Journal of Hospital Infection 102 (2019) 1–7

Available online at www.sciencedirect.com

Journal of Hospital Infection

journal homepage: www.elsevier.com/locate/jhin

Review

Can guidelines for the control of multi-drug-resistant Gram-negative organisms be put into practice? A national survey of guideline compliance and comparison of available guidelines

B.L. Lynch [a,b,*], K. Schaffer [b,c]

[a] Department of Clinical Microbiology, Mater Misericordiae University Hospital, Dublin 7, Ireland
[b] School of Medicine, University College Dublin, Dublin 4, Ireland
[c] Department of Clinical Microbiology, St Vincent's University Hospital, Dublin 4, Ireland

ARTICLE INFO

Article history:
Received 16 October 2018
Accepted 28 December 2018
Available online 5 January 2019

Keywords:
Multi-drug resistant Gram-negative organisms
Infection prevention and control

SUMMARY

Multi-drug-resistant Gram-negative organisms (MDRGNO) are an emerging global threat, reflected in the increasing incidence of infections in Ireland and elsewhere. The response to this threat has been the development of Infection Prevention and Control (IPC) guidelines. A survey of IPC teams in Ireland was undertaken to assess compliance with national guidelines. To place these survey results in context, IPC guidelines from the Irish Health Protection Surveillance Centre (HPSC) are compared with guidelines from Healthcare Infection Society (HIS), European Society of Clinical Microbiology and Infectious Diseases (ESCMID) and Centre for Disease Control (CDC). Thirty-three percent of hospitals responded across a range of hospital types. The results highlight the variability in implementation of guidelines across Ireland, as well as the variability between guidelines internationally. Respondents are less than 90% compliant with the majority of MDRGNO screening guidelines. Hospitals have variable access to isolation facilities with an average of 29% single rooms available (range 2.6–100%), resulting in some patients with MDRGNO not being isolated. Broad variability in application of guidance on personal protective equipment was demonstrated. This survey gives an insight into the real-life applicability of HPSC guidelines. Survey results are placed in context with a comparison of five MDRGNO IPC guidelines. Although core tenets of IPC are standard across guidelines, research into which practices are efficient in reducing MDRGNO transmission while being cost-effective would be worthwhile.

Introduction

Multi-drug-resistant Gram-negative organisms (MDRGNO) are an emerging global threat. In Ireland, as elsewhere, there is an increasing prevalence of MDRGNO infections [1]. The 'Guidelines for the Prevention and Control of Multi-drug resistant organisms excluding MRSA in the healthcare setting' were

* Corresponding author. Address: Department of Clinical Microbiology, Eccles Street, Mater Misericordiae University Hospital, Dublin 7, Ireland. Tel.: +353 1 803 4984.
E-mail address: bredalynch@mater.ie (B.L. Lynch).

https://doi.org/10.1016/j.jhin.2018.12.017
0195-6701/

developed by the Irish Health Protection Surveillance Centre (HPSC) in 2013 and updated in 2014 [2]. Compliance with HPSC guidelines by Irish acute hospitals was unknown. To ascertain current IPC practices as well as to identify barriers to the application of guidelines, a survey was distributed.

This paper presents the survey results as well as a review of IPC recommendations from other guidelines, to place IPC practices in Ireland in a broader context. Comparator guidelines were those from the Centre for Disease Control and Prevention (CDC) 'Management of Multidrug-Resistant Organisms In Healthcare Settings, 2006' [3] that address extended-spectrum beta-lactamase (ESBL) precautions, and the 'Guidance for Control of Carbapenem-resistant Enterobacteriaceae' 2015 update [4] as well as the 'Prevention and control of multidrug-resistant Gram-negative bacteria: recommendations from a Joint Working Party' 2016 Healthcare Infection Society (HIS) guideline [5] and the European Society of Clinical Microbiology and Infectious Diseases (ESCMID) 'Guidelines for the management of the infection control measures to reduce transmission of multidrug-resistant Gram-negative bacteria in hospitalized patients' [6].

MDRGNO is a broad term encompassing Enterobacterales as well as other Gram-negative bacteria, such as *Pseudomonas aeruginosa*, *Acinetobacter* spp. etc., resistant to multiple classes of antibiotics. Given the increasing incidence of carbapenemase-producing Enterobacterales (CPE) and ESBL-producing organisms, the focus of this survey has been on these.

The aims of this study were: (1) to determine compliance to HPSC guidelines in acute hospitals in Ireland; (2) to compare and contrast HPSC recommendations with other national and international guidelines: HIS (United Kingdom), CDC (USA) and ESCMID (Europe)

Methods

A survey was distributed nationally via the Irish Society of Clinical Microbiologists mailing list in January 2017, to IPC teams in hospitals across Ireland. This survey consisted of 38 questions (see Appendix A: Supplementary Data) on IPC practice in acute hospitals. Results were collated and analysed. A review of five IPC guidelines was undertaken including two CDC guidelines.

The CDC 2006 document contains guidance on ESBL, whereas the 2015 update pertains to CPE.

Results

Twenty-two hospital Consultant Clinical Microbiologists completed the survey (18 of 48 [37.5%] public hospitals and 4 of 21 [19%] private hospitals), representing overall 33% of hospitals in Ireland. Some data were incomplete. Of the 18 public hospitals, 6 were tertiary referral hospitals, 3 specialty hospitals (e.g. pediatric/maternity etc.) and the remaining 9 were district general hospitals.

Screening

Survey results

HPSC recommend eight patient groups are screened for MDRGNO (Table I). Of 22 survey respondents, low compliance (<90%) was reported to nearly all screening recommendations, except for CPE screening for epidemiologically linked patients and transfers from international hospitals. HPSC state that patients transferred from or with a history of admission to other Irish hospitals should be screened if there is an epidemiologically determined need, and 72.7% and 38.1% of respondents are compliant. Only 24% of hospitals (N=5) were screening patients for CPE when admitted from long-term care, which included two private hospitals. Four of 22 hospitals, two private and two specialist, were fully compliant with CPE screening, and three were fully compliant with ESBL screening. Compliance with ESBL screening was 28.5% on average, with nine hospitals (40.9%) across all sectors performing no ESBL screening.

Table I
Patient groups screened for carbapenemase-producing Enterobacterales (CPE) and extended-spectrum beta-lactamase (ESBL) carriage

Screening	Screening for CPE carriage	Screening for ESBL carriage
Epidemiologically linked[a]	95.2%	36.4%
Transfer from hospital nationally if epidemiologically determined need	72.7%	36.4%
Transfer from international hospital	100%	40.9%
History of admission in another hospital nationally if epidemiologically determined need	38.1%	14.3%
History of admission in another hospital internationally	76%	35%
High risk areas[b]	68.2%	40.9%
Long-term care facility	23.8%	18.2%
Personal history	71.4%	42.9%

[a] Epidemiologically linked is defined as patients linked to other cases of resistant Enterobacterales infection or carriage (e.g., sharing an inpatient area with a colonized or infected patient or transferred from a unit with a known resistant Enterobacterales outbreak).
[b] High risk: intensive care, high dependency, neonatal intensive care etc.

Regarding screening frequency, 73% screened patients on admission and weekly thereafter and the remainder on admission only. For identification of MDRGNO, 86% of laboratories checked susceptibility to ertapenem, 95% to meropenem and 55% to cefpodoxime. All surveyed hospitals had electronic systems for alerting if a patient has MDRGNO colonization/infection.

Guideline recommendations

Table II demonstrates similarities and differences between guidelines, focusing on multi-drug-resistant Enterobacterales only. Four of five guidelines recommend screening of epidemiologically linked patients when an MDRGNO is identified. HPSC define epidemiologically linked as patients linked to other cases of resistant Enterobacterales infection or carriage (e.g., sharing an inpatient area with a colonized or infected

Table II
Multi-drug-resistant Gram-negative organisms: comparison of recommendations across guidelines

Screening recommendations	HPSC	HIS	ESCMID	CDC 2015 (CPE)	CDC 2006 (ESBL)
Epidemiologically linked	Yes	Yes	Epidemiologically determined	Yes	Yes
Transfer from another hospital nationally	Epidemiologically determined	Epidemiologically determined	Epidemiologically determined	Discretionary	Epidemiologically determined
Transfer from another hospital internationally	Yes	Epidemiologically determined	Epidemiologically determined	Discretionary	Not explicit
Hx of admission in another hospital nationally	Epidemiologically determined	Epidemiologically determined	Epidemiologically determined	Discretionary	Epidemiologically determined
Hx of admission in another hospital internationally	Yes	Epidemiologically determined	Epidemiologically determined	Discretionary	Not explicit
High risk areas	Yes	Yes	Epidemiologically determined	Discretionary	Yes
Long-term care facility	Yes	Yes	Epidemiologically determined	Discretionary	Epidemiologically determined
Personal history	Yes	Yes	Epidemiologically determined	Discretionary	Yes
Laboratory screening methods and result reporting					
Laboratory screening methods	Detection of third-generation cephalosporin and carbapenem resistance required	Elevated meropenem MIC and cefpodoxime resistance	MacConkey agar with 1 mg/L imipenem supplementation, Selective ESBL media	Not explicit	Not explicit
Positive result notification	Not explicit	Within 6 h	Not explicit	4—6 h	Not explicit
Risk reporting	Yes	Not explicit	Not explicit	Not explicit	Not explicit
System identifying MDR colonized	Not explicit	Not explicit	Conditional recommendation	Recommended	Recommended
IPC precautions and patient placement					
Patient placement	Single room with *en suite*	Single room	Single room	Single room	Single room
Personal protective equipment	Long-sleeved gowns for patient contact	Long-sleeved gowns for patient contact	Gowns	Gowns	Gowns
Staff cohorting	Not explicit	Not explicit	Yes	Ideally	Consider
Cleaning					
Cleaning frequency	Increase frequency: attention to high-contact surfaces	Twice daily and four-hourly for high-contact surfaces	Consistent cleaning	Daily clean	Intensify and monitor
Dedicated equipment	Recommended	Not explicit	Recommended (epidemic settings)	Not explicit	Recommended

CDC, Centre for Disease Control; ESCMID, European Society of Clinical Microbiology and Infectious Diseases; ESBL, extended-spectrum beta-lactamase; HIS, Healthcare Infection Society; HPSC, Health Protection Surveillance Centre; Hx, history; IPC, Infection Prevention and Control; MDR, multi-drug-resistant; MIC, minimum inhibitory concentration.

patient or transferred from a unit with a known resistant Enterobacterales outbreak). ESCMID suggest that outside an epidemic setting, screening of epidemiologically linked patients is indicated if the isolate is from a clinical specimen or a point-prevalence study identifies further cases. HPSC, HIS and ESCMID recommend risk assessment (RA) incorporating the epidemiology of previous hospital admissions nationally or internationally to determine the need for screening.

HPSC guidance specifies the frequency of screening in 'high-risk areas' to be on admission and weekly thereafter and specify that screening should detect Enterobacterales resistant to third-generation cephalosporin and carbapenems. HIS advise that as a minimum, meropenem minimum inhibitory concentrations is used to detect CPE and cefpodoxime to detect ESBL (Table II). HPSC alone recommend that patients not isolated as per IPC team should be reported to risk management. Having a system in place to identify patients that are known MDRGNO colonized is recommended by CDC and suggested by ESCMID but not discussed by HPSC or HIS (Table II).

Infection Prevention and Control Precautions and patient placement

All guidelines acknowledge that standard Infection Prevention and Control Precautions (IPCP) should be applied to all patients, by all staff at all times. All strongly endorse additional contact precautions with an emphasis on hand hygiene for MDRGNO.

Survey results

HPSC recommend isolation in a single room with *en-suite* facilities for patients identified as colonized or infected with MDRGNO. In our survey, 100% of hospitals always recommended isolation of those with CPE and 40.9% always recommended isolation for ESBL. Sixty-eight percent of hospitals prioritized CPE carriage/infection for single-room isolation (either with *en suite* or dedicated commode) ahead of other organisms such as ESBL/*Clostridium difficile*.

As seen in Table III, of those identified with CPE, 86.4% of respondents recommended isolation of patients in a single room with *en-suite* facilities; the remainder were using single rooms with a commode. The majority (81.8%, *N*=18) reported achieving single-room isolation with *en-suite* facilities 100% of the time for CPE. Further breakdown demonstrates that this was all respondents from four private hospitals, seven of nine district hospitals, five of six tertiary referral hospitals and two of three specialist hospitals. Three of the remaining four respondents reported only achieving single-room isolation 76–100% of the time, and one 51–75% of the time. No respondent reported cohorting patients identified as carrying CPE.

For patients identified with ESBL colonization/infection, 40.9% (*N*=9) of survey respondents recommended isolation and 9.1% (*N*=2) did not. Of those recommending isolation, the majority recommended isolating in a single room, with or without *en-suite* facilities, and 15% recommended cohorting (Table III). Of the 11 survey respondents who reported recommending single-room isolation for ESBL when available or sometimes, one reported achieving this 75–100% of the time, six between 50 and 74% of the time, two between 25 and 49% and one between 1 and 24%; data were not available on one. The six hospitals with the lowest availability of single rooms (10% or less) had a range of approaches to ESBL, with two always achieving single-room isolation (one of which was fully compliant with ESBL screening guidelines), one never recommending single-room isolation and the remaining three reporting achieving single-room isolation for those with ESBL 50–74% of the time.

Table III
Survey results for Infection Prevention and Control Precautions (IPCP)

IPCP		CPE	ESBL
Patient placement	Is single room isolation recommended?	100%	40.9%
	Yes	100%	40.9%
	If yes:		
	Single room with *en suite*	86.4%	40%[a]
	Single room	13.6%	45%
	Cohort	0%	15%[b]
	Sometimes/when available	0%	50%
	No	0%	9.1%
Personal protective equipment	Recommend contact precautions	100%	85%
	If yes:		
	Long-sleeved gowns	50%	5.5%
	Long-sleeved gowns for patient contact otherwise aprons	40.9%	39.5%
	Aprons	9.1%	55%

CPE, carbapenemase-producing Enterobacterales; ESBL, extended-spectrum beta-lactamase.
[a] Where available.
[b] If required.

RA for prioritization for single-room isolation was addressed in the survey with 50% of respondents relying on RA for management of ESBL. If survey respondents answered 'when available or sometimes' when asked if they recommend isolation for ESBL, they were asked to identify what factors are considered. Of those 11 respondents, five considered both the organism (e.g., *Klebsiella pneumoniae* v *Escherichia coli)* and the clinical scenario (e.g., if patient has diarrhoea with an ESBL-producing isolate detected from rectal swab), one each considered the organism alone, the clinical scenario alone or the susceptibility of the organism. Two respondents considered a triad of room availability, the organism and the clinical scenario and one considered the specialty of ward. Some respondents preferentially isolated patients with ESBL-producing *Klebsiella* spp. ahead of ESBL-producing *E. coli*. Only 18% of all survey respondents took into consideration whether MDRGNO represented colonization or infection when determining isolation requirements. Over half (53%) of respondents reported patients that were not appropriately isolated to risk management.

Respondents were requested to rank organisms in highest priority for single room isolation: 66% ranked CPE highest priority, 20% *C. difficile*, 10% carbapenem-resistant Enterobacterales (non-carbapenemase producing) and 5% multi-drug-resistant *Acinetobacter* spp./*Pseudomonas* spp. In general, the majority ranked in the following order for priority: CPE, *C. difficile*, carbapenem-resistant Enterobacterales (non-carbapenemase producing), multi-drug-resistant *K. pneumoniae* with

ciprofloxacin and gentamicin resistance, multi-drug-resistant *Acinetobacter* spp./*Pseudomonas* spp., and then tied for either vancomycin-resistant enterococci or methicillin-resistant *Staphylococcus aureus* as lowest priority.

The survey addressed the availability of single rooms. Of 22 respondents, data were not available on five. Of the remaining 17 respondents, an average of 29% of available beds were in isolation, with a range of 2.6–100%. The average available isolation facilities in the private hospital (N=3) were 51.3% (range 15.6–100%), in the district general hospitals (N=6) were 18.8% (range 2.6–66%) and in tertiary referral centers (N=6) were 16.1% (range 8.8–30%). Of the specialty hospital respondents, 6.6% and 9.6% of beds were available as isolation.

Through the survey, one hospital reported a ward where 32 patients share one toilet. 'Nightingale' wards still existed, where up to 16 inpatients were in one room with one shared toilet. One question addressed whether those surveyed would prefer access to more isolation facilities and/or more resources for screening and 70% requested both.

With regard to personal protective equipment (PPE), HPSC recommend gowns 'for patient contact' but allows for aprons if patient contact is not anticipated. Survey respondents demonstrated large variability in application of this guidance (Table III). Whereas 100% of respondents recommended contact precautions for CPE, 9.1% of hospitals recommended aprons, 50% gowns, and the remaining 40.9% recommended gowns for anticipated patient contact, but otherwise aprons. For patients with ESBL, 85% recommended contact precautions, and of those, 55% recommended aprons, 5.5% recommended gowns, and the remainder used gowns for anticipated patient contact only.

Guideline recommendations

HPSC specifies a requirement for single rooms to have *ensuite* bathroom facilities while other guidelines don't comment (Table II). With regard to personal protective equipment (PPE), although there is variability in the terminology, all guidelines recommend gowns with HPSC and HIS specifying the use of gowns "for patient contact" and allow for aprons outside these situations. ESCMID recommend staff cohorting, CDC suggest it as an ideal but neither the HPSC nor HIS guidelines comment.

Cleaning

Survey results

Approximately half (48%) of those surveyed had access to hydrogen-peroxide vapour for adjunctive environmental cleaning. The majority (77%) of respondents increased the frequency of hand hygiene audits on wards with CPE cases. A majority (61.9%) also reported daily cleaning of high-contact surfaces, twice daily by 28.5% and more frequently in 9.6%.

Guideline recommendations

Hydrogen peroxide is mentioned by HPSC and HIS as an adjunctive measure for cleaning if there is evidence of failure of elimination of an environmental reservoir. Approaches to cleaning recommendations are variable across guidelines (Table II).

Discussion

MDRGNO are recognized as an emerging global threat [7]. Surveillance data demonstrates that markers for ESBL in *K. pneumoniae*, as well as CPE, are increasing in frequency [8]. Prudent antimicrobial usage and adherence to IPC measures are encouraged to curb these increases. In Ireland, a mandatory enhanced surveillance scheme for carbapenemase-producing Enterobacterales (CPE) has been in place since 2017, and of 39 laboratories nationwide, 32 have reported CPE. Although the majority of isolates are from screens, the healthcare burden and propensity for increasing patient morbidity and mortality are large.

To date, the approach nationally and internationally to control for the emergence and spread of MDRGNO has been through IPC guidelines. The authors undertook a survey of a range of acute hospitals across Ireland to assess compliance with national guidelines. Although only 33% of hospitals responded to the survey, we believe that the results are broadly indicative of IPC practices in Ireland. However, given that there was a proportionally higher response rate from public hospitals, there is a chance the results are more indicative of public than private hospital practice.

To place these survey results in context, we assessed against other guidelines from HIS, ESCMID and CDC. CDC guidelines in 2006 addressed ESBL-producing Enterobacteriaceae and those from 2015 addressed CPE; therefore, the relevant sections from both are used. Although all five guidelines are broadly similar, differences do exist. The variability is highlighted in the comparison shown in Table II. It is worth noting that both HIS and ESCMID guidelines [5,6] include the evidence and grading for their recommendations, where others have not. That limited evidence exists for many IPC practices is routinely acknowledged [8,9] and further research in the area is required.

Screening

The purpose of screening is the 'detection of outbreaks of resistant colonizing or infecting organisms with minimum delay' [5] and identifies patients colonized with MDRGNO who require isolation to prevent outbreaks. Comprehensive screening guidelines exist in Ireland, although compliance, as assessed by this survey, is sub-optimal. In CPE screening, only two of eight identified patient groups were being screened by over 90% of hospitals surveyed. This survey has demonstrated that 40.9% (N=9) of hospitals in all sectors were not undertaking any ESBL screening. The lower compliance of ESBL screening suggests that IPC teams are focusing limited resources on CPE ahead of ESBL. It could be argued that the survey did not interrogate or consider the epidemiology of MDRGNO in each respondent's area. If levels of ESBL carriage had reached endemicity then forgoing screening in these groups may be a sensible use of resources.

As advocated for in HPSC, a RA should be performed for patients transferred from or with a history of admission to another Irish hospital, and those coming from an area with cases/outbreaks of CPE or ESBL should be screened. As reflected in the low compliance (72.7% of hospitals risk assess direct transfers and 38.1% those with a history of admission elsewhere), this is a labour-intensive undertaking. Furthermore, the epidemiology of MDRGNO in Ireland and worldwide is changing rapidly and this RA requires significant input from an IPC practitioner. This survey was circulated in 2017 before the National Health Care Associated Infection and Antimicrobial Resistance team introduced a new CPE-specific screening

policy which replaces the need for RA by advocating for the screening of all transfers [11]. As these guidelines were published in 2018 following completion of this survey, these were not addressed.

IPCP and patient placement

Variability in IPCP and patient placement was demonstrated in this survey. While the majority of locations were recommending single-room isolation of CPE, with 100% compliance, only a proportion (81.2%) achieved this on every occasion. The wide range of available isolation facilities (2.6–100%) has been highlighted in this survey, with an average of 29% per hospital. The average available isolation facilities in the private sector were 51.3%, far higher than in district general hospitals (18.8%) and tertiary referral (16.1%). This lack of single-room isolation probably impacts on the ability of IPC practitioners to recommend isolation for patients with MDRGNO. With 68% of survey respondents prioritizing CPE ahead of other organisms such as *C. difficile*, this carries a risk of further healthcare-associated infections.

Given the paucity of single rooms, and the increasing frequency of MDRGNO, it will become increasingly more difficult to appropriately isolate. At present, less than half of respondents (40.9%) recommend isolation for ESBL routinely, with a half (50%) performing a complex RA to determine if required. A multitude of factors such as the organism, clinical scenario, etc., are considered, a process which is time consuming. This RA is advocated by HPSC guidelines and mentioned in HIS such as when a higher isolation priority on patients with ESBL-producing *Klebsiella* spp. is placed ahead of ESBL-producing *E. coli* [5].

Our survey has not only highlighted the lack of single-room isolation facilities, but has provided a snapshot of what hospital facilities are available. It has highlighted through the reporting of Nightingale wards and paucity of isolation facilities, that many locations are vulnerable to an MDRGNO outbreak, and in 2017, this was evidenced in the 13 CPE outbreaks reported nationwide [12].

Variability in use of types of PPE recommendations between hospitals and within hospitals for different organisms was evident from this survey. HPSC recommend gowns for anticipated patient contact, stating that aprons are sufficient otherwise. Fifty percent of hospitals recommend gowns on all occasions for CPE and 5.5% for ESBL. The wearing of gowns vs aprons is not likely to have a large cost impact, but may be difficult to implement for other reasons, such as staffing preference and comfort [13]. The inter-hospital variability of use of PPE, as well as within-hospital variability depending on organism or if patient contact is anticipated may lead to confusion. Although there is no robust evidence for the use of gowns vs aprons, there are papers demonstrating contamination of gowns with MDRGNO following patient contact. In a paper by Morgan *et al.* in 2012, 12.6% of gowns swabbed along forearms and waistline were culture positive for multi-drug-resistant *Acinetobacter baumannii* [14].

The most striking outcome of the survey was the question asking whether more isolation facilities or more screening resources were required to aid IPC teams and 70% of survey respondents required both. This highlights what is apparent throughout collating the survey data, that compliance with HPSC guidelines was regarded as ideal but unattainable with current infrastructure and finances.

Next steps

CPE was declared a public health emergency by the Irish Government in 2017 and legislative support and financing of IPC guidelines is anticipated. Resources are an important element for successful implementation [13]. Legislative support might ensure budgets are not solely diverted to direct patient care ahead of infection prevention. Staffing levels and structural resources such as single rooms with *en-suite* facilities should be viewed as critical IPC resources and financed at a national level.

It is irrefutable that managing an outbreak of a MDRGNO in an acute healthcare setting is costly from a patient safety perspective as well as financially. Otter *et al.* stated the cost of a CPE outbreak in the United Kingdom was €1.1 million over 10 months, with an additional €153,000 spent on estates renovations [15]. The evidence for many IPC practices is not robust, and individual practices are difficult to separate according to effectiveness [10,16]. Therefore, in an era of financial constraints, there is a need for economic evaluation of IPC practice recommendations [8].

This survey gives an insight into the variability in application of HPSC guidelines in Ireland, which we feel is secondary to a lack of resources. As there is both national and international evidence of increasing incidence of MDRGNO, investment into sound IPC practices would probably be cost-saving in the longer term.

A comparison of HPSC guidelines with those from HIS, ECDC and CDC, place survey results in a broader context. Although the core tenets of IPC are standard across guidelines, research into which practices are efficient in reducing MDRGNO transmission as well as cost-effective would be worthwhile.

Acknowledgements

The authors wish to acknowledge all survey participants, as well as the ongoing work of the Health Protection Surveillance Centre in the production of their reports.

Conflict of interest statement
The authors have no conflicts of interest to declare.

Funding sources
None

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jhin.2018.12.017.

References

[1] Health Protection Surveillance Centre. Carbapenemase-producing carbapenem-resistant Enterobacteriaceae (CRE) in Ireland. 2017. p. Q1.
[2] Health Protection Surveillance Centre. Updated guidelines on screening for carriage of resistant Enterobacteriaceae in Ireland. 2014. p. 1–5.

[3] Siegel JD, Rhinehart E, Jackson M, Chiarello L. Management of multidrug-resistant organisms in healthcare settings. 2006.
[4] Centers for Disease Control and Prevention. Facility guidance for control of carbapenem-resistant Enterobacteriaceae (CRE) November 2015 update - CRE Toolkit. 2015.
[5] Wilson APR, Livermore DM, Otter JA, Warren RE, Jenks P, Enoch DA, et al. Prevention and control of multi-drug-resistant Gram-negative bacteria: recommendations from a Joint Working Party. J Hosp Infect 2016;92:S1–44.
[6] Tacconelli E, Cataldo MA, Dancer SJ, De Angelis G, Falcone M, Frank U, et al. ESCMID guidelines for the management of the infection control measures to reduce transmission of multidrug-resistant Gram-negative bacteria in hospitalized patients. 2013.
[7] World Health Organization. Global action plan on antimicrobial resistance. 2015.
[8] European Centre for Disease Prevention and Control (ECDC). Economic evaluations of interventions to prevent healthcare-associated infections. 2017.
[9] Forland F, Kleinkauf N, Monnet DL, Todd Weber J, Giesecke J, Coulombier D, et al. Risk assessment on the spread of carbapenemase-producing Enterobacteriaceae (CPE) through patient transfer between healthcare facilities, with special emphasis on cross-border transfer. 2011. https://doi.org/10.2900/59034.
[10] Otter JA, Mutters NT, Tacconelli E, Gikas A, Holmes AH. Controversies in guidelines for the control of multidrug-resistant Gram-negative bacteria in EU countries. Clin Microbiol Infect 2015;21:1057–66.
[11] Healthcare Associated Infection and Antimicrobial Resistance Team. Requirements for screening of patients for carbapenemase-producing Enterobacteriaceae (CPE) in the acute hospital sector. 2018.
[12] Health Protection Surveillance Centre. Carbapenemase producing Enterobacterales (CPE) in Ireland: 2017. 2018.
[13] Honda H, Iwata K. Personal protective equipment and improving compliance among healthcare workers in high-risk settings. Curr Opin Infect Dis 2016;29:400–6.
[14] Morgan DJ, Rogawski E, Thom KA, Johnson JK, Perencevich EN, Shardell M, et al. Transfer of multidrug-resistant bacteria to healthcare workers' gloves and gowns after patient contact increases with environmental contamination. Crit Care Med 2012;40:1045–51.
[15] Otter JA, Burgess P, Davies F, Mookerjee S, Singleton J, Gilchrist M, et al. Counting the cost of an outbreak of carbapenemase-producing Enterobacteriaceae: an economic evaluation from a hospital perspective. Clin Microbiol Infect 2017;23:188–96.
[16] European Centre for Disease Prevention and Control (ECDC). Systematic review of the effectiveness of infection control measures to prevent the transmission of carbapenemase-producing Enterobacteriaceae through cross-border transfer of patients. 2014.