infections rather than cases of colonisation and infection to monitor the clinical impact of MRSA.

In conclusion, we documented the successful implementation of a screening programme in hospitals participating in a regional prevention network. This approach led to a significant increase of MRSA cases, but, eventually to a significant reduction of nosocomial

MRSA-cases per 1,000 patient days. The data reflects a paradoxical situation ('MRSA-screening-paradox'): Initially, more MRSA carriers are found when more patients are screened. This may make some hospitals reluctant in establishing such a screening policy due to increasing and costly efforts to isolate patients in single rooms. However, only after few years, the nosocomial MRSA burden starts to reduce, which finally may encourage the hospitals to accept this burden of prevention. Since efforts of single hospitals may not change the MRSA-situation in the long run, this argues for establishing regional networks of healthcare providers sharing a common patient catchment population and synchronising prevention methods in the networks. Within such a network, surveillance data can be used for internal benchmarking as well as for validation and improvement of local standards. Thereby the network can support the work of local infection control personnel.

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