Aalborg Universitet

Detection of meticillin-resistant Staphylococcus aureus and carbapenemase-producing Enterobacteriaceae in Danish emergency departments - evaluation of national screening guidelines

Skjøt-Arkil, H; Mogensen, C B; Lassen, A T; Johansen, I S; Chen, M; Petersen, P; Andersen, K V; Ellermann-Eriksen, S; Møller, J M; Ludwig, M; Fuglsang-Damgaard, D; Nielsen, F E; Petersen, D B; Jensen, U S; Rosenvinge, F S

Detection of meticillin-resistant *Staphylococcus aureus* and carbapenemase-producing Enterobacteriaceae in Danish emergency departments — evaluation of national screening guidelines

H. Skjøt-Arkil [a,b,*], C.B. Mogensen [a,b], A.T. Lassen [c,d], I.S. Johansen [d,e], M. Chen [b,f], P. Petersen [g], K.V. Andersen [h], S. Ellermann-Eriksen [i], J.M. Møller [j], M. Ludwig [k], D. Fuglsang-Damgaard [l], F.E. Nielsen [m], D.B. Petersen [n], U.S. Jensen [o], F.S. Rosenvinge [p]

[a] *Emergency Department, Hospital Sønderjylland, Aabenraa, Denmark*
[b] *Department of Regional Health Research, University of Southern Denmark, Aabenraa, Denmark*
[c] *Emergency Department, Odense University Hospital, Odense, Denmark*
[d] *Department of Clinical Research, University of Southern Denmark, Odense, Denmark*
[e] *Department of Infectious Diseases, Odense University Hospital, Odense, Denmark*
[f] *Department of Clinical Microbiology, Hospital of Southern Jutland, Sønderborg, Denmark*
[g] *Emergency Department, Regional Hospital West Jutland, Herning, Denmark*
[h] *Emergency Department, Aarhus University Hospital, Aarhus, Denmark*
[i] *Department of Clinical Microbiology, Aarhus University Hospital, Aarhus, Denmark*
[j] *Emergency Department, Aalborg University Hospital, Aalborg, Denmark*
[k] *Emergency Department, North Denmark Regional Hospital, Hjørring, Denmark*
[l] *Department of Clinical Microbiology, Aalborg University Hospital, Aalborg, Denmark*
[m] *Emergency Department, Slagelse Hospital, Slagelse, Denmark*
[n] *Emergency Department, Zealand University Hospital, Køge, Denmark*
[o] *Department of Clinical Microbiology, Slagelse Hospital, Slagelse, Denmark*
[p] *Department of Clinical Microbiology, Odense University Hospital, Odense, Denmark*

A R T I C L E   I N F O

S U M M A R Y

Background: Multi-resistant bacteria (MRB) are an emerging problem. Early identification of patients colonized with MRB is mandatory to avoid in-hospital transmission and to target antibiotic treatment. Since most patients pass through specialized emergency departments (EDs), these departments are crucial in early identification. The Danish National Board of Health (DNBH) has developed exposure-based targeted screening tools to identify and isolate carriers of meticillin-resistant *Staphylococcus aureus* (MRSA) and carbapenemase-producing Enterobacteriaceae (CPE).
Aim: To assess the national screening tools for detection of MRSA and CPE carriage in a cohort of acute patients. The objectives were to investigate: (i) if the colonized patients were detected; and (ii) if the colonized patients were isolated.

* Corresponding author. Address: Emergency Department, Hospital Sønderjylland, Kresten Philipsensvej 15, 6200 Aabenraa, Denmark.
  E-mail address: Helene.Skjoet-Arkil@rsyd.dk (H. Skjøt-Arkil).

Multi-resistant bacteria
Isolation

Methods: This was a multi-centre cross-sectional survey of adults visiting EDs. The patients answered the DNBH questions, and swabs were taken from the nose, throat and rectum. The collected samples were examined for MRSA and CPE. Screening performances were calculated.

Findings: Of the 5117 included patients, 16 were colonized with MRSA and four were colonized with CPE. The MRSA screening tool had sensitivity of 50% [95% confidence interval (CI) 25—75%] for carrier detection and 25% (95% CI 7—52%) for carrier isolation. The CPE screening tool had sensitivity of 25% (95% CI 1—81%) and none of the CPE carriers were isolated.

Conclusion: The national screening tools were of limited use as the majority of MRSA and CPE carriers passed unidentified through the EDs, and many patients were isolated unnecessarily.

Introduction

Infections caused by multi-resistant bacteria (MRB) constitute a rapidly growing challenge in many parts of the world [1], including Denmark. Early identification of patients colonized with MRB is mandatory to avoid in-hospital transmission and to target antibiotic treatment to the individual patient.

As most patients admitted to hospitals in Denmark pass through emergency departments (EDs), these departments are crucial in early identification of patients colonized with MRB. The authors have recently found the prevalence of MRB-colonized patients in Danish EDs to be 5.2% [extended-spectrum beta-lactamase-producing bacteria (4.5%), meticillin-resistant *Staphylococcus aureus* (MRSA) (0.3%), carbapenemase-producing Enterobacteriaceae (CPE) (0.1%) and vancomycin-resistant enterococci (0.4%)] [2].

One of two strategies is currently recommended to detect patients with MRB on admission to hospital: (i) universal screening of all patients, which is simple but costly; or (ii) targeted, exposure-based screening (questions determine risk of colonization and need for screening), which is less expensive [3] but far more complex, and holds a greater risk of missing some MRB carriers [4]. Most experience has been obtained from MRSA screening programmes, but even for MRSA there is no clear consensus; for example, Scotland [4], Ireland [5] and Denmark [6] have found targeted screening to be cost-effective whilst parts of England have replaced targeted screening with universal screening [7].

In 2016, the Danish National Board of Health published the third edition of the guidelines for targeted screening for MRSA, which was based on a few questions regarding exposures and an individual risk assessment [6]. To date, only one single-site study has evaluated the effectiveness of this approach. It concluded that the screening algorithm only detected 18—27% of the MRSA-colonized patients and only isolated 9% [8]. Recently, a targeted-exposure-based screening for CPE has been implemented in Danish hospitals [9].

The aim of this study was to assess the exposure-based targeted screening tools for detection of MRSA and CPE carriage in a cohort of acute patients. The objectives were to investigate: (i) if colonized patients were detected; and (ii) if colonized patients were isolated.

Based on a single-site study evaluating MRSA screening [10], it was hypothesized that the screening tools would only detect a minority of colonized patients.

Methods

Study design

This study is part of a Danish national multi-centre study: the AntiBiotic Resistance in Emergency Departments (AB-RED) study. Detailed information is available in the published protocol [11]. The AB-RED study was designed as a descriptive and analytic cross-sectional survey of acute patients visiting Danish EDs.

This study was designed in accordance with the Standards for Reporting of Diagnostic Accuracy Studies guidelines [12].

Study setting

The project took place in EDs at four university hospitals (Odense University Hospital, Aarhus University Hospital, Aalborg University Hospital and Zealand University Hospital) and four regional hospitals (Slagelse Hospital, Hospital of Southern Jutland, Regional Hospital West Jutland and North Denmark Regional Hospital). These eight EDs represented four of the five Danish regions; the capital region did not participate in the study.

Participants, enrolment and procedure

Patients aged >18 years who presented to the EDs were invited to participate. Patients were excluded if they were unable to give informed consent (e.g. mental incompetence or language barrier), if they had been admitted >16 h before enrolment, or if swabs could not be obtained for anatomical or surgical reasons. Repeated inclusion of the same patient was accepted if related to a new acute admission.

According to the study protocol, only patients visiting an ED for ≥4 h were eligible for inclusion. Due to organizational differences in the EDs, it was impossible to maintain this criterion; as such, the study protocol was altered to include all visiting patients.

The enrolment process was handled by dedicated project staff, and the study took place between January and April 2018, mainly on weekdays. Patients who agreed to participate were interviewed and swabbed.

Interview

The interview was carried out by the project employees and was based on the screening tools from the Danish National Board of Health's guidance on preventing the spread of CPE [9] and MRSA [6].

In the MRSA guideline, risk assessment is based on three sets of criteria: (i) general risk factors (mandatory questions to all patients); (ii) special risk factors; and (iii) individual risk factors [6]. If a general and/or special risk factor is identified, the patient must be swabbed and tested for MRSA colonization. In addition, the patient must be isolated in certain predefined high-risk situations. Criteria for swab testing and isolation are listed in Table I.

The CPE guideline is very similar to the MRSA guideline, and consists of: (i) general risk factors; and (ii) special risk factors. If a risk factor is identified, the patient should be swabbed and tested for CPE colonization, and in special situations, the patient must be isolated. The criteria for swab testing and isolation are listed in Table I.

Deviations from the screening tools

Patients often found it difficult to recall previous colonization [8] or previous questioning [13], and the authors' clinical experience indicates that it is even more difficult for patients to recall and distinguish between different MRB. It was therefore decided to reword the questions marked with an asterisk (*) in Table I to include 'resistant bacteria' instead of MRSA and CPE; for example, the first question was modified to 'Have you previously been colonized with resistant bacteria?' The two questions regarding MRSA/CPE outbreak marked with ** in Table I were not included in the study, and neither was the question regarding dialysis and antineoplastic treatment in the CPE screening tool. The answer was only based on the interview and was not checked in the health records.

Collection of swabs and microbiological analysis

Immediately after the interview, patients were swabbed in the nose, throat and rectum. The collected samples were examined for MRSA and CPE at the Departments of Clinical Microbiology at Aalborg University Hospital, Aarhus University Hospital, Odense University Hospital and Slagelse Hospital. The same method of analysis was applied at all four departments. All analyses followed the procedure described in the protocol article without deviations [11].

Data management and analysis

A patient-level database was constructed to include laboratory test results and collected questionnaire data. Data analyses were conducted in STATA 14. The laboratory test results were the standard reference. Screening performance was calculated for five different MRSA screening models: ability to detect MRSA based on (i) general risk factors, (ii) special risk factors, (iii) individual risk factors, (iv) a combination of all risk factors, and (v) need for isolation. For CPE, screening measures were calculated for three different screening models: ability to detect CPE based on (i) general risk factors, (ii) special risk factors, and (iii) need for isolation. For all analyses, sensitivity, specificity, positive predictive value, negative predictive value, accuracy and likelihood of a positive and negative test were calculated. For all screening measures, 95% confidence intervals (CI) were calculated. Detailed information about sample size calculation is given elsewhere [11].

Ethical approval and consent to participate

The project was approved by the Regional Committees on Health Research Ethics for Southern Denmark (No. S-20170182), approved by the Danish Data Protection Agency (Journal No. 17/44444), and registered at clinicaltrials.gov (NCT03352167). Informed written consent was obtained from all participants before inclusion in the study. The patients had the right of revocation in which case the patient data would be deleted from the study.

Results

Of 5117 participants with a median age of 68 years (interquartile range 54–77 years) and an equal gender distribution, 16 patients (0.3%, 95% CI 0.2–0.5%) colonized with MRSA and four patients colonized with CPE (0.08%, 95% CI 0.0–0.2%) were identified. Further details are published elsewhere [2].

MRSA screening tool

The general risk factors identified 181 of 5117 patients where a MRSA swab test was required, but only five of the 16 colonized patients were identified, resulting in sensitivity of 31% (95% CI 11–59%) (Table II). Eleven of the 16 MRSA-colonized patients remained undetected. The special risk factors detected none of the MRSA-colonized patients. Both the individual risk factors and the combination of general risk factors, special risk factors and individual risk factors had sensitivity of 50% (95% CI 24–75). According to the defined isolation criteria, 133 patients should have been isolated. Among these were four of the 16 MRSA-colonized patients, resulting in a positive predictive value of 3% (95% CI 1–8). The remaining 129 patients (2.5% of all visits) would have been isolated without having MRSA. The likelihood ratios for a negative test were close to 1 for all five models, indicating a minimal association between the screening models and MRSA colonization.

CPE screening tool

According to the general risk factors, a CPE swab test was required in 163 of 5117 patients, but only one of the four colonized patients was identified, resulting in sensitivity of 25% (95% CI 1–81%) (Table III). The special risk factors did not detect any of the CPE-colonized patients. None of the four CPE-colonized patients would have been isolated according to the screening tool, while 75 patients (1.5% of all visits) would have been isolated due to incorrect suspicion of CPE.

Discussion

The MRSA screening tool identified 31% of the patients colonized with MRSA, and only 25% of the MRSA-colonized

Table I
Criteria for swab testing and isolation according to the meticillin-resistant *Staphylococcus aureus* (MRSA) and carbapenemase-producing Enterobacteriaceae (CPE) screening tools

Screening tool	Questions
MRSA	**Swab — general risk factors** Previously been colonized with MRSA?[a] Household contact with an MRSA-colonized person within last 6 months?[a] Stayed in a clinic/hospital outside the Nordic countries and stayed for >24 h or underwent invasive procedures during the stay? Weekly or more frequent contact with living pigs or household contact with a person with contact with living pigs? **Swab — special risk factors** Daily stay in hospital, nursing home or similar situation with MRSA outbreak?[b] Worked in hospital, nursing home or similar in foreign country? Daily stay in poor hygienic conditions (e.g. asylum centre, refugee camp, homeless shelter, disaster or war zone)? Daily contact with mink farm or lived with a person who had daily contact with mink farm? Daily contact with persons who have lived in a foreign country? Stayed in a foreign country and has signs of staphylococcus infection, especially if been to prison, shared sports equipment or had tattoos/piercings performed? **Swab — individual risk factors** Wounds, recurrent abscesses, chronic skin conditions, chronic respiratory infections, indwelling catheters or tubes, and intravenous drug abuse? **Isolation** Previously been colonized with MRSA and not declared MRSA-free? Stayed for >24 h in a clinic/hospital outside the Nordic countries within the last 7 days? Had weekly or more frequent contact with living pigs?
CPE	**Swab — general risk factors** Previously been colonized with CPE?[a] Household contact with a CPE-colonized person within last 6 months?[a] Stayed in a clinic/hospital outside the Nordic countries and stayed for >24 h or underwent invasive procedures during the stay? Stayed in a foreign country while receiving antibiotic treatment within the last 6 months? **Swab — special risk factors** Daily stay in hospital, nursing home or similar situation with CPE outbreak?[b] Daily stay in poor hygienic conditions (e.g. asylum centre, refugee camp, homeless shelter, disaster or war zone)? Been on dialysis treatment or received antineoplastic medical treatment?[b] **Isolation** Previously been colonized with CPE? Daily stay for >24 h in a clinic/hospital outside the Nordic countries within the last 7 days?

[a] The question was modified to included 'resistant bacteria' instead of either MRSA or CPE.
[b] This question was not included in the study.

patients were isolated. In addition, the majority of isolations (97%) were unnecessary.

The CPE screening tool identified one out of four CPE carriers, and none of the CPE carriers were isolated. Thus all isolations were unnecessary, while 75% of the colonized patients passed through the ED without being swab tested.

Despite revisions to the MRSA screening tool in 2016, sensitivity remained low in this multi-site study. However, the challenge might be that the prevalence of MRSA carriers in Denmark is so low that it is difficult to develop a robust algorithm and thus a screening tool with sufficient sensitivity and specificity. The screening tools by the Danish National Board of Health might have been developed under the assumption that resistance will increase over time, and it is possible that the tools would be more useful in a high-prevalence setting. It seems unlikely that the performance of the screening tool is negatively affected by the longstanding Danish policies for MRSA screening and carrier treatment, as MRSA prevalence has risen significantly in the last 10 years.

Isolation is costly and known to be associated with adverse effects and treatment complications, so it seems important, especially in a low-prevalence setting, to weigh the benefits related to the low number of correctly isolated patients against the unnecessary use of isolation [14—16].

Targeted, exposure-based screening is complex, requires trained staff, is estimated to take approximately 7 min per patient [8], might interfere with the handling of acutely ill patients, and appears to perform poorly in a low-prevalence setting. In addition, the screening tool might perform more poorly in a non-study setting, as staff compliance is likely to be associated with a number of different factors (e.g. integration and prioritization of screening in the admission

Table II
Evaluation of the meticillin-resistant *Staphylococcus aureus* screening tool to detect which patients should be swabbed and which should be isolated

	Swab — general risk factors	Swab — special risk factors	Swab — individual risk factors	Swab — general, special and individual risks	Isolation
Number of patients	181	150	1786	1964	133
True positive	5	0	8	8	4
True negative	4925	4951	3323	3145	4972
False positive	176	150	1778	1956	129
False negative	11	16	8	8	12
Screening values					
Sensitivity	31% (11—59)	0% (0—21)	50% (24—75)	50% (25—75)	25% (7—52)
Specificity	97% (96—97)	97% (97—98)	65% (63—67)	62% (60—63)	98% (97—98)
PPV	3% (1—6)	0 (0.0—2.4)	0.4% (0.2—0.9)	0.4% (0.2—0.8)	3% (1—8)
NPV	100% (100—100)	100% (100—100)	100% (100—100)	100% (100—100)	100% (100—100)
Accuracy	96% (96—97)	98% (96—97)	65% (64—66)	62% (60—63)	97% (97—98)
Likelihood ratios					
Positive test	9.1 (4.3—19.0)	0 (—)	1.4 (0.9—2.3)	1.3 (0.8—2.1)	9.9 (4.2—23.5)
Negative test	0.7 (0.5—1.0)	1.0 (1.0—1.0)	0.8 (0.5—1.3)	0.8 (0.5—1.3)	0.8 (0.6—1.0)

PPV, positive predictive value; NPV, negative predictive value. 95% confidence intervals are indicated in brackets.

process, monitoring/feedback, and local culture and beliefs) [17].

Hence it seems necessary to evaluate other strategies. It may well be possible to optimize the screening algorithm (e.g. by combining different MRB in the same algorithm), but nonetheless, it seems highly likely that performance will be related to the prevalence of MRB. Universal screening is another possibility, but will unavoidably rely on fast, costly point-of-care testing, and may therefore not be cost-effective in a low-prevalence setting [13].

The problems associated with unnecessary isolation may be minimized by selective use of fast point-of-care testing, but patients who remain undetected in the screening programme will still be an unknown, possible source of in-hospital transmission. It is possible, however, that a high general infection control standard is sufficient to hinder transmission. This is supported by observations from Denmark where exposure/risk-based screening was introduced by the health authorities in

2006. In spite of the fact that the number of new community-acquired MRSA cases has risen approximately 350% over the past 10 years (3579 cases in 2017), and despite the low screening sensitivity shown in this study, the number of hospital-acquired cases has remained low and almost constant (approximately 50 cases/year) [18]. A high general infection control standard is supported by other studies which favour a prevention approach, focusing on body washes with antiseptics, hand hygiene compliance and antibiotic stewardship, compared with a pathogenic-specific approach, based on screening, isolation and eradication [19].

Strength and limitations

The strength of this study is that it was the first multi-centre study to assess the performance of two national screening tools. However, the study also had some limitations. First, the patients were asked to recall previous colonization with

Table III
Evaluation of the carbapenemase-producing Enterobacteriaceae screening tool to detect which patients should be swabbed and which should be isolated

	Swab — general risk factors	Swab — special risk factors	Swab — general and special risks	Isolation
Number of patients	163	62	223	75
True positive	1	0	1	0
True negative	4951	5051	4891	5038
False positive	162	62	222	75
False negative	3	4	3	4
Screening values				
Sensitivity	25% (1—81)	0% (0—60)	25% (1—81)	0% (0—60)
Specificity	97% (96—97)	99% (98—99)	96% (95—96)	99% (98—99)
PPV	1% (0—3)	0% (0—6)	0% (0—2)	0% (0—5)
NPV	100% (100—100)	100% (100—100)	100% (100—100)	100% (100—100)
Accuracy	97% (96—97)	97% (96—97)	96% (95—96)	98% (98—99)
Likelihood ratios				
Positive test	7.9 (1.4—43.5)	0 (—)	7.9 (1.4—43.5)	0.0 (—)
Negative test	0.8 (0.4—1.4)	1.0 (1.0—1.0)	0.8 (0.4—1.4)	1.0 (1.0—1.0)

PPV, positive predictive value; NPV, negative predictive value. 95% confidence intervals are indicated in brackets.

resistant bacteria instead of previous colonization with MRSA or CPE. This change might have increased the number of false-positive results. Second, questions regarding MRSA/CPE outbreaks and dialysis/antineoplastic therapy were not included in the study. This deviation might have decreased the number of true- and false-positive patients in some of the screening models. Third, only 16 MRSA carriers and four CPE carriers were identified in the study, resulting in wide CIs. Fourth, some patients might have been unwilling to participate because they feared that they were colonized with MRB, and hence at risk of additional treatments, isolation and possibly stigmatization. Fifth, the questions were based on past events and required a certain level of recall ability for the acutely ill patient. This might increase the number of false-negative and -positive results. The last two limitations apply generally to risk-based screening.

In conclusion, the exposure-based targeted screening guidelines for MRSA and CPE carriage published by the Danish National Board of Health were of limited use as the majority of MRSA and CPE carriers passed unidentified through the EDs, and many patients were isolated unnecessarily.

Conflict of interest statement
None declared.

Funding sources
This work was supported by the Ministry of Health Denmark and Region of Southern Denmark.

References

[1] WHO. Antimicrobial resistance - Global report and surveillance. Geneva: World Health Organization; 2014.

[2] Skjot-Arkil H, Mogensen CB, Lassen AT, Johansen IS, Chen M, Petersen P, et al. Carrier prevalence and risk factors for colonisation of multiresistant bacteria in Danish emergency departments: a cross-sectional survey. BMJ Open 2019;9:e029000.

[3] Collins J, Raza M, Ford M, Hall L, Brydon S, Gould FK. Review of a three-year meticillin-resistant *Staphylococcus aureus* screening programme. J Hosp Infect 2011;78:81—5.

[4] Coia JE, Leanord AT, Reilly J. Screening for meticillin resistant *Staphylococcus aureus* (MRSA): who, when, and how? BMJ 2014;348:g1697.

[5] Creamer E, Galvin S, Dolan A, Sherlock O, Dimitrov BD, Fitzgerald-Hughes D, et al. Evaluation of screening risk and nonrisk patients for methicillin-resistant *Staphylococcus aureus* on admission in an acute care hospital. Am J Infect Control 2012;40:411—5.

[6] Sundhedsstyrelsen. Vejledning om forebyggelse af spredning af MRSA. Copenhagen: Sundhedsstyrelsen; 2016. Available at: https://www.sst.dk/-/media/Udgivelser/2016/Vejledning-om-forebyggelse-af-spredning-af-MRSA-3,-d-,-udgave.ashx?la=da&hash=EF2A0366E2F370E88C5DFE61A181B0A0EAE171AC [last accessed September 2019].

[7] Otter JA, Tosas-Auguet O, Herdman MT, Williams B, Tucker D, Edgeworth JD, et al. Implications of targeted versus universal admission screening for meticillin-resistant *Staphylococcus aureus* carriage in a London hospital. J Hosp Infect 2014;87:171—4.

[8] Mogensen CB, Kjaeldgaard P, Jensen C, Chen M. MRSA screening in emergency department detects a minority of MRSA carriers. Dan Med J 2015;62:A5151.

[9] Sundhedsstyrelsen. Vejledning om forebyggelse af spredning af CPO. Copenhagen: Sundhedsstyrelsen; 2018. Available at: https://www.sst.dk/-/media/Udgivelser/2018/CPO/Vejledning-om-forebyggelse-af-spredning-af-CPO.ashx?la=da&hash=060943943A71EA7E2AA6B51C229577B87E5937A3 [last accessed September 2019].

[10] Mogensen CB, Kjaeldgaard P, Jensen C, Chen M. Simplified screening in an emergency department detected methicillin-resistant *Staphylococcus aureus*. Dan Med J 2016;63:A5195.

[11] Mogensen CB, Skjot-Arkil H, Lassen AT, Johansen IS, Chen M, Petersen P, et al. Cross sectional study of multiresistant bacteria in Danish emergency departments: prevalence, patterns and risk factors for colonization (AB-RED project). BMC Emerg Med 2018;18:25.

[12] Cohen JF, Korevaar DA, Altman DG, Bruns DE, Gatsonis CA, Hooft L, et al. STARD 2015 guidelines for reporting diagnostic accuracy studies: explanation and elaboration. BMJ Open 2016;6:e012799.

[13] Wilson HJ, Khokhar F, Enoch DA, Brown NM, Ahluwalia J, Dougan G, et al. Point-prevalence survey of carbapenemase-producing Enterobacteriaceae and vancomycin-resistant enterococci in adult inpatients in a university teaching hospital in the UK. J Hosp Infect 2018;100:35—9.

[14] Lupion-Mendoza C, Antunez-Dominguez MJ, Gonzalez-Fernandez C, Romero-Brioso C, Rodriguez-Bano J. Effects of isolation on patients and staff. Am J Infect Control 2015;43:397—9.

[15] Abad C, Fearday A, Safdar N. Adverse effects of isolation in hospitalised patients: a systematic review. J Hosp Infect 2010;76:97—102.

[16] Wassenberg MW, Severs D, Bonten MJ. Psychological impact of short-term isolation measures in hospitalised patients. J Hosp Infect 2010;75:124—7.

[17] Currie K, King C, McAloney-Kocaman K, Roberts NJ, MacDonald J, Dickson A, et al. Barriers and enablers to meticillin-resistant *Staphylococcus aureus* admission screening in hospitals: a mixed-methods study. J Hosp Infect 2019;101:100—8.

[18] Bager FBV, Ellis-Iversen J, Hendriksen RS, Høg BB, Jensen LB, Jensen AN, et al. DANMAP 2018 — Use of antimicrobial agents and occurrence of antimicrobial resistance in bacteria from food animals, food and humans in Denmark. Copenhagen: Statens Serum Institut and National Food Institut; 2018. Available at: https://www.danmap.org/-/media/arkiv/projekt-sites/danmap/danmap-reports/danmap-2018/danmap_2018.pdf?la=en [last accessed September 2019].

[19] Lemmen SW, Lewalter K. Antibiotic stewardship and horizontal infection control are more effective than screening, isolation and eradication. Infection 2018;46:581—90.