Health Information and Quality Authority

An tÚdarás Um Fhaisnéis agus Cáilíocht Sláinte

Report of the review of antimicrobial stewardship in public acute hospitals

July 2016

About the Health Information and Quality Authority

The Health Information and Quality Authority (HIQA) is an independent authority established to drive high-quality and safe care for people using our health and social care services in Ireland. HIQA's role is to develop standards, inspect and review health and social care services and support informed decisions on how services are delivered. HIQA's ultimate aim is to safeguard people using services and improve the safety and quality of health and social care services across its full range of functions.

HIQA's mandate to date extends across a specified range of public, private and voluntary sector services. Reporting to the Minister for Health and the Minister for Children and Youth Affairs, HIQA has statutory responsibility for:

- **Setting Standards for Health and Social Services —** Developing person-centred standards, based on evidence and best international practice, for health and social care services in Ireland.
- **Regulation —** Registering and inspecting designated centres.
- **Monitoring Children's Services —** Monitoring and inspecting children's social services.
- **Monitoring Healthcare Safety and Quality —** Monitoring the safety and quality of health services and investigating as necessary serious concerns about the health and welfare of people who use these services.
- **Health Technology Assessment —** Providing advice that enables the best outcome for people who use our health service and the best use of resources by evaluating the clinical effectiveness and cost-effectiveness of drugs, equipment, diagnostic techniques and health promotion and protection activities.
- **Health Information —** Advising on the efficient and secure collection and sharing of health information, setting standards, evaluating information resources and publishing information about the delivery and performance of Ireland's health and social care services.

Note on terms and abbreviations used in this report

A full range of terms and abbreviations used in this review is contained in a glossary at the end of this report

Our mission

The mission of the Health Information and Quality Authority (HIQA) is derived from the statutory functions described in the Health Act 2007 and can be summarized as:

'Drive high quality and safe care for people using our health and social services.'

Our values

- Putting people first — we will put the needs and the voices of service users, and those providing them, at the centre of all of our work.
- Fair and objective — we will be fair and objective in our dealings with people and organizations, and undertake our work without fear or favour.
- Open and accountable — we will share information about the nature and outcomes of our work, and accept full responsibility for our actions.
- Excellence and innovation — we will strive for excellence in our work, and seek continuous improvement through self-evaluation and innovation.
- Working together — we will engage with people providing and people using the services in developing all aspects of our work.

Find out more on the Authority's website: www.hiqa.ie.

Table of contents

Executive summary

Antimicrobial resistance — a major and growing threat

The ability to treat infection with antimicrobial agents represented one of the major technological triumphs of the 20th century. Millions of lives have been saved or improved globally since the discovery of penicillin, and other antimicrobial agents. However, resistance to antimicrobials has begun to outpace the discovery of new antimicrobial medicines, with highly resistant — and indeed untreatable — infection beginning to emerge in some parts of the world.[1;2] In the short to medium term, this situation is likely to get worse, and the World Health Organization has declared this to be a 'major global threat' to healthcare.[3]

Resistance to antimicrobials represents one of the major global challenges of the 21st century. A recent report commissioned by the UK government has estimated that if left unchecked, this problem could conservatively account for in excess of 10 million global deaths annually by 2050, more than cancer and diabetes combined.[4] This HIQA review report sets out how these and other related risks are being managed in Ireland's public acute hospital system.

What can be done to address this problem?

Even with careful use, the emergence of antimicrobial resistance will occur. Bacteria and other infecting pathogens can evolve quickly to overcome newly introduced antimicrobial agents. As a result, there is a need to continually invest in this area to ensure a steady pipeline of new antimicrobials, which may be used where resistance to existing treatment options emerges. In addition, healthcare systems also need to try to prevent the emergence and spread of multidrug resistant organisms. This may be achieved through good infection prevention and control practices, and by ensuring prudent and effective usage of currently effective antimicrobial agents through what is known as antimicrobial stewardship.

What is antimicrobial stewardship?

The term antimicrobial stewardship describes a set of coordinated measures which aim to improve the quality of usage of antimicrobials, with the goals of:

- improving patient-health outcomes
- reducing adverse effects
- reducing the emergence of resistance
- and reducing healthcare costs.[5]

In short, antimicrobial stewardship programmes aim to ensure that every patient receives the right antimicrobial therapy at the right dose, route and duration, and for the right infection type at the right time. In addition, it also intends to ensure that therapy is continually reviewed, refined and discontinued where the patient's condition allows. Evidence continues to emerge which suggests that, in addition to other quality and safety benefits for patients, effective antimicrobial stewardship programmes can also save money for implementing hospitals.[6]

In Ireland, in 2009, the Health Information and Quality Authority (HIQA) published the *National Standards for the Prevention and Control of Healthcare Associated Infection* [7] (referred to in this report as the Infection Prevention and Control Standards), to promote improved practice in the areas of infection prevention and control, and in the best usage of antimicrobial agents through antimicrobial stewardship.

All publically-funded healthcare providers are expected to implement these Standards. In recent years, HIQA has undertaken a rolling programme of inspections against these Standards to promote improvement in infection prevention and control practices across these acute hospitals.

This review of antimicrobial stewardship in public acute hospitals aims to reinforce HIQA's inspections by examining how these hospitals ensure best practice in antimicrobial stewardship.

Review methodology

This review began in June 2015, and at its outset the 49 public acute hospitals in Ireland were required to complete and return a self-assessment questionnaire to HIQA about antimicrobial stewardship in their hospitals (see Appendices 1 and 2). This tool was developed by HIQA, with the assistance of an external advisory group. HIQA later carried out announced inspections in 14 of these hospitals. This pilot sample included hospitals that had well-advanced antimicrobial stewardship programmes, alongside those with less well-developed programmes. Hospitals from all seven hospital groups were inspected, including paediatric and maternity hospitals, in order to gain a national perspective of the current arrangements in place across the acute healthcare sector.

In addition, HIQA examined the overall national approach to managing antimicrobial stewardship in public acute hospitals. This report provides an overview of the national provision of antimicrobial stewardship in Irish public acute hospitals.

Summary of key findings

- Progress has been made, particularly in the major academic teaching hospitals in implementing antimicrobial stewardship programmes, in response to investment. However, at the time of this review, several general hospitals, defined as Model 3 hospitals, require further investment and or the sharing of resources across their respective hospital groups to effectively implement these programmes.

- A number of smaller local hospitals, defined as Model 2 hospitals, had no antimicrobial stewardship programme in place. These hospitals had not received specialized resources to support setting up such programmes.

- At the start of this review, the national structures to support antimicrobial stewardship and infection prevention and control within the Health Services Executive (HSE) lacked coordination. However, in early 2016, the HSE identified a named person responsible for coordinating and managing its national antimicrobial stewardship programme.

- The Irish Government has commenced planning a new national action plan in relation to the threat of antimicrobial resistance, in line with Council of the EU requirements.[8] This action plan is to be ready by mid-2017.

- Provision for antimicrobial stewardship and infection prevention and control in non-acute settings needs to be both significantly enhanced and integrated within existing services. The HSE organizational structure includes seven hospital groups, nine HSE community health organizations, and eight public health departments in the country. Not all of their catchment areas are geographically aligned. Therefore, the potential for seamless coordination across each area of responsibility for infection prevention and control and antimicrobial stewardship may be additionally complicated.

- HIQA found a progressive approach to monitoring antimicrobial consumption in Irish hospitals. The HSE has established good systems for recording and benchmarking antimicrobial prescribing, and for recording and comparing antimicrobial resistance rates for serious infections with other European countries.

- The review found most hospital information and communication technology (ICT) systems dealing with infection operated independently of each other. There is greater potential for ICT to further support antimicrobial stewardship and infection prevention and control.

- HIQA has identified a relative lack of screening for multidrug resistant organisms in hospitals compared to the level recommended in national guidelines.[56] As a consequence, it is likely that the true incidence of multidrug resistant organism colonization among hospitalized patients in Ireland may be underestimated.
- Ireland has the highest proportion of vancomycin-resistant *Enterococci* (VRE) causing bloodstream infection observed anywhere in Europe.

Leadership, governance and management of infection prevention and control and antimicrobial stewardship

In conducting this review, it became increasingly evident to HIQA that performance in the linked areas of antimicrobial stewardship and infection prevention and control are significantly hampered by the lack of an up-to-date national plan to inform progress in both the health sector and other related areas, to effectively address what is recognized to be a key strategic risk for the country.

More recently, the Irish Government has commenced planning a national action plan to address antimicrobial resistance. This initiative, which has been spearheaded by the Council of the EU under the Dutch Presidency,[8] requires all member states to formulate a national action plan in this area by mid-2017. Council of the EU requirements state that this plan should adopt a 'one-health' approach. This means that all of the players involved in the antimicrobial usage and development process, including healthcare, agricultural and veterinary stakeholders, are required to come together to contribute to the formulation and implementation of a national plan in this area. It is important that as part of this process, the strategic requirements in this area within the health and social care sectors are considered and included in the action plan, and that the findings and recommendations contained within this report be acted on.

At an individual hospital level, this review identified that many Irish hospitals have performed very well in implementing antimicrobial stewardship and infection prevention and control best practice. However, there is a need for nationally coordinated mechanisms to be put in place to provide more effective support to those hospitals that perform less well, or indeed find themselves having to deal with specific resistance problems which are beyond their individual capacity to deal with in isolation.

Allied to this, the review found that there is a need to improve structures to manage the risk of antimicrobial resistance across care settings. Existing structures and resources have been predominately directed towards public acute hospitals, whereas antimicrobial resistance issues increasingly span across acute hospital, residential care and community settings.

HIQA identified a number of contributory groups and bodies within and outside of the HSE that are involved in trying to improve the national approach to these two challenges. A notable area of success as a consequence of the work that these groups have engaged in has been the development of initiatives to define and articulate best practice.

However, these groups provide advice and support only, and do not have responsibility and authority to ensure their recommendations are acted on. They also do not have a defined remit to actively intervene locally to help manage infection prevention and control and antimicrobial stewardship. There is also no formal pathway for escalating and managing risk through these groups, which is a significant concern.

Greater clarity in relation to who is ultimately in charge of antimicrobial stewardship and infection prevention and control within the HSE emerged during the review. These clarified arrangements for national leadership, governance and management in this area should be clearly communicated to all those involved in working at the front line in this field.

Gram-negative bacteria most commonly cause urinary tract infection, abdominal and bloodstream infections and pneumonia, while they are regularly identified as the causative bacteria in cases of life-threatening sepsis. This review also found that the response by the HSE nationally to managing the Gram-negative threat, and ongoing problems with vancomycin-resistant *Enterococci* (VRE), would indicate that its governance arrangements around mobilizing a sufficient nationally coordinated response to such risks has been insufficient.

In particular, examination of the recent national HSE approach to managing emerging Gram-negative resistance has identified significant scope for improvement. As part of this review, HIQA looked at the HSE management of two outbreaks in Ireland involving newly emergent antimicrobial resistance infections. HIQA considered a national outbreak of the Gram-negative extended-spectrum beta-lactamase (ESBL) producing *Klebsiella pneumoniae*.

HIQA also examined the national measures taken to support health services in the Mid-West Region, including University Hospital Limerick, in dealing with an increased incidence of Gram-negative carbapenemase producing Enterobacteriacea (CPE). Significant scope for improved coordination and performance by the national HSE in managing both of these outbreaks was identified. Evaluation of the learning from the way these problems continued to be managed at the time of the review revealed a need for improved national HSE governance in this area, with better surveillance systems and a more effective risk management approach needed.

Recent governance changes within the HSE in this area may address these concerns, although it was too early to evaluate these changes at the time of this review. Crucially, it is of critical importance that the HSE accompany these new arrangements with a clear

associated operational plan which includes all relevant care settings, to inform future practice.

Antimicrobial stewardship workforce

There has been extensive investment across the Irish health service in appointing specialized staff to implement antimicrobial stewardship and infection prevention and control in public acute hospitals in Ireland since 2001. There was clear evidence that where appropriate resources have been provided, progress in implementing antimicrobial stewardship programmes has generally advanced. However, while progress has been made, some public acute hospitals and particularly general hospitals (Model 3 hospitals) did not collectively have the recommended number of specialized staff needed to fully comply with national standards and guidelines at the time of this review.

It is of significant concern to HIQA that in addition, a small number of hospitals do not have any dedicated specialized staff at all. Other hospitals have struggled to recruit and retain specialist staff, in particular, consultant microbiologists. Limited clinical pharmacy services were also identified in some hospitals during this review, thereby hindering the effectiveness of antimicrobial stewardship and the wider hospital approach to medication safety.

The HSE organizational structure includes seven hospital groups, nine HSE community health organizations, and eight public health departments in the country. However, not all of their catchment areas are geographically aligned. Therefore, the potential for seamless coordination across each area of responsibility for infection prevention and control and antimicrobial stewardship may be additionally complicated.

Nonetheless, good professional networks have formed within relevant staff disciplines working across hospitals. However, there is further scope for greater multidisciplinary collaboration at national and hospital-group level among specialized staff working in this area. Moreover, while out of the direct scope of this review, it became evident during the review process that resource allocation to acute hospitals has not been matched with equivalent resources in non-acute settings. This relative mismatch should inform future workforce planning.

Nationally established antimicrobial stewardship support systems

HIQA found the approach taken to determine performance in relation to the measurement of antimicrobial consumption in Irish hospitals has been progressive. The HSE has established good systems for recording and benchmarking antimicrobial prescribing, and for recording and comparing antimicrobial resistance rates for serious infections with other European countries. However, there is scope for improved awareness at HSE national level about locally emerging antimicrobial resistance problems.

The review found systems to ensure better visibility at a national HSE level of emergent resistance — which does not result in invasive infection (for example in otherwise healthy persons who are colonized with a multidrug resistant organism but not infected, or those who are infected with such an organism in sites other than their bloodstream or cerebrospinal fluid) — were uncoordinated and under-developed. This meant an issue could arise locally without being detected nationally, and therefore confronted in a timely fashion.

There is also greater potential for information and communication technology (ICT) to further support antimicrobial stewardship and infection prevention and control. The review found most hospital ICT systems dealing with infection operated independently of each other. The current and future development of information and communication technology in these areas should be included strategic plans generated following this review.

Meanwhile, outpatient parenteral antimicrobial therapy (OPAT) services — where select patients receive intravenous antimicrobials in their own homes — have made good progress since 2010 when a publically-funded national programme was established. Services were available in nearly two out of three hospitals in 2015, compared to limited services before this time. However, geographic restrictions limited the full extent of this programme's availability.

Antimicrobial stewardship in individual hospitals

Good progress has been made in the majority of Irish hospitals with the implementation of antimicrobial stewardship best practice. In the most successful hospitals, there was clear evidence that this has been enabled by the presence of:

- an appropriate complement of well-trained and well-led specialized staff, working as a team
- a support framework which includes good laboratory, information technology, surveillance and clinical pharmacy resources, and
- appropriate governance arrangements with effective senior management support.

Notable success has been identified in higher performing hospitals in the development of:

- regularly reviewed evidence-based empiric prescribing* guidelines
- protected antimicrobial prescribing rights for key strategic antimicrobial agents
- point-of-care interventions
- good collaboration between hospitals to make best use of resources, and

* **Empiric antimicrobial therapy**: antimicrobial therapy given for an anticipated and likely cause of infection based upon probability, but where the causative organism has not yet been identified through microbiological testing.

- the integration of antimicrobial stewardship with wider medication safety and risk management programmes.

Performance in other hospitals was proportionately hindered by the lack of the various critical elements outlined above. In particular, the scope for greater formal cooperation and collaboration between hospitals to make best use of resources was identified. Some progress in this area has been made, but there is significant scope for more.

A small number of hospitals did not have a drugs and therapeutics committee in place to oversee the antimicrobial stewardship programme, contrary to National Standards. This is a significant concern, not only from an antimicrobial stewardship perspective, but also in terms of wider medication safety. A further concern was that a number of other hospital drugs and therapeutics committees were not as active as they were intended to be. Again, this was of concern to HIQA.

Other hospitals have made very good progress in developing medication safety programmes. Much can be learnt from those hospitals that lead the way in this regard to enable wider establishment across all acute hospitals.

Finally, a small number of hospitals had no antimicrobial stewardship programme in place. These hospitals were smaller local hospitals, defined by the HSE as Model 2 hospitals, which had not received specialized resources to support the establishment of such programmes. This is a significant patient safety concern, is not in compliance with National Standards and should be reviewed as a matter of urgency by the HSE.

Conclusions

This review looked at how the HSE is addressing the global threat of antimicrobial resistance through the promotion of best practice in antimicrobial stewardship in public acute hospitals. As the review progressed, it became apparent to HIQA that while the HSE has significantly invested in this area in acute hospitals over a number of years, the job of ensuring the full provision of antimicrobial stewardship in the best interest of patients in all public acute hospitals remains incomplete.

The nature of the antimicrobial resistance threat has changed in Ireland and internationally in recent years. While infection caused by Meticillin-Resistant *Staphylococcus aureus* (MRSA) has reduced in Ireland, outbreaks of colonization or infection caused by very resistant Gram-negative organisms, such as the outbreak seen in the Mid-West Region, have become more prevalent. This trend is a significant concern, as there are a smaller selection of less than ideal treatment options left to treat such Gram-negative infection.[(9)]

Therefore, the response has to change also, and be extended from acute hospitals into other non-acute residential and community care settings. However, this review found that existing structures and resource allocation has been weighted almost exclusively to acute hospitals, and that the strategy to deal with these problems in Ireland has not been updated since 2001.

Therefore, separate to other EU-level initiatives in the area of agriculture and veterinary medicine, the HSE needs to re-energize its national efforts in this area. More recent plans from the Irish Government to advance a national action plan in this area are a positive development, and should be supported by all relevant stakeholders in the best interest of the public. A key part of this plan should aim to provide greater strategic direction for the HSE in advancing both antimicrobial stewardship and infection prevention and control across all health and social care settings under its control.

In particular, better surveillance systems are needed nationally so that emergent problems across care settings can be more effectively identified, and acted upon at an appropriate level. Crucially, national leadership, governance and management of the interlinked areas of infection prevention and control and antimicrobial stewardship within the HSE need to be enhanced, giving greater authority to those best placed and informed to take the actions required. Clear lines of accountability and responsibility need to be communicated to all involved.

In recent years, much progress has been made at individual hospital level in setting up antimicrobial stewardship programmes, a number of which would compare very well internationally. As the Irish health system progresses towards the latter part of this decade, it is imperative that the HSE builds upon the progress made at a local level in individual hospitals to further enhance antimicrobial stewardship. In particular, strengthening antimicrobial stewardship and infection prevention and control in non-acute healthcare settings should be pursued as part of a whole-healthcare system approach to dealing with the rising demands of this critical public health threat.

Recommendations

Recommendation 1

The HSE must address identified gaps in antimicrobial stewardship and infection prevention and control identified throughout this review. To begin addressing these deficiencies, the following measures are required:

a. The establishment of a permanent national Health Service Executive (HSE) operational management and oversight group, with sufficient authority to ensure the timely implementation of required infection prevention and control measures across acute hospital, community and residential care settings.

b. Better mechanisms to enable this national group to actively seek assurance with respect to performance and risk across the entire HSE, through better national surveillance systems for antimicrobial resistance and Healthcare Associated Infection, and setting up effective reporting mechanisms to senior HSE management.

c. A full evaluation of the roles, responsibilities and accountability of each current national contributory group or body involved in infection prevention and control and antimicrobial stewardship in the HSE to ensure collective clarity of function and defined lines of reporting.

d. An evaluation of current and future workforce needs, and the necessary information and communication technology (ICT) resources and other supports required to progress this work.

Recommendation 2

At a hospital-group and individual hospital level, efforts should be extended to build upon progress made to date in relation to antimicrobial stewardship and infection prevention and control. Improvement efforts should focus on:

a. Ensuring full compliance with relevant National Standards and guidelines, in particular those in relation to governance and risk management arrangements.

b. Ensuring that those remaining hospitals that do not have antimicrobial stewardship programmes in place are appropriately supported to enable their establishment.

c. Ensuring that where deficiencies in resources have been identified as a barrier to fully implementing infection prevention and control and antimicrobial stewardship best practice, that these deficiencies be addressed in a timely and sustainable way.

    1. The potential for the allocation of additional resources along hospital group lines should be considered as a mechanism to improve efficiency and promote greater group collaboration.

    2. Additional resources should be prioritised in the short term to those Model 3 hospitals that fare least well currently relative to others from a resource allocation perspective.

Chapter 1 — Introduction

1.1 Introduction

On any given day in Irish hospitals, about one in three patients receive antimicrobial medicines* to treat or prevent bacterial, viral or fungal infection. The discovery and ongoing development of antimicrobials, and the ability to better treat infection, represents one of the key technological triumphs of the 20th century. Modern medicine relies on antimicrobials to provide both routine and ever more advanced treatment to patients.

Resistance to antimicrobials is an important patient safety and public health issue, particularly as there are very few new antimicrobials being developed globally.(10) Good antimicrobial stewardship is therefore essential to improve antimicrobial prescribing and thereby improve patient outcomes, reduce adverse effects and decrease antimicrobial resistance. In parallel, infection prevention and control measures are necessary to reduce the risk of antimicrobial resistant organisms being spread from one patient to another and to reduce the need for antimicrobials.

This report presents the findings of a HIQA review of antimicrobial stewardship in public acute hospitals in Ireland. Antimicrobial stewardship refers to a set of coordinated strategies which aim to improve the quality of usage of antimicrobials, with the goals of:

- improving patient-health outcomes
- reducing adverse effects
- reducing the emergence of antimicrobial resistance
- and reducing healthcare costs.

In short, the aim of antimicrobial stewardship programmes is to ensure that every patient receives the right antimicrobial therapy at the right dose, route and duration, and for the right infection type at the right time.(5) In addition, it also intends to ensure that therapy is continually reviewed, refined and discontinued where the patient's condition allows. Evidence continues to emerge which suggests that effective antimicrobial stewardship programmes in hospitals can also save them money.(6)

Antimicrobial stewardship and infection prevention and control both come under the umbrella of HIQA's *National Standards for the Prevention and Control of Healthcare Associated Infections*.(7) This review aimed to identify how well public acute hospitals in Ireland are configured to promote best practice on antimicrobial stewardship. As this was

* Throughout this report, the term antimicrobial describes a medicine which is capable of treating or preventing infection caused by a bacterium, fungus, virus or other infecting organism. For simplicity, the terms antimicrobial and antibiotic are considered synonymous throughout the report.

a national review, the approach taken by HIQA allowed for an evaluation of both local and national hospital management structures, with a particular focus placed on overall leadership, governance and management.

HIQA wishes to acknowledge the contribution of all interested parties who contributed to this review.

1.2 Background

The introduction of antimicrobials, initially in the late 1930s and more widely during the 1940s, transformed healthcare, and society at large. Infections that were once potentially life-threatening became routinely treatable. The leading causes of death in developed countries reverted from infections such as pneumonia and Tuberculosis to other causes such as heart disease and cancer.[11]

As modern medicine continued to evolve, the introduction of advanced treatment options such as cancer chemotherapy, organ transplantation and complex surgery were allowed to develop through the use of antimicrobials, which could treat or prevent infection that might unavoidably occur as a result of these life-saving interventions.

Furthermore, the ability to use antimicrobials to prevent infection meant that complication rates associated with routine general surgery, or bone and joint surgery were significantly reduced.[12-14]

1.3 Emergent antimicrobial resistance — a societal threat

Antimicrobials are not a limitless resource. Since the discovery of penicillin, it has been recognized that the emergence of resistance to a new antimicrobial agent should be anticipated after a period of time following its introduction into clinical or agricultural practice.[15] Bacteria can adapt and evolve over time to overcome threats posed by agents formerly toxic to them, such as antimicrobials, even with the most careful use. To overcome this evolutionary response to antimicrobial use, it is imperative that a number of complementary measures need to happen together, including:

- Antimicrobial prescribers and patients need to ensure that the value of antimicrobial agents currently in use is preserved for as long as possible through careful and expert usage, through an initiative known as antimicrobial stewardship.
- Antimicrobial usage in veterinary and agricultural practice needs to be carefully managed to ensure prudent usage.
- The development of new antimicrobials needs to stay ahead of the rate of emerging antimicrobial resistance.
- Strict adherence to best practice on infection prevention and control should be observed in all healthcare settings.

1.4 The diminishing supply of new antimicrobials

The development of any new medicine is a complex, time-consuming and expensive. It is estimated that the total cost of developing a new medicine may extend to over €2.3 billion.[16]

Since the late 1980s, and especially over the past 10–15 years, the rate of investment by pharmaceutical companies in the development of antimicrobial agents has declined significantly.[10] As a consequence, and in addition to increasing technical difficulty in discovering new antimicrobials,[17] the approval rate for new antimicrobial agents has declined considerably and has failed to keep up with the rate of emergence of antimicrobial resistance.

Figure 1. New antimicrobial drug approvals in the United States from 1983–2012[18]

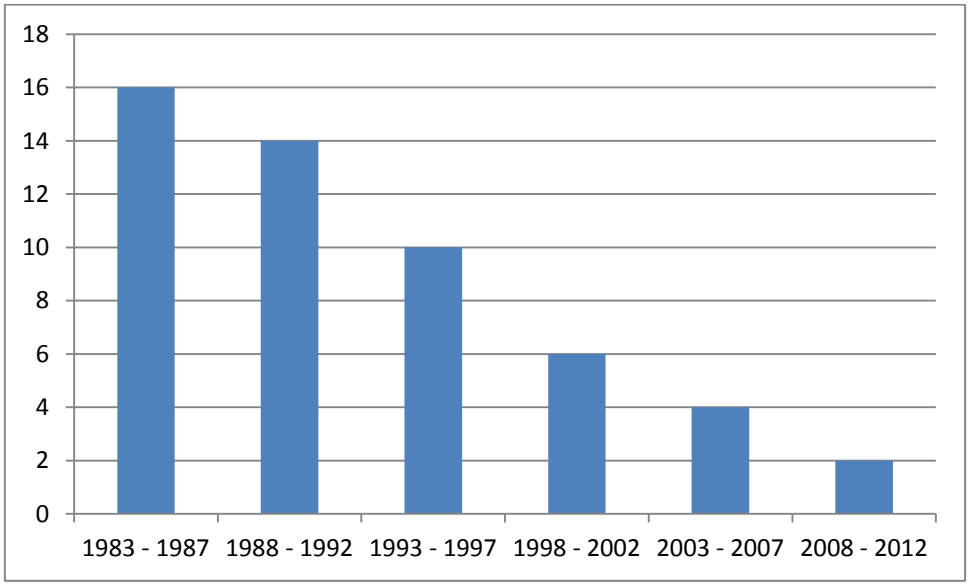


Figure 1 shows the decreasing rate of new antimicrobial medicine approvals in the United States in recent decades. The mismatch between reduced drug discovery and emerging antimicrobial resistance is greatest amongst certain strains of Gram-negative bacteria.[10] Gram-negative bacteria most commonly cause urinary tract infection, abdominal infection, bloodstream infection and pneumonia, and are regularly identified as the causative bacteria in cases of life-threatening sepsis (see Appendix 5 for an insight into this type of bacteria).

The failure to maintain investment in new antimicrobials has required prescribers to begin to rely on older, less effective or more toxic antimicrobial agents to treat infection.

1.5 How serious is the problem of antimicrobial resistance?

Antimicrobial resistance represents an extremely serious public health problem that has increased in recent years, and represents not just a healthcare, but a wider societal threat. In 2014, the World Health Organization (WHO) declared antimicrobial resistance as a 'major global threat', and warned that the world was closer than ever to entering a post-antimicrobial era.[3] In 2015, the WHO subsequently launched a global action plan aimed at containing this problem.[19]

In the United States, the risk associated with this problem was declared a national security threat in the same year. This prompted the declaration of a presidential executive order aimed at addressing this crisis.[20] In the United Kingdom, the British Prime Minister has commissioned a series of strategic reviews aimed at identifying what the UK government needs to anticipate and plan for in order to fully address this threat.[4;21]

In 2015, the German federal government launched a five-year strategy to address this threat[22] — it also used its position as host of the G7 Summit held in October of that year to both raise awareness and broker agreement around a global response to this issue.[23]

In an Irish context, following the financial crisis, efforts by government to try to better identify and therefore mitigate major strategic risks of national significance has, since 2014, prompted the drafting and ongoing maintenance of an annually updated Draft National Risk Assessment. In every annual update published so far, the threat of antimicrobial resistance has been recognized as a major risk of national significance.[24-26]

1.6 What does this mean for patients, and what is being done internationally to address antimicrobial resistance?

In 2009, the European Centre for Disease Control estimated that approximately 25,000 Europeans died each year as a direct consequence of multidrug-resistant infection.[27] Likewise, in the United States, approximately two million illnesses and 23,000 deaths annually have been attributed to antimicrobial resistance.[28] With every year, the progressive increase in antimicrobial resistance encountered adds to this annual burden.

At the time of this report, a pattern of antimicrobial resistance in Ireland which requires using less conventional and less effective antimicrobials has begun to emerge for some patients.[29;30]

Internationally, infection with bacterial strains that are resistant to all antimicrobials have been described.[1;2] In late 2015, reports from China of cases of antimicrobial resistance in certain species of Gram-negative bacteria to a 50-year old antimicrobial called colistin emerged.[31] This medicine, which has been rarely used in healthcare since the 1970s due to its toxicity, is increasingly being used again to treat very sick patients in Ireland and

elsewhere, due to a lack of other treatment options. In China, the emergence of this resistance was traced back to widespread use of the medicine in animals.

Researchers were able to identify the gene responsible for conferring resistance in the bacteria in question. Following this work, other researchers internationally have subsequently identified the presence of colistin resistance via this mechanism in a number of other countries, including countries in Europe[32] and in the United States.[33]

At the time of this review, a recent UK report predicted that the consequence of inaction in the face of growing antimicrobial resistance could result in multidrug resistant bacteria conservatively accounting for more annual deaths globally than cancer and diabetes combined by 2050, with a 15-fold increase in annual mortality compared to what is seen today.[4]

The international response to address this problem has seen governments and other international bodies enacting measures to improve the commercial incentive for pharmaceutical companies to increase investment in new antimicrobial agents.[34;35] Recent reports suggest that some progress has begun to occur in developing new agents.[36] However, before or if new antimicrobial medicines become available, there is a risk that some multidrug resistant infections may be untreatable.

Some governments have responded to this threat by developing detailed national strategies, and through forming cross-departmental strategic oversight and implementation groups.[22;37-42] Such groups, which in some instances are led at head-of-government level, often sit across multiple governmental departments, and may include input from the departments of health, agriculture, education, research, defence and foreign affairs or equivalent.

It was reported that in 2016, the Irish Government had commenced planning for participation in an EU initiative spearheaded by the Council of the EU[8] to fast-track individual national action plans across EU member states by mid-2017 to address this threat in a coordinated pan-European way.

1.7 The Strategy for the Control of Antimicrobial Resistance in Ireland (SARI), and national antimicrobial stewardship recommendations

In 2001, a working group from the National Disease Surveillance Centre — now the Health Protection Surveillance Centre (HPSC) in the Health Service Executive (HSE) — formulated the first formal Strategy for the Control of Antimicrobial Resistance in Ireland (SARI)[43] on behalf of the Department of Health and Children, which aimed to define the challenge faced by Ireland in addressing this threat. The strategy proposed a plan for the country to address this challenge.

This document took a system-wide 'one-health' approach which took in the management of both human and animal antimicrobial use in line with best practice. Within this, it outlined a number of recommendations aimed at acute hospitals to improve infection prevention and control practices and antimicrobial stewardship. These recommendations included setting up a national response across hospitals, through widely applying evidence-based best practice, greater multidisciplinary collaboration and practice-based research and learning.

In addition, the appointment of specialized healthcare staff in acute hospitals to form infection prevention and control and antimicrobial stewardship teams was recommended in the SARI report.

1.8 National Standards

In 2009, HIQA published the *National Standards for the Prevention and Control of Healthcare Associated Infection* (referred to in this report as the Infection Prevention and Control Standards).[7] HIQA uses these Standards to monitor infection prevention and control performance in individual hospitals.

Hospital antimicrobial stewardship programmes need to be supported and accompanied by an effective and wider programme of infection prevention and control in order to be successful. Furthermore, local and national governance structures need to be aligned to ensure that both elements are fully integrated in order to best manage this issue.

1.9 National *Guidelines for Antimicrobial Stewardship in Hospitals in Ireland*

In recognition of the importance of the role of antimicrobial stewardship in addressing the risk of antimicrobial resistance, a specialist subcommittee established under SARI, and reporting to the SARI national committee, produced *Guidelines on Antimicrobial Stewardship in Irish Hospitals* in 2009.[44] These guidelines outline a number of evidence-based principles which should be implemented by all publically-funded acute hospitals in Ireland. Relevant recommendations for the national coordination of antimicrobial stewardship included a requirement that:

- Rational antimicrobial usage in hospitals should be a strategic goal of the Health Service Executive (HSE).
- All acute hospitals should have an antimicrobial stewardship programme in place, and hospital managers and or chief executives should be required to provide annual evidence of their hospitals' performance in relation to each programme's effectiveness.
- Appropriate, trained specialized personnel are provided to enable effective stewardship programmes to be developed.
- National prescribing guidelines should be developed.

- There should be a national programme to advance clinical pharmacy services in hospitals. Pharmacy information technology systems should be developed to meet the increased audit and surveillance requirements that stewardship programmes demand.
- The HSE should explore the potential benefits of developing electronic patient records, electronic prescribing and computer-based surveillance in all hospitals.
- Training from academic and professional bodies should be provided for all staff who are involved in antimicrobial prescribing, handling and administration.

These guidelines also recommended key governance and workforce requirements to enable effective antimicrobial stewardship to take place, which include:

- governance oversight from a multidisciplinary drugs and therapeutics committee and (where the hospital size is sufficient to warrant it) a dedicated antimicrobial stewardship subcommittee
- ready access to consultant medical microbiologists or infectious diseases physicians, who have a formal on-site commitment and dedicated time allocated to antimicrobial stewardship activities
- appointment of an antimicrobial pharmacist, with time dedicated to antimicrobial stewardship activities allocated on the basis of hospital size and complexity
- access to a laboratory-based surveillance scientist
- formation of a multidisciplinary antimicrobial stewardship team in each hospital, which includes, but is not limited to, the key personnel listed above.

Core, high-impact, evidence-based stewardship interventions recommended by this document included clinical review of patients to provide the best possible antimicrobial therapy, antimicrobial surveillance and audit, and restricting the availability of key antimicrobials to use under expert supervision. The document also recommended improving prescriber education, and routine and ongoing updating of empiric antimicrobial[±] prescribing guidelines (guidelines designed to advise prescribers on best antimicrobial choice for standard infection types) for all hospitals.

Access to high-quality laboratory services to allow for effective diagnosis, appropriate antimicrobial selection and ongoing review of progress with infection treatment were also recommended for all hospitals.

While outside the direct scope of this review, the importance of prudent antimicrobial prescribing practice in non-acute care settings — such as nursing homes — has a critically

[±] **Empiric antimicrobial therapy**: antimicrobial therapy given for an anticipated and likely cause of infection based upon probability, but where the causative organism has not yet been identified through microbiological testing.

important role to play in managing the risk of emergent antimicrobial resistance. A number of positive initiatives have been enacted nationally to try to incentivize good practice in this field. These have included developing an agreed national prescribing guideline document for primary care, which has been accompanied by educational and training initiatives for prescribers.[45]

In addition, an annual winter advertising campaign — aimed at better informing members of the public that using antimicrobials is futile for treating viral common colds — has been a regular focus for the HSE. Focusing on all areas where antimicrobials are used to ensure prudent usage is critically important in dealing with what is a complex problem spanning across all areas of health and social care provision, and beyond.

1.10 The parallel importance of good infection prevention and control practice

To fully address the risk of emergent antimicrobial resistance, it is very important that hospitals continue to promote and enhance good practice in infection prevention and control as part of a programme that complements their antimicrobial stewardship programmes. Measures that prevent infection in the first instance, and reduce the spread of resistant organisms where patient infection or colonization with multidrug resistant organisms is found, are vital to tackling this emerging problem.

While this HIQA review was underway, the Authority continued its regulatory monitoring focus on the wider aspects of infection prevention and control practice in hospitals through its programme of unannounced inspection against the Infection Prevention and Control Standards. This culminated in 39 unannounced inspections in 2015.[46] Overall, this work identified that environmental hygiene standards in Irish hospitals deteriorated in 2015 when compared to 2014.

On a more positive note, however, the Authority identified that hand hygiene performance and awareness is improving in most Irish hospitals. Given the gravity of the threat posed by antimicrobial resistance, it is critically important that all hospitals and the wider health service continue their efforts across all fronts to try to achieve high performance in ensuring compliance with National Standards, and in doing so mitigate this risk.

Chapter 2 — National leadership, governance and management of infection prevention and control and antimicrobial stewardship

Summary of key findings

- The Irish Government has started planning the formulation of a new national action plan in relation to the threat of antimicrobial resistance, in line with Council of the EU requirements.[8] It is intended that this action plan is to be completed by mid-2017.
- A number of contributory groups and bodies are involved nationally in working to improve antimicrobial stewardship and infection prevention and control within the Health Service Executive (HSE).
- There was confusion at the start of this review over where overall governance, accountability and responsibility rested for these critically important patient safety measures at a senior leadership level in the HSE. This was clarified by the HSE as the review progressed.
- The HSE needs to improve its approach nationally to anticipating and managing emergent risk around antimicrobial resistance, in particular following its approach to managing emerging Gram-negative resistance.
- Existing structures and resources have been predominately directed towards acute hospitals, whereas antimicrobial resistance issues increasingly affect acute hospital, residential care and community settings.
- Recent governance changes within the HSE in the area of antimicrobial stewardship may address concerns identified during this review, although it was too early to evaluate these changes at the time of writing.

2.1 Introduction

This chapter looks at the national leadership, governance, and management arrangements in place to oversee the prevention and control of infection, the management of antimicrobial stewardship, and the risk of antimicrobial resistance across health and social

care services provided or funded by the HSE. The chapter includes findings and analysis in relation to:

- national strategy
- governance oversight and operational management within the Health Service Executive (HSE)
- risk management
- parallel advice and support structures
- success in ensuring the uniform implementation of national guidelines and recommendations.

The chapter concludes with recent changes made by the HSE in this area during the course of the review, and HIQA's overall conclusions in relation to national leadership, governance and management of antimicrobial stewardship, and infection prevention and control.

2.2 National strategy

This review examined the approach taken by the HSE to address the combined threats of antimicrobial resistance and Healthcare Associated Infection, through antimicrobial stewardship and infection prevention and control. Significant scope for improvement in the national approach taken by the HSE with respect to leadership, governance and management in this area were identified during this review and will be further evaluated below.

The most recent national strategy document which is in place to holistically address the threat of antimicrobial resistance across both health and other settings in Ireland dates back to 2001. However, it was reported that the Irish Government has begun work on a new national action plan in relation to the threat of antimicrobial resistance, in line with Council of the EU requirements.[8] This action plan is to be formulated by mid-2017.

This EU initiative advocates for the adoption of a 'one-health' approach to this issue, with the involvement of all relevant informed and interested parties including health and social care providers, and agriculture and veterinary stakeholders. This initiative aims to promote the formulation of a national plan to address this issue in each participant country by mid-2017, and is a positive development. It is important that efforts are advanced to provide greater strategic direction to the HSE in the interlinked areas of antimicrobial stewardship and infection prevention and control. In particular, there would be benefit in re-examining the current approach so that issues that manifest in non-acute care settings are more effectively addressed.

2.3 National HSE leadership, governance and management arrangements for antimicrobial stewardship and infection prevention and control

This review identified a complex organizational structure within the HSE which had been put in place to help manage the related issues of antimicrobial stewardship and infection prevention and control across health and community services that are provided and funded by the HSE. This structure consisted of operational management structures and parallel, but separate, support and advisory groups or committees. The HSE structures for operational management, and support and advice in relation to these issues are described in further detail in Appendix 4 of this report.

2.3.1 Overall executive leadership, governance and operational management

The term governance describes the system through which an organization arranges itself to ensure it achieves its strategic objectives. Those who hold responsibility for governance must continually consider if the organization is travelling in the right strategic direction, and if it is effectively anticipating and managing risk.[47]

During this review, HIQA worked to identify the key personnel involved in antimicrobial stewardship and infection prevention and control within the HSE. Responsibility for the operational management of these areas within each relevant division of the HSE (Acute Hospitals, Social Care, Primary Care, and Health and Wellbeing) is regarded as a line management responsibility. So, ultimate responsibility for line management in each division lies with the relevant HSE national director. In the Acute Hospitals Division for example, the HSE National Director for Acute Hospitals holds overall responsibility for infection prevention and control and antimicrobial stewardship in hospitals.

However, at the outset of the review, it was unclear to HIQA which member of the senior HSE management team held overall governance responsibility for an integrated approach to antimicrobial stewardship and infection prevention and control across the entire HSE service, including primary, community and acute care. It was subsequently clarified by the HSE to HIQA, during this review, that the HSE National Director for Health and Wellbeing holds overall governance responsibility in this area. However, this recent change, at the time of this review, was not well understood by those working at the front line in this area and needs to be clearly communicated by the HSE to all relevant stakeholders.

This report now goes on to describe and analyse the existing high-level governance structures in place at the start of the review to support antimicrobial stewardship and infection prevention and control within the HSE, and the arrangements for governance oversight and management through line-management reporting lines.

2.3.2 Organizational structure

The HSE has undergone a re-organization in recent years in both the acute hospital and community healthcare settings.

Since 2012, each public acute hospital has become part of a hospital group with the ultimate aim of forming seven independent hospital trusts.[48] However, the move to the new structure has been slow, and at the time of this report, hospital groups have only been established on an administrative basis, pending a change in the law.

Likewise, in the community setting, nine community health organizations are also being formed. It was explained at interview with senior HSE managers that governance and management structures within these organizations were under development. Finally, there are also eight public health departments in the country, which have long-standing areas of defined geographic responsibility.

HIQA notes that the boundaries and catchment areas of these community health organizations and public health departments are not universally aligned with those catchment areas of the new hospital groups. Therefore, in some parts of the country, such as Kilkenny or Cavan, patients and other service users may live in separate hospital group and community health organization catchment areas. As a result, the potential for seamless coordination across each area of responsibility for infection prevention and control and antimicrobial stewardship may be additionally complicated.

Such an arrangement is avoided in many healthcare settings through the closer integration or indeed collective management of hospital and community services on a geographic basis. This yields benefits in the management of the risks associated with antimicrobial resistance, as this issue is a whole-health and social care system problem requiring an integrated approach across functions.

In addition, HIQA found that specialized infection prevention and control and antimicrobial stewardship resources, such as those allocated to acute hospitals, are not reflected in community healthcare settings in Ireland. It was explained to HIQA during the review that the HSE prioritized investment in infection prevention and control and antimicrobial stewardship predominantly in acute hospitals, as at the time of investment it was felt that this represented the best allocation of resources on the basis of risk.

However, the evolving nature of this problem into community and residential care settings means that this approach now needs to be re-evaluated. The HSE needs to determine how best to establish infection prevention and control and antimicrobial stewardship programmes in community care settings, with due consideration to the geographic alignment of its community health organizations and hospital groups.

2.3.3 Management through the HSE Accountability Framework

The HSE introduced an 'Accountability Framework' in 2015 as a management tool to aid senior managers in the monitoring and management of performance and risk.[49] This framework was aimed at clearly defining the responsibilities of senior managers, and describes the means by which managers within the HSE would be held accountable for efficiency and control in providing services and promoting patient safety.

This framework, as described in the HSE's 2016 service plan,[50] is designed to improve corporate, clinical and financial accountability by identifying and clarifying governance arrangements at all levels of the organization. Key to the application of this accountability framework in practice is the monitoring of key performance indicators (these are quantifiable measures that are used to indicate an organization's success). It is through this framework mechanism that infection prevention and control, in addition to antimicrobial-resistance-related risk, is managed at a senior level within the HSE.

2.3.4 Performance measurement and assurance in relation to infection prevention and control and antimicrobial stewardship

The HSE's national service plan for 2016 outlines the most up-to-date HSE national performance indicators for Healthcare Associated Infections and antimicrobial stewardship.

For performance indicators to indicate an organization's success accurately, they must reflect what the organization has identified as being its critical success factors. Although it is possible to measure many different parameters, what makes performance indicators different is that they monitor the vital parameters that are essential for the organization to meet if it is to achieve its identified corporate goals.[51] However, performance indicators with an overly narrow focus may inappropriately direct the way in which an organization channels its efforts, and how it is perceived, and may provide an inaccurate level of assurance.

The HSE's Acute Hospital Division performance indicators in relation to Healthcare Associated Infection and antimicrobial stewardship include:

- Meticillin-Resistant *Staphylococcus aureus* (MRSA) bloodstream infection
- *Clostridium difficile* infection
- antimicrobial consumption
- alcohol hand rub consumption
- and hand hygiene compliance.

The HSE's service plan for 2016[50] includes plans to start monitoring the percentage of patients colonized with multidrug resistant organisms that cannot be isolated in single rooms with dedicated toilet facilities in line with national guidelines. Its Primary Care

Division also has a performance indicator for consumption of antimicrobials in community settings. However, significantly, the service plan does not list measuring performance related to the risks associated with Gram-negative bacteria resistance through this formal management reporting mechanism. As will be further described, this is significant as Gram-negative resistance is an increasing problem both in Ireland and internationally.

Additionally, the HSE's 2016 service plan does not include key performance indicators that directly relate to antimicrobial resistance or infection prevention and control in its Health and Wellbeing Directorate[†] and in its Social Care Division. This is a notable omission in the service plan given the widespread nature of the risk of antimicrobial resistance across services covered by these divisions, the fact that patients likewise travel between divisions as they progress through treatment, and the overarching public health role played by the Health and Wellbeing Division.

The prevention and control of Healthcare Associated Infection and antimicrobial resistance is complex. The accurate assessment of risk in this area requires the input of specialized expertise. In evaluating all of the information gathered during this review, HIQA found a fundamental disconnect between those with specialized expertise who are best placed to evaluate and advise on the management of risks, and those with operational management responsibility within the national HSE with the necessary level of authority to actively address those risks.

The current HSE Accountability Framework provides a narrow focus for national assurance oversight of Healthcare Associated Infection and antimicrobial resistance risks. HIQA identified weaknesses in these arrangements through evaluating the HSE's approach to the anticipation, monitoring and active management of the growing issue of Gram-negative resistance in healthcare, which are further discussed in this chapter.

This review found that performance measurement in relation to infection prevention and control and antimicrobial resistance at a national level is limited and is not fully focused on potential key risks to patients. There is significant potential to progress national measurement systems to improve assurance around performance in relation to Healthcare Associated Infection incidence, and to monitor, at the most senior level of the HSE, emergent resistance risks.

As a first step towards addressing this issue, a full evaluation of where the main gaps lie in the monitoring of performance needs to take place. In some instances, existing information could be used more effectively for assurance, for example, in the monitoring of antimicrobial resistance patterns. There is also potential scope for expansion of

[†] In the broader context of communicable disease control, the Health and Wellbeing Division has key performance indicators in relation to immunisation uptake and infectious disease outbreak notifications.

surveillance functions with a focus on patient outcomes — however, this will require increased investment.

In Ireland, there are currently no nationally mandated surveillance programmes or defined performance expectations for invasive-device-related or surgical site infection surveillance in hospitals. This is despite national guidelines published as far back as 2009 that had recommended surveillance of intravascular-catheter-related infection,[52] and a previous SARI (Strategy for the Control of Antimicrobial Resistance in Ireland) subcommittee recommendation in 2008 which identified the need to coordinate and resource infection surveillance across hospitals.[53]

Ongoing surveillance of invasive-device-related infection, and indeed of surgical site or implant infection across hospitals, is limited, with many hospitals not performing any surveillance in these areas. While the efforts of some individual hospitals to improve or introduce surveillance in these areas are noted by HIQA, there have been variable levels of progress overall. This is a missed opportunity in terms of improving the quality of patient care and reducing the incidence of Healthcare Associated Infections and resulting increased healthcare costs.

Nonetheless, Ireland has regularly participated in international point prevalence studies to determine infection rates.[54] These represent a helpful snapshot-in-time audit which can be used as a focus to direct improvement efforts. While this approach represents a positive example of the power of collective working, there is significant scope for further development of ongoing surveillance systems which look to standardize and pool findings from locally collated surveillance data to allow for a national overview of composite performance.

This review has found that HSE national performance indicators for Healthcare Associated Infection had been expanded in 2016, but they remain limited. Given the changes and increased risk associated with antimicrobial resistance trends in Ireland already discussed, these performance measures need to be re-evaluated to include recognition of the national problems being experienced in the areas of Gram-negative resistance and vancomycin-resistant *Enterococci* (VRE).

2.3 Current key antimicrobial resistance threats in Ireland, and the national HSE approach to risk management in this area

Extended-spectrum beta-lactamase (ESBL) and carbapenemase-producing Enterobacteriaceae (CPE)

In Ireland at the time of this HIQA review, key antimicrobial resistance risks may be summarized as follows:[55]

- Among Gram-negative *Escherichia coli* (E.Coli) and *Klebsiella pneumoniae* isolates, resistance to certain antimicrobials (beta-lactam antimicrobials) — from enzymes known as extended spectrum beta lactamases (ESBLs) — is becoming more common and increasingly found in bloodstream infections in Ireland. Many of these bacteria are also resistant to multiple other antimicrobials. Of serious concern is the emergence of what is termed carbapenemase producing Enterobacteriaceae (CPE), which results in some cases of bacteria being resistant to all conventionally used antimicrobials, with limited treatment options remaining.
- A widespread, national outbreak of multidrug-resistant extended spectrum beta lactamase (ESBL) producing Gram-negative bacteria has been ongoing in Ireland since 2013.
- In 2014, an outbreak of CPE centred on University Hospital Limerick and the wider Mid-West Region was identified.
- HIQA has identified a relative lack of screening for multidrug resistant organisms in hospitals compared to the level recommended in national guidelines.[56] As a consequence, there is a potential that the true incidence of multidrug resistant organism colonization among hospitalized patients in Ireland may be underestimated.
- Ireland has the highest proportion of vancomycin-resistant *Enterococci* (VRE) causing bloodstream infection observed anywhere in Europe.

The implications of this composite profile of resistance risks in Ireland is serious, as infection related to Gram-negative resistance in particular brings a significant risk of serious illness or death.[2;10;57] This specific problem has been seen in other European countries and could significantly hamper the delivery of healthcare in Ireland. Operational management of both the national outbreak of Gram-negative bacteria and the outbreak of CPE in University Hospital Limerick and the wider Mid-West Region is discussed in more detail below.

2.3.1 National multidrug resistant Gram-negative bacteria outbreak

In late 2013, a national outbreak of ESBL producing *Klebsiella pneumoniae* was detected by the HSE. The pattern of the outbreak suggested involvement of both hospitals and residential care settings. A national outbreak control team was convened by the Health Protection Surveillance Centre (HPSC). In early 2014, after evaluation of the problem over a number of months, the Outbreak Control Team believed that the formation of a specialist task force within the HSE — with senior management involvement — was required to effectively manage this problem. The Outbreak Control Team determined that it did not have the requisite executive management authority to do this and existing mechanisms within the HSE had not effectively managed this issue at that point in time.

Despite requests to the HSE from the Outbreak Control Team for executive management involvement, a significant delay — in the opinion of the Authority given the context of the risks involved — ensued in responding to this request. HIQA became aware of this delay during the course of monitoring against the Infection Prevention and Control Standards,[7] and wrote to senior members of the HSE leadership team in November 2014 to express concern in relation to this delay.

HIQA was informed by the HSE in late September 2015 that a task force was still in the process of being formed to deal with this issue. At that time it had yet to generate any recommendations or actions. Ten months had therefore passed between HIQA initially raising concern in relation to this matter and the establishment of national body to operationally address this issue. Nearly two years had passed between identifying the initial problem and forming a task force. In HIQA's opinion, this was an unacceptable delay in dealing with a serious national risk.

2.3.2 Carbapenemase-producing Enterobacteriaceae (CPE) outbreak in the Mid-West Region, including at University Hospital Limerick

University Hospital Limerick was among the first hospitals in Ireland to report the identification of carbapenemase-producing Enterobacteriaceae (CPE), which are especially resistant Gram-negative bacteria that may cause infection in patients. The hospital has experienced a number of outbreaks with bacteria that contain this antimicrobial resistance mechanism. It is known that a certain small proportion of the patient population in the hospital's catchment area are chronically colonized with CPE.

Prior to this review, HIQA identified through its ongoing programme of monitoring against the Infection Prevention and Control Standards that the hospital had experienced a significant increase in the incidence of CPE-colonized and or infected patients at the hospital during 2014. Further investigation of this issue by HIQA culminated in a request for the University of Limerick Hospitals Group in July 2014 to formally escalate this risk through HSE risk management reporting arrangements.

This was requested to ensure that there was full visibility at a national HSE level of an issue that HIQA regarded as a high risk to patients. This was required so that appropriate supports from a national perspective might be provided to both the hospital and other affected community healthcare settings to deal with what was a difficult problem, which spanned both the hospital and surrounding catchment area. It is known that similar problems have been experienced in healthcare systems internationally. While very challenging to deal with, coordinated national intervention has proven effective in containing this risk elsewhere.[58]

In the time between HIQA's initial identification of this issue in July 2014, and the allocation of national funding to the hospital for improved isolation facilities in 2015, HIQA wrote to the National HSE in November 2014 to raise concern with respect to the apparent lack of additional supports provided to the hospital to deal with this issue. Escalation of these concerns was further motivated by the fact that existing national assurance mechanisms within the HSE had neither proactively identified, nor mobilized a sufficient response to the CPE risk in the Mid-West Region, as identified at University Hospital Limerick at that point in time.

HIQA acknowledges that the HSE has significantly invested in upgrading some areas of the hospital more recently, and has opened a newly built cohort unit with some single-room capacity. HIQA also notes that the HSE and the hospital are still working to complete the building of a new Emergency Department in University Hospital Limerick — the existing department was identified as a significant risk for the hospital during a previous review conducted by HIQA and published in 2014. However, this new department remains unfinished and is not due for completion until 2017.

Despite some progress, HIQA believes that the hospital still has insufficient isolation facilities and the ongoing poor infrastructure in some other areas in the hospital (for instance in the Emergency Department), does not facilitate strong and reliable infection prevention and control practices.

HIQA notes with concern that at the time of preparing this report, that there were no formalized and established operational management arrangements in place in the national HSE to provide active and coordinated external expert support to a hospital experiencing an extensive and difficult to manage outbreak of a multidrug-resistant organism, such as the CPE outbreak in the Mid-West Region and University Hospital Limerick.

2.3.3 Overall analysis of the national HSE approach to risk management in this area

All health services should have an effective and comprehensive process in place to identify, understand, monitor and address current and future risks. This process should be dynamic, anticipatory and proactive.

As part of this review, the HSE was asked to submit its corporate risk register to HIQA to find out the degree to which it has captured risk in this area. A revised draft HSE corporate risk register dated January 2016 was received. This document indicated one risk in relation to Healthcare Associated Infection. The risk was described as:

> 'Healthcare Associated Infection risk to patients due to the inconsistent adherence to and implementation of Healthcare Associated Infection and antimicrobial resistance standards throughout the organisation.'

The existing controls were described as:

- Department of Health and HSE corporate commitment to the reduction of Healthcare Associated Infection and antimicrobial resistance
- Healthcare Associated Infection and Antimicrobial Resistance Clinical Programme with a clinical lead, an Irish College of General Practitioners (ICGP) lead and a nursing lead
- national and local surveillance programmes for Healthcare Associated Infection and antimicrobial resistance across acute and non-acute settings
- quality improvement/safety programmes associated with Healthcare Associated Infection and Antimicrobial Resistance Clinical Programme
- core infection prevention and control knowledge and skills framework completed.

While the general risk associated with this area is therefore reflected on this register, specific reference to many of the risks outlined by HIQA in this chapter are not explicitly referred to. Moreover, the controls listed have not been effective in dealing with the emergent resistance among Gram-negative bacteria and vancomycin-resistant *Enterococci* (VRE) threat to date. Indeed, at the time of this review, existing HSE arrangements did not ensure timely proactive risk management at a national level as observed in relation to the management of the outbreak of antimicrobial-resistant bacteria in University Hospital Limerick and the wider Mid-West Region.[‡]

Risks in relation to Healthcare Associated Infection and antimicrobial resistance at hospital level are predominantly escalated from the front line to national HSE level. This surveillance system appears to rely heavily on local escalation of risks, particularly with respect to problems which are not captured within the narrow confines of the key

[‡] During the due process phase of formulating this report, it was highlighted to HIQA by the HSE that in addition to reporting of information via the HSE Accountability Framework, data from EARS-Net (a European surveillance system which Ireland participates in) is additionally circulated within the HSE to inform emergent antimicrobial resistance in Ireland. HIQA found during this review that as with the data collected via the Accountability Framework, this mechanism did not flag the emergence of this carbapenem resistance problem in the Mid-West Region with senior HSE management. EARS-Net only records invasive (such as bloodstream or cerebrospinal fluid) infection, and does not detect underlying colonization incidence or non-invasive infection (such as urinary tract infection) which are much more common, and therefore a more sensitive marker of emergent Gram-negative resistance problems.

performance indicators reviewed through the HSE's accountability framework, or via nationally reported surveillance systems.

HIQA has concerns in relation to the ability of this system to fully identify emergent risk. In particular, current systems may not fully identify situations where multidrug resistant infection or colonization occurs outside of the eligible categories for capture via the EARS-Net system (such as bloodstream or cerebrospinal fluid infection in a defined group of organisms), or in situations where problems occur across care settings. The response by the HSE nationally in relation to the management of the Gram-negative threat, and ongoing problems with VRE, would indicate that this reporting line has been ineffective in mobilizing a sufficient nationally coordinated response to such risks.

The approach to identifying risks from an executive level outside of the narrow confines of the HSE Accountability Framework means that there is an over-reliance on unstructured, bottom-up reporting. This potentially creates a danger of high risks remaining undetected at an appropriate level in the HSE in the absence of such nationally coordinated reporting. There is evidence that such a situation, involving unstructured, bottom-up reporting, initially occurred in relation to the CPE outbreak at University Hospital Limerick and the Mid-West Region.

In short, current risk management systems in relation to Healthcare Associated Infection and antimicrobial resistance at a senior level within the HSE need to improve. For example, they typically rely on upward reporting from hospitals, rather than actively seeking out information. Significant progress needs to be made to better anticipate and enable proactive management of issues such as the Gram-negative resistance problem, rather than waiting for a crisis to emerge before mobilizing an active response.

2.4 Parallel advice and support structures

While responsibility for the operational management of infection prevention and control and antimicrobial stewardship lies within the line management functions of each HSE division, this review identified a number of parallel advice and support functions in place which have been established to support work in this area within the HSE. These structures include:

- A National Clinical Programme aimed at addressing Healthcare Associated Infection and Antimicrobial Resistance. This programme is part of the HSE Division of Quality Improvement, and it was explained that its role was to support quality improvement in this area across the HSE.
- A Clinical Advisory Group which reports to the Royal College of Physicians of Ireland. Membership of this group largely comprised representatives nominated by relevant professional bodies, the HSE, the Department of Health and other key

stakeholders. It was explained during this review that this group was established to support the aforementioned clinical programme.

- A National Subcommittee of the above Clinical Advisory Group which has been assigned to support antimicrobial stewardship in hospitals.

Collectively, each of these separate groups has worked towards addressing risk in this area across the HSE nationally. In particular, a notable area of success has been initiatives to define and articulate best practice through the development and publication of guidance documentation. However, these groups provide an advice and support function only, and do not have responsibility to ensure the implementation of recommendations; nor do they have a function to identify the degree of compliance with implementation in healthcare settings. Furthermore, these groups do not have a defined remit to actively intervene at a local level with respect to the management of infection prevention and control and antimicrobial stewardship. Finally, HIQA identified the lack of a formal pathway for the escalation and management of risk within these structures, which was a significant concern.

In addition to these groups, the Health Protection Surveillance Centre (HPSC) provides a support role across the HSE with respect to infection prevention and control, and antimicrobial stewardship. Similarly to public health departments, the HPSC also has an operational role in coordinating the management and control of outbreaks of communicable disease (see Appendix 4).

2.4.1 The need for supplementary operational support mechanisms

While there are a number of bodies in place to provide advice and support across the HSE in the areas of antimicrobial stewardship and infection prevention and control, this review has identified that there are currently no established mechanisms in place to provide additional proactive 'on the ground' support to struggling hospitals in response to risk escalated to a national level. This issue is compounded by the fact that the line management functions which are expected to manage this risk work only within their individual HSE division, whereas the issue of antimicrobial resistance increasingly spans across HSE divisions and geographic areas.

There is a need for a mechanism to provide additional proactive support to organizations who struggle to manage antimicrobial resistance risk at the front line, or across healthcare settings. HIQA notes that existing infectious diseases legislation provides the HSE with the authority to actively intervene on public health grounds in situations where healthcare organizations struggle to independently manage infection related issues. It has been reported to HIQA during this review that to date, this provision has not been comprehensively exercised to manage multidrug-resistant organism outbreaks in hospitals. It is recommended that the HSE examine current arrangements to ensure that there is

planned provision for active intervention as an extra safety net in managing risk, should a situation arise where this may be required.

2.5 Success in ensuring full implementation of national guidelines and recommendations

In addressing the Healthcare Associated Infection and antimicrobial resistance threat in the recent past in Ireland, the health service has succeeded in defining best practice in a way which may be easily understood by those responsible for implementing it, through publishing national guidance.

However, this review identified that full implementation of these guidelines is often not achieved in all hospitals, even in situations where it would aid in mitigating serious risks. A prime example of this is the non-implementation in many locations of national guidelines for the prevention and control of multidrug-resistant organisms other than MRSA[56] — at a time when Gram-negative resistance is increasing and national VRE rates remain the highest in Europe.

This review has also identified a number of examples where national outbreak control teams or relevant expert bodies have made important high-level recommendations. However, full implementation of these recommendations was not subsequently achieved, and the experts making these recommendations had no authority to ensure their advice was acted on.

As a consequence of this review, it is recommended that the HSE thoroughly examines the national approach to managing the interlinked risks of Healthcare Associated Infection and antimicrobial resistance. This will require more effective national oversight of collective performance through active assurance, strong leadership, and effective strategic planning.

While funding difficulties remain within the health system, not implementing recommendations aimed at protecting patients from potential harm also presents a financial as well as clinical risk to the service. It is vital that strategic investment decisions reflect the risks across the entire health system.

2.6 Recent changes to national HSE governance in this area

As this HIQA review was under way, a number of governance changes took place within the HSE which are relevant to the national approach to leadership, governance and management in the area of Healthcare Associated Infection and antimicrobial resistance.

The Director General of the HSE officially delegated responsibility — for overall governance of Healthcare Associated Infection and antimicrobial resistance mitigation across all HSE divisions in the health service — to the HSE's National Director of Health and Wellbeing.

In order to further clarify the role of the HSE's Healthcare Associated Infection and Antimicrobial Resistance Clinical Programme in light of these management changes, new reporting arrangements were being explored towards the latter end of this HIQA review. Under these plans, the Clinical Programme lead would report both to the National Director of Health and Wellbeing alongside the existing reporting relationship to the HSE's National Director for Quality Improvement.

In addition, the HSE has now established a National Task Force for Healthcare Associated Infection and Antimicrobial Resistance which first met in September 2015. At the time of writing this report (summer 2016), this task force had met three times. A press release issued by the HSE on 31 March 2016[59] stated that the task force had been established to:

- ensure rational antimicrobial use across all healthcare settings
- ensure effective diagnostic support for infection
- reduce the incidence of multidrug resistant organisms
- decrease the incidence of Healthcare Associated Infections
- improve professional education, training and public engagement to promote a wider understanding of the need for appropriate use of antimicrobials
- ensure compliance with HIQA standards for the prevention of Healthcare Associated Infection across all healthcare settings.

While all of these developments are potentially beneficial and would appear to address some of the concerns outlined during this review, at the time of writing this report it was too early to assess the efficacy of these new arrangements.

2.7 Conclusion

This review identified that there are multiple committed stakeholders within and outside the health service in Ireland who are involved in trying to combat the threat posed by Healthcare Associated Infection and antimicrobial resistance. Moreover, progress has been made within the HSE in working to advance infection prevention and control and antimicrobial stewardship practice, particularly at the individual hospital level in most hospitals.

However, this review also identified that recent progress has been hampered by the lack of an up-to-date national plan in this area. The lack of such a plan has resulted in a situation whereby development has been driven in an uneven way. Pockets of excellent practice exist in some hospitals, yet others lag behind, and progress in non-acute settings

has been very limited. Such progress, where it has occurred, has often been driven by front-line staff, rather than from a more strategic vantage point.

A more strategically driven and nationally coordinated approach which would allow for better planning, tailored to address current and future risks, and designed to ensure uniform high performance in all hospitals should be pursued. Potential plans to develop a new national action plan in this area by the Irish Government are a positive step. These plans should aim to address the findings in this report as part of its wider overarching focus.

In addition, this review and ongoing monitoring work conducted by HIQA have identified coordination deficiencies at a national leadership level in the HSE with respect to the leadership, governance and management arrangements in place to address these threats. This is despite evidence of good leadership and judgment being shown in many cases by senior managers. In part, a lack of strategic direction may have impacted on governance and management effectiveness.

However, much of the scope for improved performance in this area is within the direct gift of the HSE and requires a more organized approach to enhance national governance of existing structures already in place on the ground in many hospitals. In particular, this review found a fundamental disconnect between clinical experts who had a good awareness of the growing risks, and those in more executive management roles who were in a better position to quickly and effectively address these risks. Improvement in this area should be readily achievable through reorganization of existing national governance structures, rather than through radical change at all levels within the organization.

At the time of this review, existing national HSE assurance and risk management arrangements had not effectively identified developing problems in relation to Gram-negative bacteria resistance, and had not been effective in dealing with high vancomycin-resistant *Enterococci* (VRE) rates in Ireland. The HSE must improve its formal approach to assurance and surveillance at a national level, and strengthen its approach to risk management. This approach needs to be more forward looking, dynamic and proactive, as the quantum of risk presented by antimicrobial resistance is only likely to increase from this point in time.

Chapter 3 — Antimicrobial stewardship workforce in public acute hospitals

Summary of key findings

- Since 2001, there has been extensive investment in hiring specialized staff to implement antimicrobial stewardship and infection prevention and control in public acute hospitals in Ireland.
- Where appropriate resources have been provided, progress in implementing antimicrobial stewardship programmes has generally advanced.
- However, at the time of this review, public acute hospitals did not as yet collectively have the recommended number of specialized antimicrobial stewardship staff.
- The allocation of these specialized staff across hospitals varies across the country, in that:
  - Allocation of specialized staff is mostly concentrated in larger academic teaching hospitals or Model 4[¥] hospitals.
  - Many Model 3 hospitals have very limited specialized staffing resources which limits antimicrobial stewardship, and is an issue which needs to be addressed.
  - Some Model 2 hospitals do not have any dedicated specialized staffing resources, and this is of significant concern to HIQA.
  - Some hospitals have struggled to recruit and retain specialized staff, in particular, consultant microbiologists.
- Limited clinical pharmacy services were reported to HIQA across the public acute hospitals. This deficiency hinders effective antimicrobial stewardship and the wider hospital approach to medication safety.
- There is a need to evaluate current and future workforce needs as part of the planned wider strategic planning process. This plan should include workforce requirements in non-acute health and social care settings.
- Governance arrangements for antimicrobial stewardship have not been formalized in all hospitals.
- Good professional networks have been formed within relevant staff disciplines working across hospitals. However, there is further scope for greater multidisciplinary collaboration at national and hospital-group level among specialized staff working in this area.

[¥] For definitions of the various models of hospital care, see the glossary section of this report.

3.1 Introduction

This chapter provides an overview of the allocation of specialized staff to support antimicrobial stewardship activities in public acute hospitals. The reported numbers of specialized staff are based on self-assessment submissions made to HIQA by public acute hospitals in July 2015. Forty-five submissions were received in respect of all 49 public acute hospitals (one hospital group submitted one self-assessment on behalf of five hospitals that share antimicrobial stewardship resources).

In the context of staffing resources in hospitals, it should be noted that the function of antimicrobial stewardship is, in most cases, just one component of the overall role of the specialized staff mentioned in this report. Additionally, in some cases, specialized staff may have all or a defined proportion of their overall workload assigned specifically to antimicrobial stewardship.

The 2001 Strategy for the Control of Antimicrobial Resistance in Ireland (SARI) identified that much needed to be done to build the country's capacity and capability to effectively address the threat of antimicrobial resistance. Over the following decade, there was significant public investment in the national healthcare infrastructure to manage this threat. This included recruiting specialized staff and related resources. Investment was informed by a growing evidence base, which recommended developing specialized teams in hospitals to direct infection prevention and control and antimicrobial stewardship programmes.

HIQA's 2009 Infection Prevention and Control Standards outlined baseline standards for the governance and management of infection prevention and control, including antimicrobial stewardship, in the health and social care system in Ireland. In addition, the SARI (2009) *Guidelines for Antimicrobial Stewardship in Hospitals in Ireland*[44] made recommendations on how antimicrobial stewardship programmes should be governed and managed. This section of the report outlines the progress made with implementing good practice, standards and guidelines.

3.2 National investment in antimicrobial stewardship and infection prevention and control

During this review, senior HSE managers reported to HIQA that the HSE had prioritized investment in infection prevention and control and antimicrobial stewardship programmes predominantly in the acute hospital setting. They explained that at the time of the investment, this was judged to be the best allocation of resources based on the risks. Therefore, this review of national investment in the area of antimicrobial stewardship and infection prevention and control has primarily focused on resource allocation within acute hospitals.

The Infection Prevention and Control Standards and the SARI *Guidelines for Antimicrobial Stewardship in Hospitals in Ireland* recommend the implementation of antimicrobial stewardship programmes in acute hospitals. Recommendations for the core specialized staff needed to implement antimicrobial stewardship programmes at hospital level include:

- consultant medical microbiologists and infectious disease physicians
- antimicrobial pharmacists
- surveillance scientists.

While these core members should represent a baseline complement of specialized staff for an antimicrobial stewardship programme, it would be expected that in most hospitals, involvement in antimicrobial stewardship would also include infection prevention and control nurses, quality and risk managers, and prescribers such as non-consultant hospital doctors (NCHDs), consultants and some nursing staff.

The hospital manager or a designated senior member of the hospital management team should have corporate responsibility for ensuring that an effective programme is in place and that this is appropriately resourced. There should be effective governance, with the organizational structure for the service outlining clearly the roles, responsibilities and reporting relationships of staff for:

- the prevention and control of Healthcare Associated Infections
- antimicrobial stewardship
- managing antimicrobial resistance at all levels of the service.

Prevention and control of Healthcare Associated Infections and implementing HIQA Standards should be monitored and regularly reported on by the hospital manager or equivalent who holds overall accountability for the service, through established management and reporting structures.

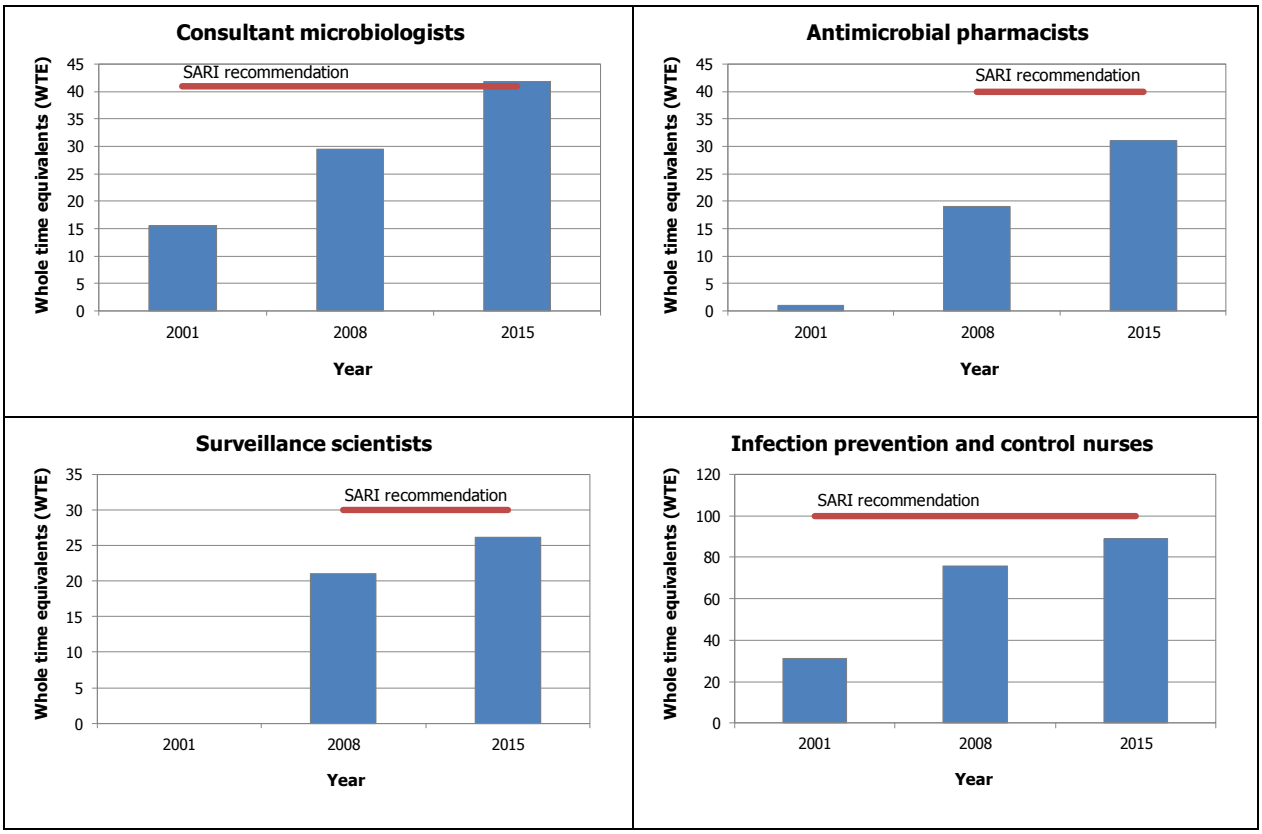
Implementing an effective antimicrobial stewardship programme relies on the capacity and capability of specialized staff to effectively implement it. However, it is important that there is support from — and engagement with — prescribers and senior hospital managers to ensure success.

3.3 Workforce planning

Workforce planning is essential for forecasting possible future workforce needs and maintaining a well-structured, effective workforce of an appropriate size, which is able to meet the evolving service needs in an efficient manner.[60] Workforce planning helps to ensure sufficient staff availability at the right time, with the right skills, diversity and flexibility to deliver high-quality care.

In the years following the publication of the 2001 SARI report, there was significant national investment in specialist antimicrobial stewardship and infection prevention and control staff. Consultant microbiologists, consultant infectious diseases physicians, antimicrobial pharmacists, surveillance scientists, and infection prevention and control nurses were appointed. These positions (see Figure 2) were predominantly assigned to acute hospitals.

Figure 2. Staffing compared to national SARI recommendations for WTE specialized staff for infection prevention and control, and antimicrobial stewardship



Notes:

- WTE = whole-time equivalent.
- The red line ——— denotes the SARI recommendations for staffing levels.[61] Staffing levels refer to posts in publicly-funded acute hospitals and do not include academic sessions, public health and other non-hospital appointments.
- Consultant microbiologists: SARI recommendation based on Royal College of Pathologists guidance for minimum staffing.
- Antimicrobial pharmacists: based on the SARI recommendation of at least one whole-time equivalent for large acute hospitals, and at least 0.5 whole-time equivalent for smaller acute hospitals.
- Surveillance scientists: based on the SARI recommendation of at least one whole-time equivalent for large clinical laboratories, and at least 0.5 whole-time equivalent for smaller clinical laboratories.
- Infection prevention and control nurses: based on a past minimum ratio of one infection control nurse to every 125 acute inpatient beds. This does not include requirements for long-stay institutions and community-based services.

In 2008, the onset of a severe economic downturn in Ireland resulted in a significant decline in the public finances, and a reduction in overall healthcare expenditure. As one of the emergency financial control measures introduced to deal with this crisis, a government

moratorium on recruitment and promotion across the public health sector was enacted in March 2009.[62]

This government policy, coupled with various incentivized exit schemes, led to significant reductions in staff numbers across the healthcare sector at a time of increasing health service demand. Health service staff numbers reduced from a peak of 112,771 whole-time equivalents (WTE) in 2007 to 103,884 in December 2015.[63] Therefore, the period following the moratorium necessitated extensive re-organization, restructuring and reform.

This HIQA review assessed the allocation of the specialized workforce necessary for antimicrobial stewardship, and infection prevention and control, in light of the contraction of the workforce in public acute hospitals. Specific findings are outlined further in the report, but in general terms it can be seen that overall staffing levels in key specialist positions have in fact increased since 2008, at a time when overall staffing levels in the health service have declined.

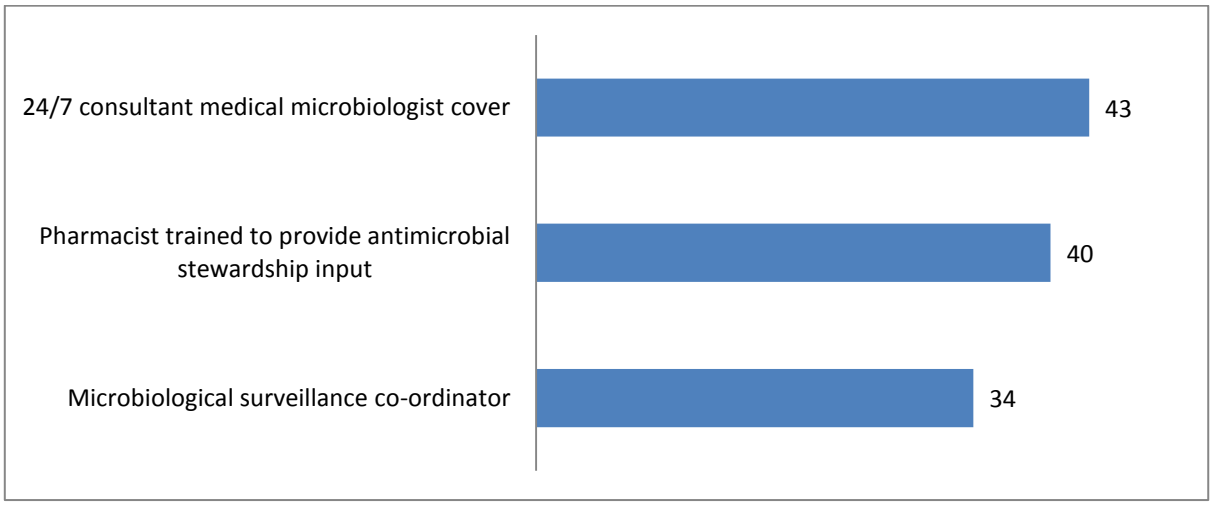
3.4 Antimicrobial stewardship team essential elements

The HIQA self-assessment tool identified a number of essential baseline essential elements for antimicrobial stewardship that were deemed to be necessary for all hospitals to have in place to provide a minimally acceptable level of antimicrobial stewardship. In terms of workforce requirements, the following criteria were considered to be essential elements for antimicrobial stewardship in public acute hospitals:

- 24-hour access to a consultant medical microbiologist
- a clinical pharmacist who contributes to the antimicrobial stewardship programme
- a named staff member with responsibility and allocated time for microbiological and infection surveillance.

Self-assessment information was received from 45 providers in respect of all 49 acute hospitals (see Figure 3).

Figure 3. Number of hospitals out of 49 public hospitals where essential workforce elements for antimicrobial stewardship were in place, July 2015



Note: one combined response was received from four hospitals who share resources in the same hospital group. Overall, there were therefore 45 responses relating to 49 hospitals.

The most notable staffing deficiencies were observed in some Model 2 hospitals, and a number of Model 3 hospitals. Some hospitals highlighted difficulties in attracting and retaining consultant microbiologists. This issue was most pronounced in Model 2 and 3 hospitals.

In determining the best possible configuration of staff required to implement an effective antimicrobial stewardship programme, all public acute hospitals need to continually evaluate their arrangements in relation to specialist staffing. This is to ensure that they have the correct staff, with the required skills and competencies, and in sufficient quantity, to ensure an effective antimicrobial stewardship programme tailored to each hospital's individual needs.

However, this review identified that regardless of hospital type, access at an absolute minimum to an antimicrobial pharmacist, working with a medical microbiologist, represented a core requirement for any programme to succeed. This HIQA review found that the failure to have both of these specialists working together in some hospitals resulted in significantly less effective antimicrobial stewardship, thereby likely increasing risks to some patients.

3.5 Specialist workforce

3.5.1 Consultant medical microbiologists

National Standards and guidelines state that antimicrobial stewardship programmes should be led by either a consultant medical microbiologist or a consultant infectious diseases physician with dedicated time to lead and direct the antimicrobial stewardship programme.[44] National Standards state that all prescribers in acute hospitals should have 24-hour access to clinical microbiology or infectious diseases expertise.[7]

The 2001 SARI strategy[43] said the number of consultant medical microbiologists then in place nationally was inadequate (at 15.5 whole-time equivalents). SARI recommended that the minimum number of consultant medical microbiologist posts required in Ireland at that time was 41.7 whole-time equivalents (WTEs). This recommendation was produced by the Royal College of Physicians of Ireland's Faculty of Pathology, and was based on the UK's Royal College of Pathologists' guidelines,[64] which took account of workload and population.

In July 2015, the number of WTE consultant medical microbiologists in post nationally was identified as 41.52 (see Figure 4). Medical microbiology NCHDs comprised 17.5 WTE registrars and one WTE senior house officer. Thirty-eight hospitals had a consultant medical microbiologist with a dedicated on-site commitment. Of the hospitals that had an antimicrobial stewardship programme in place, 36 hospitals reported that the consultant medical microbiologist was responsible for leading the programme. HIQA found that two hospitals did not have access to a consultant microbiologist for advice on a 24-hour, seven-days-a-week basis in line with national guidelines.

Therefore, in July 2015, some 14 years following the SARI recommendation, minimum national staffing requirements for consultant microbiologists had been achieved. However, in the corresponding years, the Irish healthcare system, patient populations, advances in healthcare interventions and the range and complexity of work undertaken by medical microbiologists have changed significantly. Workforce requirements need to be reviewed to reflect these changes.[◇]

An announced inspection by HIQA in one hospital, as part of this review of antimicrobial stewardship, identified that where access was not available 24 hours a day, the lack of an adequate consultant microbiologist resource resulted in the following situation.

[◇] SARI's calculation of the required number of medical microbiologists made reference to guidance then provided by the UK Royal College of Pathologists. HIQA is aware through personal communication that this guidance recommendation is currently under review by that body. Any further workforce planning in this area should note any future change in recommendations made by the Royal College of Pathologists.

- Expert advice was unavailable to support staff in the effective treatment of infected patients in an out-of-hours situation, or at weekends.
- The microbiology laboratory could not qualify for laboratory accreditation, which is not in compliance with the Infection Prevention and Control Standards.
- Microbiological tests were being performed without clinical oversight of microbiology laboratory reporting results.

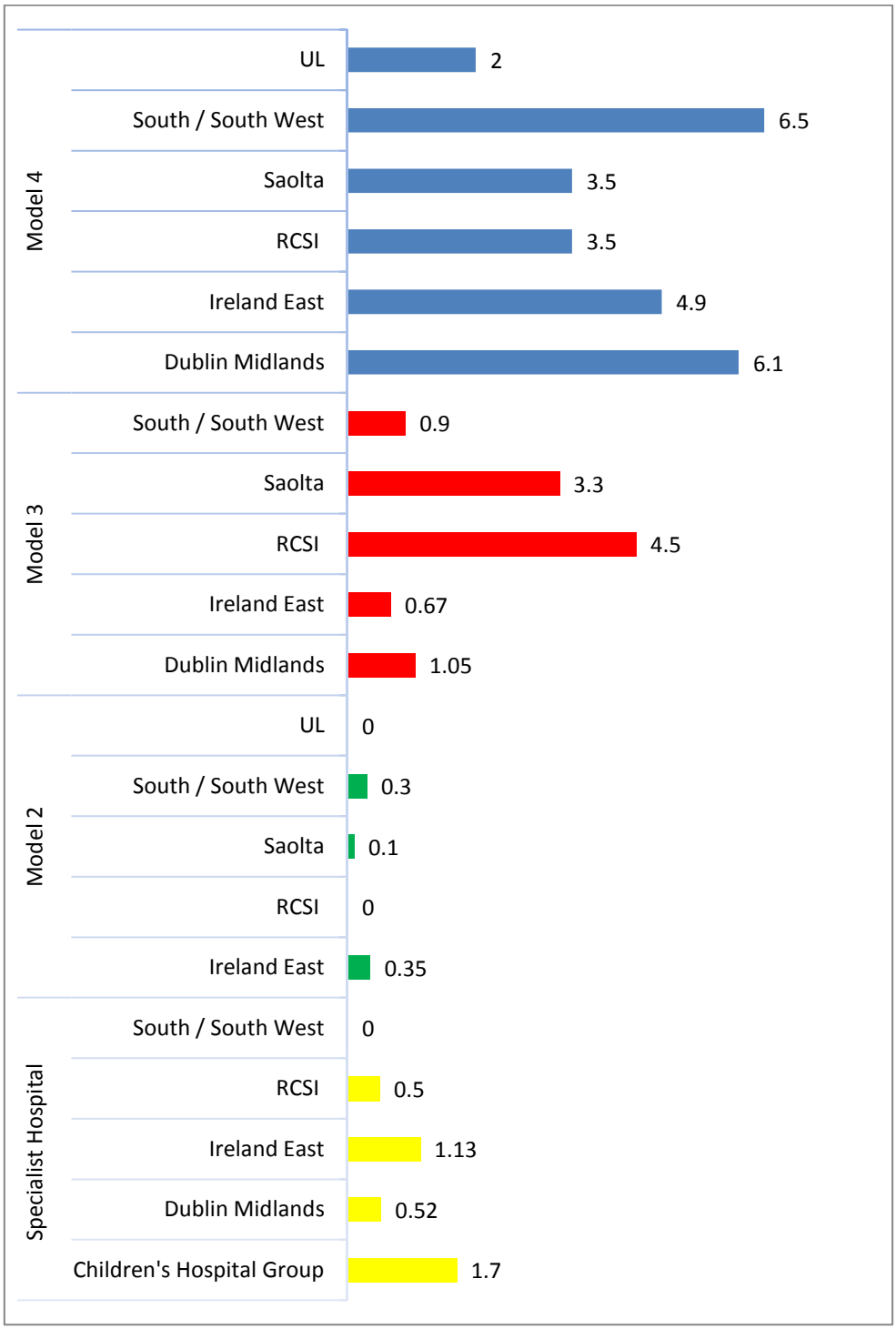
HIQA believes such arrangements represent a high risk to patient safety, and in this particular case formally escalated its concerns to the relevant hospital group management team so that the risks associated with this situation might be mitigated.

During HIQA's announced inspections, it emerged that some vacant positions nationally have historically struggled to attract any applicants, particularly in locations where medical microbiologists are required to provide out-of-hours cover with limited relief.

Announced inspections found some medical microbiologists were on call every evening and at weekends (except for periods of leave), and that while others had shared rosters, the on-call commitment was significant. This represents a significant challenge for staff and has implications for long-term sustainability and staff retention.

A reliance on temporary rather than permanent consultant microbiologists in a number of hospitals had impacted on their ability to plan for the future. A lack of continuity of leadership and reduced resources in some hospitals had in general hampered antimicrobial stewardship programmes. Without stable leadership, advancement in hospitals of antimicrobial stewardship, and indeed other areas of compliance with the Infection Prevention and Control Standards, will most likely fail to progress. Additional measures in some hospitals are required in order to better support consultant microbiology posts, help with staff retention and make these positions more sustainable and effective.

Figure 4. Total number of WTE consultant medical microbiologist positions allocated by hospital type in each hospital group in public acute hospitals, July 2015



As proposed in *The Establishment of Hospital Groups as a transition to Independent Hospital Trusts*,[48] published by the Department of Health in 2013, seven regional hospital groups, each containing smaller and larger hospitals, are in the early stages of being developed.

As a result of the formation of these new hospital groups, this review identified that a number of consultant microbiologists had existing joint on-site hospital commitments which spanned two hospital groups under the new organizational structure. However, at the time of this review, working arrangements had not changed to realign their services with the new group configuration. It is therefore important that future changes in hospital configuration are planned to positively impact on antimicrobial stewardship programmes, and that effective governance arrangements are put in place.

During this review, HIQA also identified the presence of newly created joint appointments of consultant microbiologists across hospitals within individual groups. It was evident that such an arrangement can lend itself to collaboration across the group, and can result in synergies if planned and implemented well. However, in establishing such posts, it is important that sufficient resources are allocated to enable effective services to be provided across sites, because it was evident during this review that resources were not evenly distributed within the hospital groups.

In evaluating the distribution of consultant medical microbiologist positions by hospital group, HIQA identified that the allocation was largely proportionate to the cumulative number of beds provided in each group. However, on further review, it became clear that a higher concentration of positions were allocated to Model 4 hospitals (the largest hospitals, providing tertiary care and, in certain locations, supra-regional care) and also specialist paediatric and maternity hospitals.

In comparison, consultant microbiology resources were lacking in some Model 2 hospitals (general hospitals without 24-hour acute surgery). Furthermore, resources in Model 3 hospitals were regularly deployed thinly across those hospitals. These findings are illustrated in Figure 4, which shows a relatively reduced distribution of consultant microbiology staffing resources across Model 2 and Model 3 hospitals, relative to hospital size, in comparison to other hospitals types.

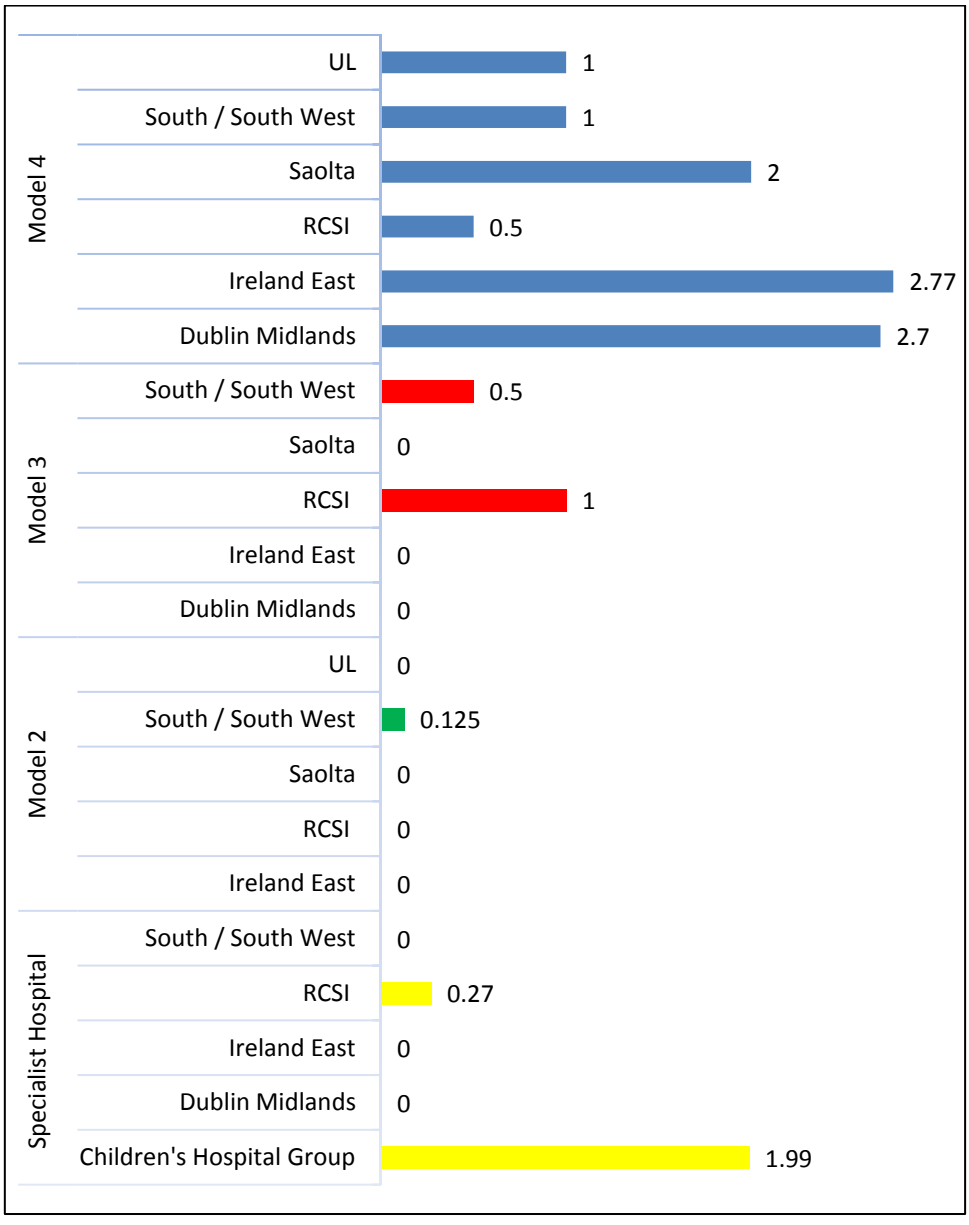
3.5.2 Infectious diseases physicians

It was reported that there were 13.8 WTE consultant infectious diseases physicians in post in July 2015 (see Figure 5). These posts were additionally supported by a national complement of assigned non-consultant hospital doctor (NCHD) posts, which comprised 11 WTE registrars and 11.5 WTE senior house officers. Thirteen hospitals (just over one in four) had access to an infectious diseases physician. Infectious diseases physicians were identified as the leaders of antimicrobial stewardship programmes in three hospitals; these were predominantly in Model 4 hospitals.

Where hospitals had access to an infectious disease physician, there was evidence of strong collaboration between the infectious diseases physicians and other core stewardship team members, including medical microbiologists and antimicrobial

pharmacists. This cooperation has created an effective model for dealing with the many challenges of antimicrobial stewardship in those hospitals. It was reported that infectious diseases physicians add extra capacity and expertise to the stewardship programme by providing expert antimicrobial advice and education, and by developing and implementing evidence-based antimicrobial guidelines as part of the stewardship team.

Figure 5. Total number of WTE infectious diseases consultant positions allocated by hospital type in each hospital group in public acute hospitals, July 2015



Infectious diseases physicians also play an important role where present in the provision of outpatient parenteral antimicrobial therapy (OPAT) services. During this review, HIQA identified that OPAT services managed and led locally by infectious diseases physicians were more likely to be able to enable the use of self-administered outpatient antimicrobial

treatment, which increased programme capacity and reduced costs for suitable candidates.

In evaluating the current allocation of infectious diseases physicians in Ireland, HIQA notes that unlike many other specialist roles, direct recommendations as to where the role of infectious diseases physician fits, from an overall workforce planning perspective, were not included in relevant SARI or subsequent reports. It is likely that this reflected the relative lack of positions in place for this speciality at the time of publication of national recommendations for antimicrobial stewardship.

However, it is important that this situation be addressed in national strategic planning that must happen following the recommendations of this review. It is important that clarity with respect to desired outputs from this group of specialist physicians, from a national antimicrobial stewardship viewpoint, is clearly articulated in national planning that follows this HIQA report.

3.5.3 Antimicrobial pharmacists

The role of the antimicrobial pharmacist has developed in a number of acute hospitals systems internationally over the past decade or more.[65] This role, which is generally fulfilled by a specialist trained clinical pharmacist, is recognized as integral to the success of antimicrobial stewardship efforts in hospitals. Typical roles and responsibilities include the regular provision of specialist clinical knowledge, expertise and intervention in the clinical setting, combined with project management and quality improvement responsibilities aligned to the individual requirements of the antimicrobial stewardship programme.

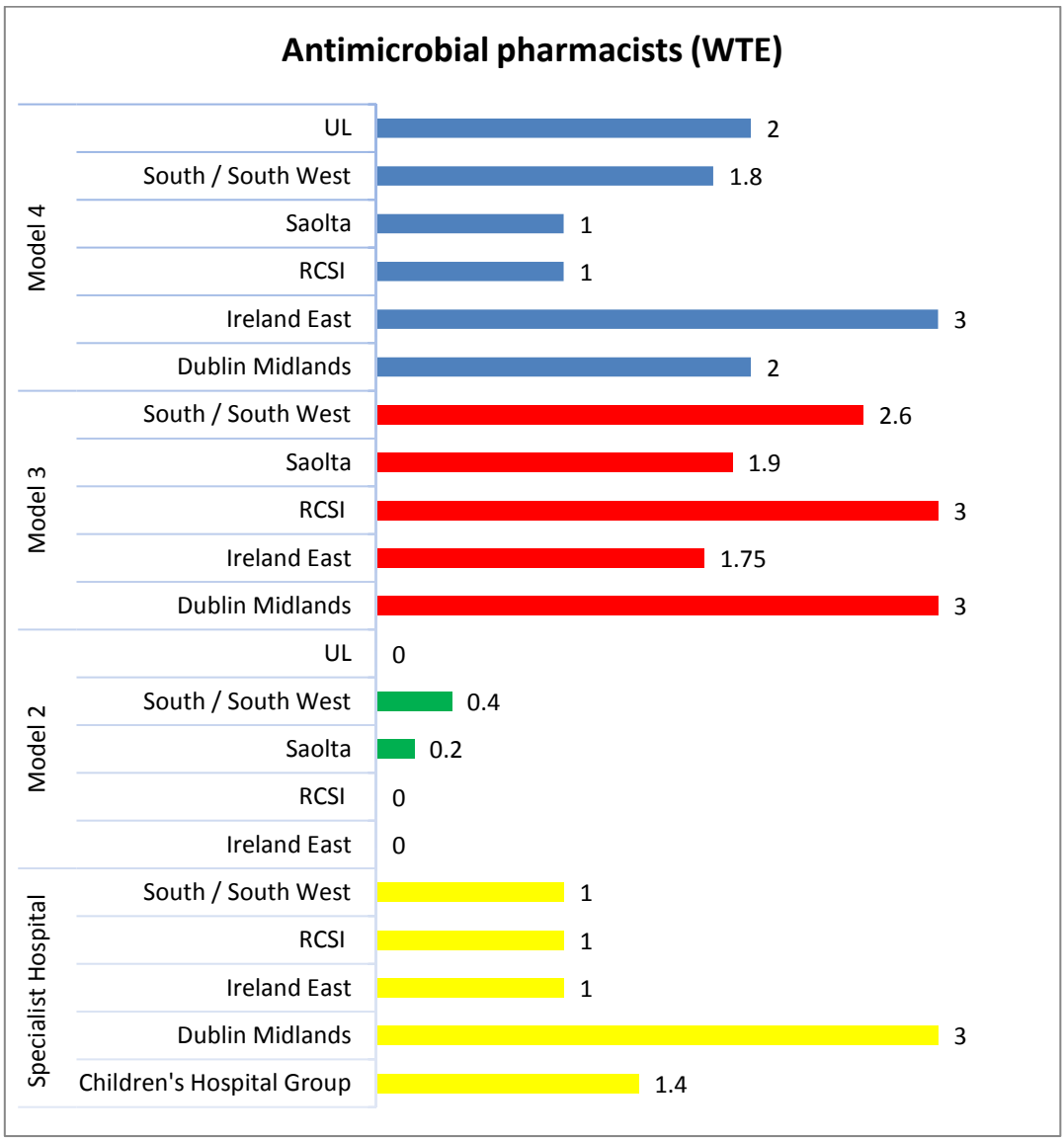
Irish national guidelines recommend that all acute hospitals must have at least one clinical pharmacist with dedicated responsibility for antimicrobial stewardship. Larger hospitals will require one or more full-time positions, where the antimicrobial pharmacist would oversee the antimicrobial stewardship activity of clinical pharmacists if available. Smaller hospitals should have at least one clinical pharmacist with a part-time commitment to antimicrobial stewardship. Antimicrobial pharmacists should receive specialized training.

In 2001, the SARI strategy had recommended a minimum number of 40 WTE antimicrobial pharmacist positions. Despite considerable investment in this resource since the 2001 SARI strategy, HIQA found that there were 31.05 WTE antimicrobial pharmacists in post in public acute hospitals nationally in July 2015. While HIQA found that all Model 4 hospitals had a dedicated antimicrobial pharmacist on site, 12 hospitals, mostly Model 2, did not have access to a specialist antimicrobial pharmacist on site.

A previous investigation conducted by HIQA in 2013 identified a need for further investment in the area of antimicrobial pharmacists in some maternity services.[66] There

was evidence during this review that this recommendation had been implemented in stand-alone maternity hospitals in each hospital group. Figure 6 shows the distribution of antimicrobial pharmacist positions by hospital type and hospital group.

Figure 6. Total number of WTE antimicrobial pharmacist positions allocated by hospital type in each hospital group in public acute hospitals, July 2015



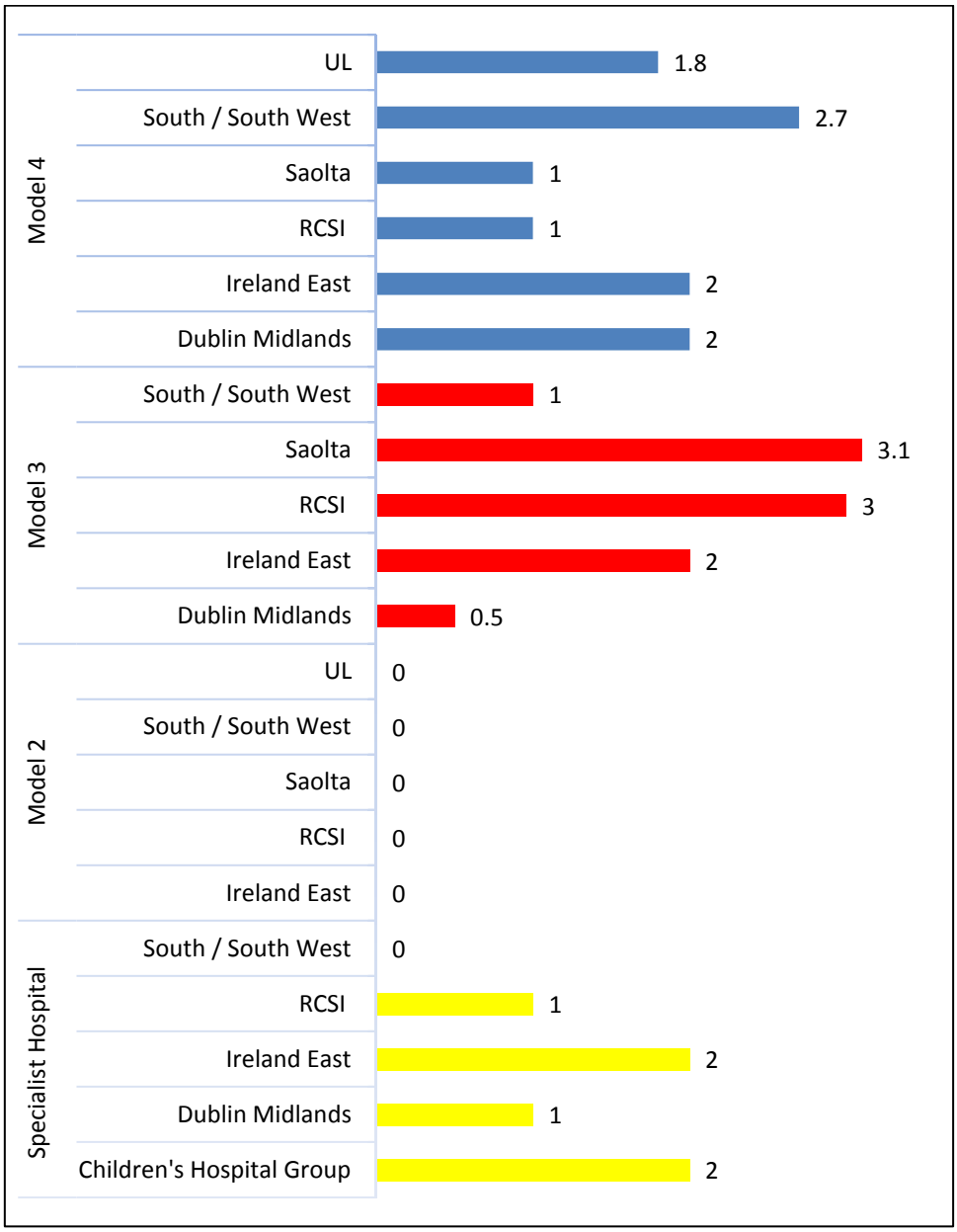
3.5.4 Surveillance scientists

The Infection Prevention and Control Standards state that all diagnostic microbiology laboratory services should include a designated surveillance scientist with sufficient protected time to deliver surveillance requirements. It is recommended that all hospitals have access to a laboratory-based surveillance scientist.

One key role that surveillance scientists fulfil in many hospitals is the production of regularly updated antimicrobial resistance surveillance data, which indicate antimicrobial susceptibility and resistance patterns for key pathogens. This data is crucially important in informing guideline development, and in tracking emergent resistance patterns. Duties also typically include preparing regular surveillance data for the infection prevention and control team to aid assurance and improvement efforts, and preparing monthly and quarterly surveillance data for feedback to the wards, prescribers, relevant managers and to external bodies.

HIQA found that 26.1 WTE surveillance scientists were in position nationally in July 2015 (see Figure 7) — still short of the original SARI recommendations of 30 WTEs. Contrary to current national recommendations, not all hospitals had a named individual with responsibility for coordinating microbiology surveillance. Surveillance scientists are predominantly located in the Royal College of Surgeons in Ireland (RCSI) and Ireland East hospital groups. Twenty-four acute hospitals had one or more WTE surveillance scientists on site.

Figure 7. Total number of WTE surveillance scientist positions allocated by hospital type in each hospital group in public acute hospitals, July 2015



Announced inspections conducted as part of this review further identified a significant variation in how surveillance programmes were being implemented throughout the country. It was evident that output is strongly influenced by the quality and capabilities of information technology systems in each hospital. Moreover, the relative degree of training, experience, dedicated allocation of time, and support provided to surveillance scientists also impacted on their output. Overall, the review identified potential for more coordinated surveillance between hospitals to better inform national surveillance and assurance in the area of antimicrobial resistance and antimicrobial stewardship.

In order to develop an effective national surveillance programme, surveillance activities need to be further standardized, consistent and coordinated at local, regional and national levels.

It would be beneficial to set up a nationally standardized approach for how the data is gathered, processed, analysed and fed back to clinicians at the hospital level. In working to advance a new national plan in this area, careful consideration as to how to further progress the coordination of surveillance should occur to enable greater benefit from what has been a significant staffing investment. Evaluation as to the overall sustainability of such programmes in hospitals in light of regular redeployment of resources should likewise occur within the HSE.

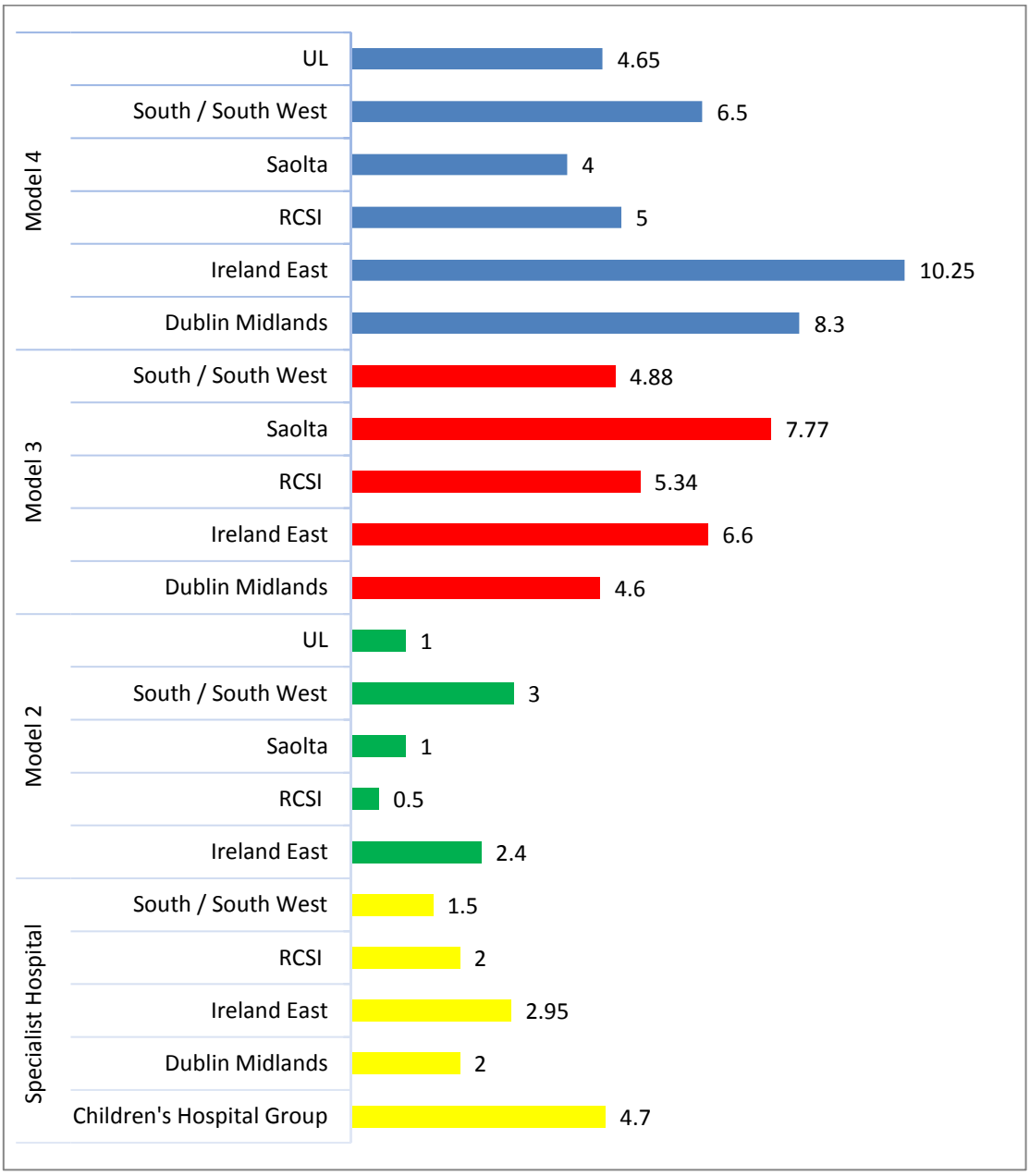
3.5.5 Infection prevention and control nurses

HIQA found that all 49 acute hospitals had access to an infection prevention and control nursing resource. In all, there were 89 WTE infection prevention and control nurse positions in public acute hospitals in Ireland in July 2015 (see Figure 8). While this is a significant increase on the 31 positions identified in 2001, this figure is still below the minimum requirement of 100 infection control nurses identified by SARI in 2001. Internationally, new recommendations regarding the estimation of required infection prevention and control nurse staffing levels have been made since 2008.[67;68] A full evaluation of recent changes to the evidence base in this area should be taken into consideration in future workforce planning.

It is recommended that hospital antimicrobial stewardship programmes should either be integrated with, or work closely with, a hospital's infection prevention and control programme. Such collaboration can potentially improve the effectiveness of antimicrobial stewardship programmes and the wider infection prevention and control programme.

There are a number of areas where infection control and antimicrobial stewardship programmes could cooperate and coordinate. Infection control teams can play an important role in rapidly identifying emergent resistance problems or patients in need of early intervention by the antimicrobial stewardship team. They may also play a key role in ensuring that stewardship activities and infection control improvement efforts are aligned and are complementary, and that education and training of staff is consistent.

Figure 8. Total number of WTE infection prevention and control nurse positions allocated by hospital type in each hospital group in public acute hospitals, July 2015



Close collaboration may also yield benefit in collectively addressing the risk associated with key pathogens, such as *Clostridium difficile*, which will only be effectively controlled through the application of a broad range of infection control and antimicrobial stewardship measures implemented in concert.[(69)]

During this HIQA review, it was evident that input from and collaboration with infection prevention and control nurses was especially important for stewardship programmes in

relatively resource-poor hospitals such as Model 2 hospitals in particular, where the infection prevention and control teams and antimicrobial stewardship teams had common membership, and relied on good teamworking from the limited resources employed.

3.6 Clinical pharmacy services

Highly effective antimicrobial stewardship programmes rely on clinical pharmacy services being available to supplement the efforts of antimicrobial stewardship teams. Historically, pharmacy departments in hospitals largely fulfilled a medication supply function. However, internationally and in most Irish hospitals, this traditional role has long since significantly evolved to include greater clinical involvement in ensuring the safe and effective usage of medicines. The role of the clinical pharmacist — and more recently the pharmacy technician — has advanced to one of intervention in the clinical setting, as part of the multidisciplinary team. The role of the clinical pharmacist as it relates to antimicrobial stewardship is further explored in Chapter 5 of this report.

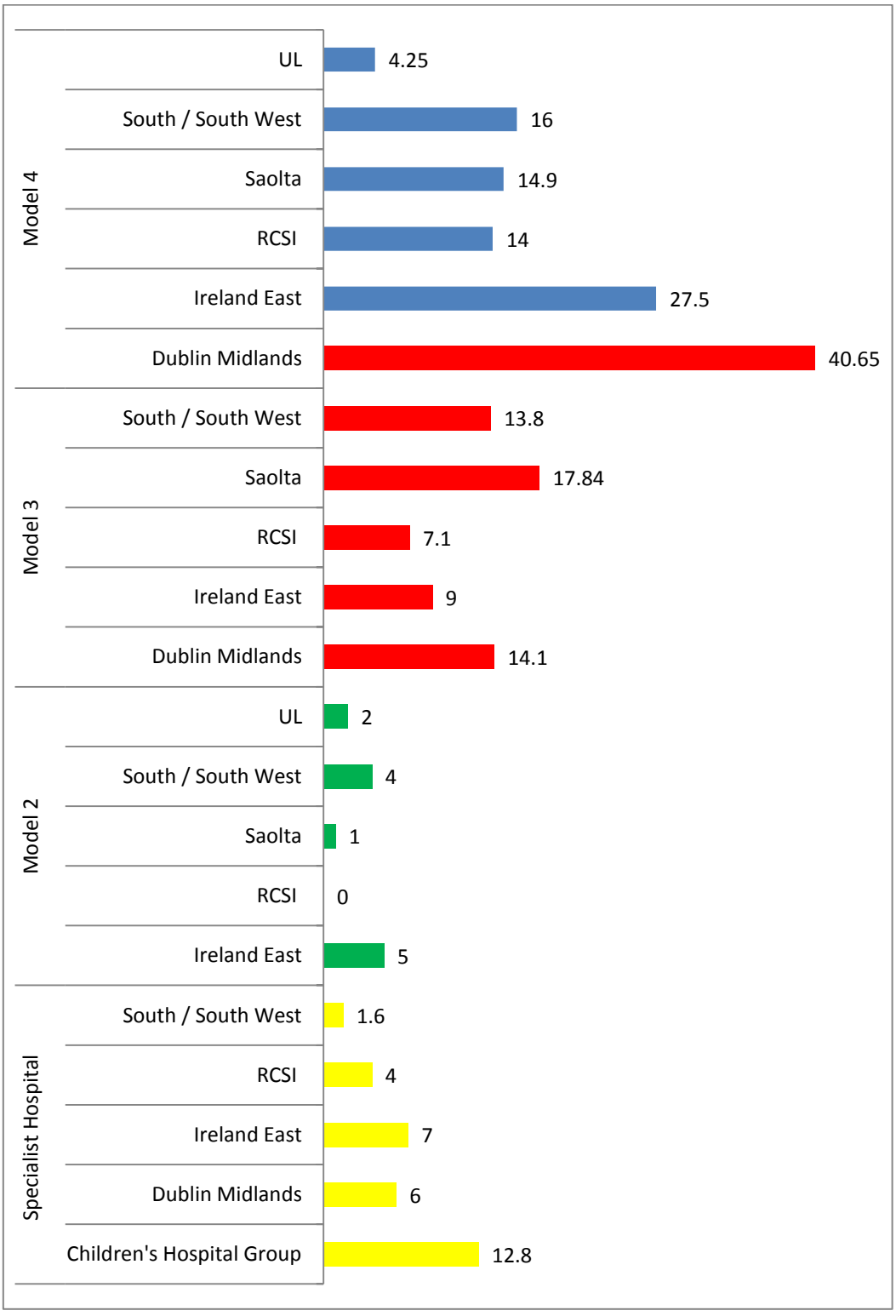
As part of this review, HIQA needed to find out how clinical pharmacists were engaged in ward-based clinical activities (as opposed to strictly medication supply, managerial or other support roles) across the country. This line of enquiry was driven by a need to understand the wider landscape of support for antimicrobial stewardship teams from the perspective of quality assuring prescribing.

Evaluation of responses demonstrated significant variation among the level of staffing by hospital type and geographic location. HIQA found there were 222 WTE clinical pharmacists involved in ward-based activity in post nationally as of July 2015 (see Figure 9). Of these:

- 52.7% worked in Model 4 hospitals
- 27.8% worked in Model 3 hospitals
- 5.4% worked in Model 2 hospitals and
- 14.1% provided service in specialist hospitals.

This HIQA review found that almost half of clinical pharmacist posts were located in the major Dublin academic teaching hospitals. In examining the staffing levels in each hospital — in whole-time equivalent posts divided by the number of hospital beds — HIQA identified that staffing is most thinly spread in statutory Model 3 hospitals, particularly those in rural settings.

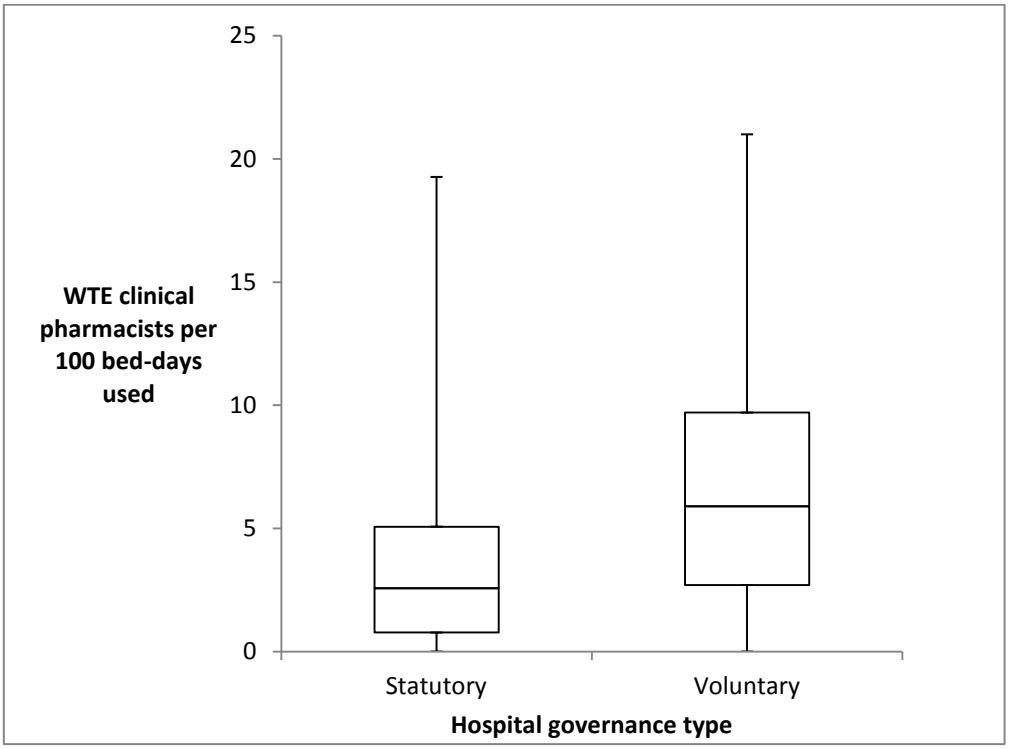
Figure 9. Total number of WTE clinical pharmacist positions allocated by hospital type in each hospital group, July 2015



Further evaluation also outlines a higher degree of national deployment of clinical pharmacist posts in voluntary hospitals (which are funded by the HSE but independently

run), rather than statutory hospitals (those funded and directly run by the HSE) (see Figure 10).

Figure 10. A box plot outlining the relative degree of clinical pharmacist employment per 100 bed-days used in statutory (HSE) hospitals and voluntary hospitals funded by the HSE



A higher proportion of voluntary hospitals in Ireland provide specialist or tertiary services, compared with HSE hospitals, and it might be expected that there may be a greater degree of need for specialist clinical staff in these settings. However, it is also true to say that many of the services provided by clinical pharmacy services are generally applicable in all acute hospital settings.

While a small number of the better resourced departments in some Irish voluntary hospitals would be comparable with international norms in some healthcare systems,[70-72] most Irish hospitals would experience leaner resourcing.

In contrast to the work conducted under the initial guidance of the SARI strategy to develop infection prevention and control and antimicrobial stewardship, HIQA is aware that a similar approach to medication safety is still awaited.

Consequently, there are no defined national standards specifically outlining what each public acute hospital should have in place to promote best practice in medication safety and medicines management. Internationally, there is limited information to guide what is an appropriate level of a clinical pharmacy service and related staffing in a general

hospital setting, although there is information to support particular staffing levels in specialist units such as adult and neonatal intensive care units.

In the past, however, in many healthcare systems, clinical pharmacy resourcing levels and corresponding services have been progressively built up beyond those found in many Irish hospitals. In addition, while specific workforce recommendations may not be readily available, many healthcare systems and accreditation bodies have set standards for pharmaceutical care which require an inherent investment in human and other resources.

Specific standards such as these referred to immediately above are not in use in publically-funded acute hospitals in Ireland, although the *National Standards for Safer Better Healthcare* (2012)[73] highlight the overall importance of medication safety. In the absence of specific standards, it is Irish voluntary hospitals that have historically had more autonomy to recruit staff and determine individual workforce needs, and that have invested more extensively in this area.

HIQA found that clinical pharmacy staffing varied widely across public acute hospitals. During the announced inspections, it was evident that this has had a significant impact on what can be achieved by antimicrobial stewardship programmes. While there may be a case for significant investment in many hospitals, it is important that any investment is accompanied by a clear strategic vision of what needs to be achieved. Any evaluation of need should also consider the desired model of care to be adopted, the required level of necessary supports for management grades, and the potential role for technology in promoting efficiency.

3.7 Redeployment of core specialist staff to other duties

HIQA found that as a result of staffing shortages, some core specialist grades of staff in approximately one in five hospitals were redeployed to other hospital duties at some stage over the preceding five years. Sixty percent of hospitals reported that they had insufficient staff to carry out all desired antimicrobial stewardship activities. Surveillance scientists and antimicrobial pharmacists were the most frequently redeployed antimicrobial stewardship team members, with typical weekly redeployment ranging up to 24 hours per working week for some staff members.

3.8 Education and training of specialist staff

A key component of any antimicrobial stewardship programme is a well-trained and informed workforce. Such a workforce will include specialized staff who are responsible for coordinating and operationally managing the programme, and the wider staffing complement who are involved in the antimicrobial usage process, including prescribers.

As part of the self-assessment process, hospitals were asked to outline the education and training supports they provide to specialized staff responsible for coordinating the antimicrobial stewardship programme. Three out of four respondents said they provided either allocated time or funding to support training and education around antimicrobial stewardship.

However, the remaining hospitals reported that they provided neither. It was also reported to HIQA that continuing professional development for members of the specialized antimicrobial stewardship teams was unstructured, with potential for greater support for education and training. Following the self-assessment, it was evident that varying levels of support are afforded to antimicrobial stewardship teams to avail of continuous professional development.

There are currently a limited number of training programmes available for staff wishing to specialize in antimicrobial stewardship. Comprehensive interdisciplinary educational resources are required to guide teams in effectively planning, implementing and evaluating antimicrobial stewardship programmes. To achieve this, the development and application of a competency framework, such as those developed elsewhere,[74] should be considered. Such a framework would set out the necessary skills and competencies for key personnel involved in antimicrobial stewardship. This could provide a benchmark for individuals and institutions to evaluate team resources, and develop roles essential to improving antimicrobial use in patient care.

In relation to the ongoing education of staff around antimicrobial stewardship, it is clear that a significant body of work has occurred and is ongoing to improve the standard of knowledge and expertise nationally around antimicrobial stewardship. This is happening both amongst specialized staff and those more generally involved in the antimicrobial usage process. There is potential, however, for greater support for structured education, and training of specialized staff in particular.

3.9 Conclusion

It is evident from this review that there has been significant investment at a national level in the recruitment of specialized staff to create antimicrobial stewardship teams in acute hospitals. Progress in this area should be recognized in the context of a baseline staffing complement, which before the SARI report in 2001, was extremely limited. Furthermore, investment in this area has continued to increase at a time when overall staffing levels have significantly declined across the HSE.

Nonetheless, in examining the distribution of those resources, the degree of specialized resource allocation across hospitals varies significantly. The larger academic teaching hospitals tended to be more comprehensively resourced, with all required team members generally in place. Outside of these hospitals, resource allocation, at the time of this

review, was spread more thinly. In part, this unevenness in distribution has been shaped by difficulties in filling positions in some hospitals, particularly in rural locations. These positions have often required more onerous out-of-hours on-call commitments with less relief, often working alone. In hospitals affected in this way, antimicrobial stewardship activities were less advanced.

While initial workforce requirements were integrated into the SARI process, during this review, HIQA identified a general lack of more recent workforce planning, with some smaller hospitals never having received resources. As a consequence, gaps in antimicrobial stewardship remain.

In comparing resource allocation to the relative size and complexity of services from a risk perspective, it is evident that Model 2 and Model 3 hospitals in particular fare less well in general terms. Many of these hospitals are additionally disadvantaged through weaknesses in resource allocation across each of the elements of a stewardship programme. For example, some Model 3 hospitals lacked on-site consultant microbiologists, allied to a lack of clinical pharmacy services and limited surveillance resources.

As a matter of urgency, further investment in this area should be prioritized on the basis of outstanding risk. This review identified that with the evolution of the new hospital groups, the recent recruitment of joint consultant microbiologist positions across hospitals has begun to positively impact upon group working. If done well, this can improve the collective provision for stewardship across hospital groups, and result in more sustainable working arrangements for individuals in particular posts. This should be further explored by HSE senior management.

Overall, investment in this area has been significant. However, there is a need for a strategic re-evaluation of current and future workforce needs, both in terms of staffing deployment, and expected outputs from staff both individually and collectively. In formulating such a strategy document, progress made in other countries in this area should be considered, as should the relative lack of investment in non-acute healthcare settings, to this point in time.

Chapter 4 — Nationally established antimicrobial stewardship support systems

Summary of key findings

- A progressive approach has been taken to determine performance on antimicrobial consumption in Irish hospitals.
- Ireland has established systems for recording and benchmarking antimicrobial resistance rates with other European countries for key pathogens causing invasive infection, such as bloodstream infection.
- There are less advanced systems to ensure the health service is aware of emergent resistance which does not result in invasive infection (for example in persons who are colonized with a multidrug resistant organism but who are not infected). This means that nationally, these kinds of problems could arise without being detected in a timely fashion.
- There is significant potential for information and communication technology to further support antimicrobial stewardship and infection prevention and control. Possible areas for investment could include electronic prescribing, microbiological surveillance and pharmacy dispensing and recording systems. Planned advances in national microbiology laboratory information technology systems and electronic prescribing in the community are potentially important developments. The current and future development of such systems should be included in national strategic planning that follows this HIQA review.
- Outpatient parenteral (intravenous) antimicrobial therapy (OPAT) services have significantly improved since 2010, when a publically-funded national programme was established. Services were available in nearly two out of three public acute hospitals in 2015, compared to very limited services before this time. However, geographic restrictions currently limit the full extent of this programme's availability.

4.1 Introduction

Chapter 4 describes progress that has been made nationally in Ireland on setting up systems or initiatives that support antimicrobial stewardship activity in hospitals. These systems include antimicrobial consumption surveillance systems and communicable disease and infection surveillance systems. This chapter discusses the current and further potential role for laboratory diagnostics, and improved information and communication

technology supports to aid antimicrobial stewardship efforts. Finally, it describes progress that has been achieved in establishing a publically-funded system of outpatient parenteral antimicrobial therapy (OPAT).

4.2 Antimicrobial consumption surveillance

4.2.1 The current surveillance system for antimicrobial consumption

Ireland has an established national system for reporting on antimicrobial consumption in hospitals. This system was developed and designed by the Health Protection Surveillance Centre (HPSC) in collaboration with acute hospitals in order to convert raw antimicrobial dispensing data from individual hospital pharmacy department dispensing records into an internationally comparable unit of usage by agent type (known as the 'defined daily dose').

This produces a global number of defined daily doses by agent type and class, and also allows for a total consumption number to be generated for a given time period. This data is then divided by the number of bed-days used for each hospital to allow variation over time to be corrected against hospital occupancy and size. This is a mandatory reporting requirement by the HSE, and is collated and measured nationally through the HSE's Accountability Framework.

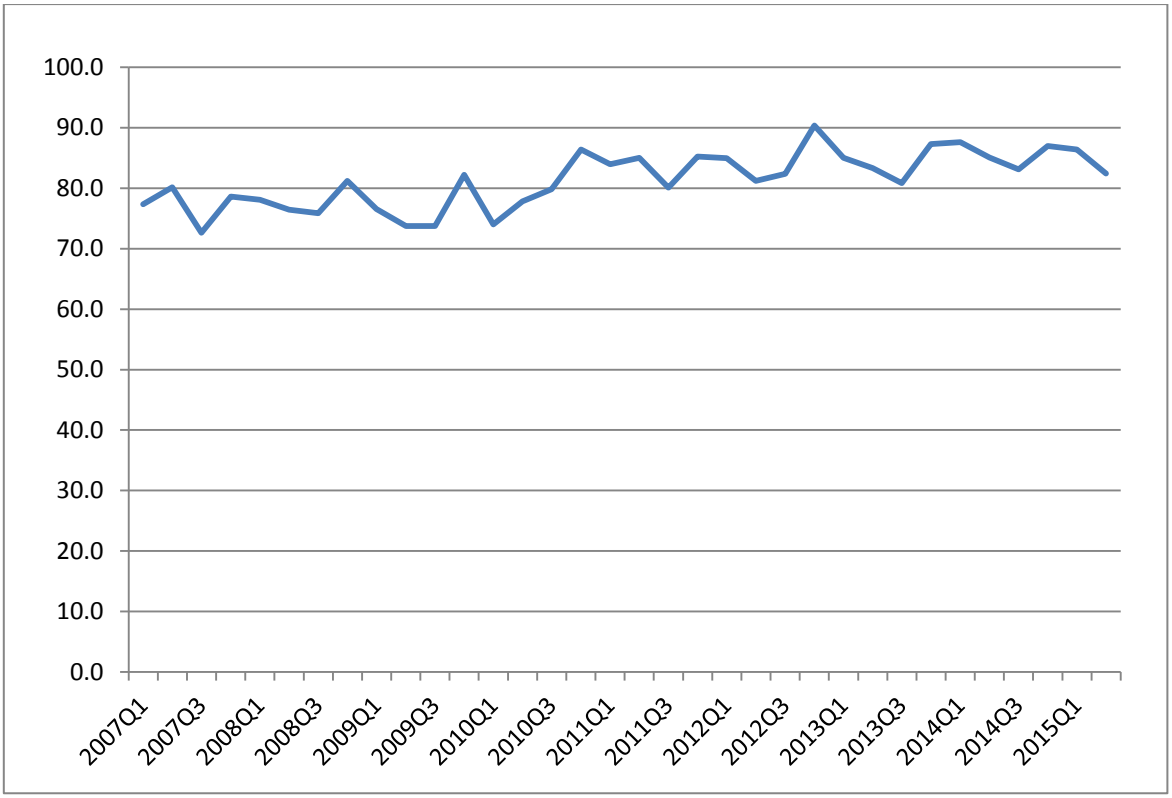
The data is also publically reported on the HPSC's website.[75] Antimicrobial consumption data prepared by the HPSC is fed back to individual hospitals twice a year in the form of a detailed report. This data allows for benchmarking against anonymized peer hospitals, and allows for comparison against a number of key quality measures, including relative usage patterns by antimicrobial class. During the review, HIQA saw evidence of this information being used productively by hospitals to inform improvement efforts. This is further discussed in Chapter 5 of this report.

In an international context, the approach taken in Ireland to advance this system has been progressive. An evaluation of composite national data indicates that overall, antimicrobial consumption appears to have increased slightly since pre-2010 levels, but has remained relatively steady since then, with seasonal increases during winter months. This trend is illustrated in Figure 11.

However, caution needs to be exercised in evaluating this data, as there are a number of confounding factors which can influence the overall result that hospitals report. These factors can include patient casemix and age, the relative length of stay and intensity of treatment provided at the hospital, or differences in antimicrobial dosing policy.

While antimicrobial consumption data can be a crude measure of performance, it does provide a useful benchmark for overall prescribing practice, especially when comparing data over time in an institution, or when comparing regions or countries.

Figure 11. Total national antibacterial usage volume in Irish public acute hospitals (defined daily doses per 100 bed days used), from first three months of 2007 to the first three months of 2015



Note: Q = quarter of year

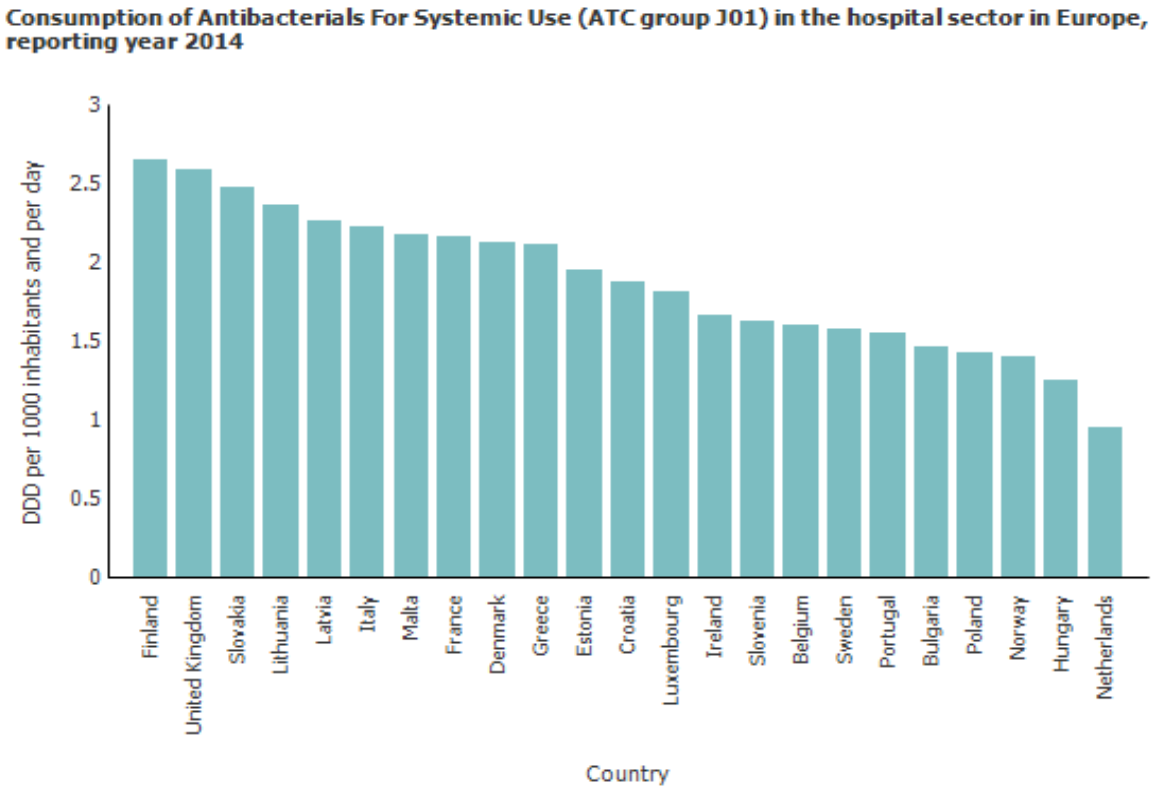
The Irish health service has significantly improved how it measures antimicrobial consumption, with benchmarked feedback being provided to individual hospitals. However, use of this measure should be accompanied by measuring other relevant key performance indicators in order to give a balanced overview of performance across the health system.

4.2.2 International benchmarking

Despite its inherent limitations, measuring antimicrobial consumption is useful for comparing the overall approach to antimicrobial usage internationally. Such measurement has allowed for benchmarking with other healthcare systems, through Irish participation in the European Surveillance of Antimicrobial Consumption programme which is coordinated by the European Centre for Disease Prevention and Control.[76]

The most recent comparable data, which corresponds to usage in 2014, highlights that Irish antimicrobial consumption is slightly less than average when compared to 23 other European countries. This information is illustrated in Figure 12. It should be noted, however, that the relative performance regarding antimicrobial prescribing rates in community settings — as benchmarked by the European Surveillance of Antimicrobial Consumption — would indicate that prescribing rates in Ireland are above average in the community sector.

Figure 12. Consumption of antimicrobials for systemic use in the hospital sector in Europe in 2014[±]



[±] Source — European Centre for Disease Prevention and Control

4.3 National communicable disease surveillance

Ongoing monitoring of antimicrobial resistance is another important quality assurance measure that should be considered alongside antimicrobial consumption when evaluating antimicrobial stewardship performance.

In Ireland, the HPSC is responsible for coordinating communicable disease surveillance at a national level. Collation of locally collected surveillance data enables further early detection of emerging pathogens, monitoring of epidemiologic trends, and measuring the

effectiveness of interventions. Doctors and microbiology laboratories are required by law to report specified communicable diseases. These reports, called notifications, are submitted electronically in individual hospitals to the Computerised Infectious Disease Reporting System managed by the HPSC. This national web-based information system is used to provide standard surveillance reports on the incidence and burden of notifiable communicable diseases nationally, regionally and locally.

Ireland also takes part in the European Antimicrobial Resistance Surveillance Network (EARS-Net), which collects data on antimicrobial resistance of bacteria-causing invasive infection from 28 EU countries in addition to Iceland and Norway. The network undertakes surveillance of antimicrobial resistance patterns of eight indicator pathogens causing invasive infection; it also monitors trends in antimicrobial resistance over time and by country.

Current microbiological reference laboratory services contribute to the collection of data for Ireland as part of EARS-Net and Ireland's international obligations to European surveillance programmes. The HPSC compiles the results for the European Centre for Disease Prevention and Control. Ireland's participation in the EARS-Net programme provides a valuable source of information on levels of antimicrobial resistance among invasive pathogens of public health importance and allows for high-level benchmarking with other European countries. While this system provides valuable surveillance data, it is limited as data is based on samples from patients with invasive infection, meaning the true burden of overall infection and colonization remains unknown.

The 2013 HIQA report, *Investigation into the safety, quality and standards of services provided by the Health Service Executive to patients, including pregnant women, at risk of clinical deterioration, including those provided in University Hospital Galway, and as reflected in the care and treatment provided to Savita Halappanavar*[66] highlighted flaws in the surveillance reporting system. It showed that microbiological or infection surveillance systems in Ireland at that time did not have the capacity to automatically generate national laboratory-based alerts of emerging microbial threats including multidrug resistant organisms. The gaps in Ireland's surveillance infrastructure have previously been highlighted in national guidelines. At the time of this review, these gaps remained.

Investment is needed to further develop national surveillance for all significant multidrug resistant organisms, which includes relevant data not currently captured in the national dataset, including non-invasive infection and colonization. Such a system should aim to integrate data from national, hospital-group, and local levels. National laboratory information systems should provide a platform for surveillance of multidrug resistant organisms and allow for an efficient process of population-based surveillance to be effectively carried out. Such national information technology surveillance systems have

successfully been developed in a number of European countries, and these examples should be used inform implementation in Ireland.

4.4 The role for improved microbiology laboratory diagnostics

Improvements in the approach to diagnosis of infection can help to promote the best possible treatment decisions, and can decrease unnecessary or inappropriate use of antimicrobials. Throughout this review, HIQA identified that significant investment has occurred in many hospitals to advance microbiological laboratory diagnostics. In particular, many hospitals have invested in technology to assist with rapid microbiological testing.

Hospitals reported to HIQA that such an approach had yielded positive benefits: reducing the need for antimicrobials and enabling timely clinical decision-making. For example, one paediatric hospital highlighted reduced bed use, shorter length of stay and reduced antimicrobial usage through its ability to rapidly differentiate viral respiratory infection from bacterial infection through the use of such technology.

National guidelines for antimicrobial stewardship recognize the importance of investing in microbiological diagnostic technology in assisting stewardship efforts. This review identified the need for a more strategic approach to investment at a national level. This requirement should be considered alongside other related national investment decisions in national strategic planning that occurs following this review.

4.5 Information and communication technology resources

The scope for information and communication technology to enhance antimicrobial stewardship and infection prevention and control practice is significant. The next section of this report briefly outlines the current information and communication technology infrastructure in place to support antimicrobial stewardship activities. This infrastructure includes pharmacy department dispensing systems and electronic prescribing systems. Planned developments around electronic health records and laboratory information and communication technology systems are also discussed.

4.5.1 Pharmacy department information technology systems

National guidelines for antimicrobial stewardship in hospitals recognize the importance of having an information and communication technology (ICT) infrastructure in place in hospital pharmacy departments which allows for rapid monitoring of antimicrobial consumption patterns. During this review, HIQA found that the systems in place in the inspected hospitals had been designed with some functionality to allow for report generation. However, it was highlighted to HIQA by front-line staff during the review that more could be done in this area. Further investment in pharmacy department ICT systems

should focus on improved report generation, to aid with quality assurance and improvement efforts.

4.5.2 Electronic prescribing and the electronic health record

Most prescribing in Irish hospitals occurs through use of paper-based systems which are usually unique to individual hospitals. Furthermore, these systems may vary dependent on the ward or unit where a patient is located, meaning that as patients move between units and hospitals and the community as part of their journey of care, re-transcription of documentation is required.

Electronic prescribing has been slow to evolve in publically-funded Irish hospitals. Currently, electronic prescribing has been introduced in a small number of individual units in some hospitals. This review identified that nine hospitals have put in place electronic prescribing systems in their intensive care units (ICUs). These systems allow for prescribing functions to operate alongside other electronically available information such as diagnostic results, which can act as a useful safety and time saving function. The ability to rapidly audit practice is likewise aided by such systems.

In addition, the review identified the presence of electronic prescribing systems in a small number of hospitals in patient populations other than the ICU. Again, these systems had been developed for use in specific patient populations rather than in the wider hospital. It was highlighted in one large academic teaching hospital that advanced plans had been developed to progress a whole-hospital electronic prescribing system. However, it was explained that it was anticipated that implementing such a system was a number of years away.

At the time of this review, most Irish hospitals dispense medicines from their pharmacy departments to a named clinical area rather than on a named-patient basis. There are some exceptions to this, for example, the dispensing of some highly specialized medications. The introduction of named-patient dispensing across all hospitals would require a significant investment in pharmacy department staffing above current staffing levels.

The absence of named-patient dispensing limits the ability of pharmacies to track prescribing to individual patients and individual prescribers. The introduction of electronic prescribing would allow for improved audit, surveillance and reporting, and would significantly aid antimicrobial stewardship activities in hospitals.

While important progress has been made in this area in some units, Ireland remains significantly behind many other healthcare systems in introducing electronic prescribing systems. Some hospitals have local plans to move in this direction, while the individual capability of each hospital to do this differs and depends significantly on the baseline

provision of the wider information technology infrastructure in place. However, if collective improvement is to happen, a strategic national approach to planning and funding is needed.

HIQA is aware that electronic prescribing systems in primary care settings are being developed, in line with the National e-Health Strategy. This HSE e-pharmacy programme is in the very early stages of development, and represents a step in the right direction. Further development of a national standardized approach to electronic prescribing in hospitals should also be explored. It is acknowledged that this will represent a significant medium- to long-term commitment. However, it is important that the HSE promotes this through a national strategic approach, to avoid disparate systems emerging through locally developed and independent initiatives.

Allied to the requirement for electronic prescribing systems is the need for an electronic health record in Ireland. During this review, HIQA explored progress with the HSE in developing an electronic health record. Preliminary work has begun in order to advance such a system. However, given the scale of such a project, it is likely that overall development will take more than a decade to reach from this point in time. Key to the deployment of electronic records in Ireland is the existence of a national health identification number on which the records system is centred.

4.5.3 Medical laboratory information system

Providing high-quality laboratory services is a critical component of patient care, involving diagnostic, monitoring and screening services. A National Health Service Pathology Review carried out in the UK identified that 70–80% of all healthcare decisions affecting diagnosis or treatment involve a pathology investigation, with individual treatment decisions and the monitoring of their response to treatment often dependent on a range of pathology-based tests and investigations.[77]

Ireland currently has 43 HSE-funded hospital laboratories providing diagnostic laboratory medicine services nationwide. However, existing medical laboratory information systems operate independently with limited lab-to-lab connectivity. This mirrors most hospital-wide systems, with each hospital generally operating its own independent information technology system. To address this, these fragmented systems in HSE-funded labs will be replaced over the next four years by a single nationally coordinated Medical Laboratory Information System.

The Medical Laboratory Information System project aims to allow clinicians a complete view of patients' current and historical results. A single complete view is clinically important as it allows for a comprehensive assessment of the patient's laboratory data, comparison with previous results, and is critical in preventing inappropriate re-ordering of tests. It is intended that the new system will support rapid and up-to-date 24-hour

electronic access to test results by healthcare providers across all sites, and a securely stored patient laboratory record. It is important that data collected by this new system is developed to inform and improve national and local antimicrobial resistance surveillance.

4.6 Outpatient parenteral antimicrobial therapy

In a small but increasing proportion of patients who require antimicrobial therapy, long courses of intravenous (also known as parenteral) therapy may be required in order to effectively treat their infection. In some instances, the required course of therapy may last for weeks. Historically, such therapy would require a prolonged stay in hospital to facilitate antimicrobial administration, even though a patient might otherwise be suitable for discharge.

Internationally, many healthcare systems have established programmes which enable intravenous antimicrobials to be given to patients in their home, through what is known as outpatient parenteral antimicrobial therapy (OPAT). In appropriately selected candidates requiring intravenous antimicrobial therapy, outpatient parenteral antimicrobial therapy is a preferred option by patients, and it can reduce length of hospital stay and therefore increase hospital bed availability.

Irish national guidelines advocate the use of outpatient parenteral antimicrobial therapy programmes as a key antimicrobial stewardship intervention. Prior to 2010, various outpatient antimicrobial therapy programmes had evolved locally in hospitals and their surrounding catchment areas. In 2010, outpatient antimicrobial therapy practice guidelines were published by the Infectious Diseases Society of Ireland (IDSI).[78]

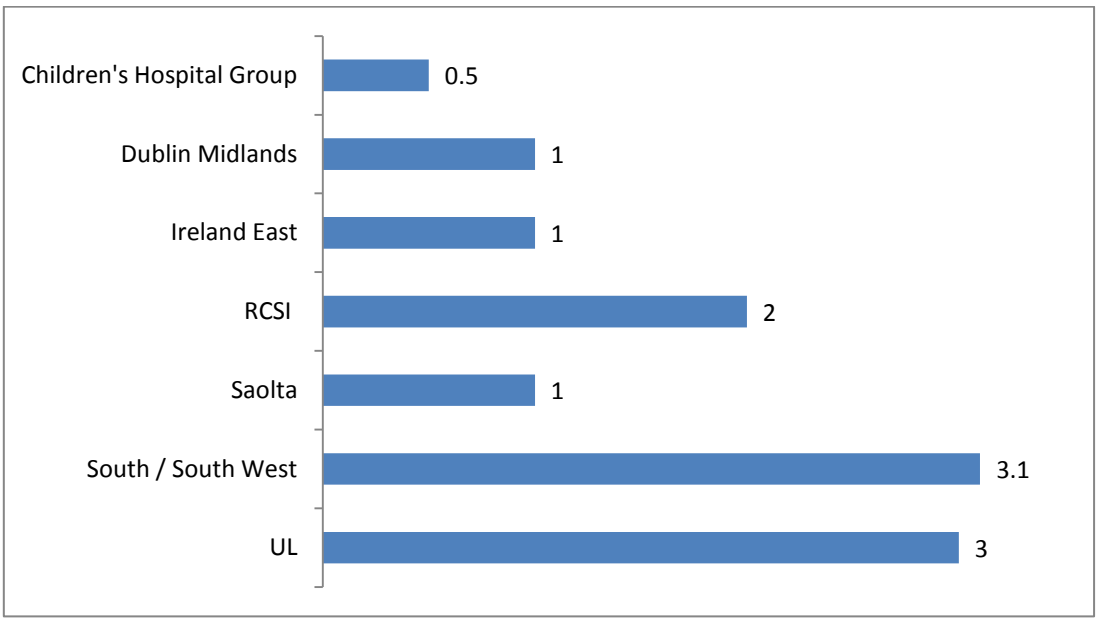
The HSE's National Clinical Programme for Outpatient Parenteral Antimicrobial Therapy was established in the same year. It aims to ensure that no patient receiving intravenous antimicrobials who could be treated outside a hospital setting remains in hospital. It has also been established to develop defined models of care, including standardized care pathways and guidelines to ensure patient safety.

The national outpatient parenteral antimicrobial therapy programme was initially run on a test basis at four sites. These regional hubs were led by infectious diseases consultants who oversaw providing regional outpatient antimicrobial therapy services. The programme was rolled out nationally in 2013. In July 2015, HIQA found that only 62% of hospitals had used outpatient antimicrobial therapy services. Variation in the availability of such services across hospitals was confirmed during the course of HIQA's announced inspections.

A number of Model 4 hospitals have invested in dedicated outpatient antimicrobial therapy nurses to coordinate services locally, leading — it was reported to HIQA — to increased uptake of the service. Future HSE strategic planning should aim to determine the best workforce structure and resources required to expand this initiative. As of July 2015, there

were 11.6 WTE outpatient antimicrobial therapy nurses in post, in 10 hospitals nationally. These hospitals were predominately located in the University of Limerick and South/South West Hospitals Group (see Figure 13).

Figure 13. Distribution of WTE outpatient parenteral antimicrobial therapy nurse positions across hospital groups, July 2015



National guidelines recommend that infectious diseases physicians or medical microbiologists should formally evaluate and select patients suitable for outpatient antimicrobial therapy. There are two outpatient antimicrobial therapy options available in Ireland. Healthcare administered-outpatient parenteral antimicrobial therapy (H-OPAT) is administered by a healthcare professional. In practice, this typically requires a trained nurse to call to the patient's home to administer intravenous antimicrobial treatment. Alternatively, self-administered-outpatient parenteral antimicrobial therapy (S-OPAT) may be used, where antimicrobials are administered either by patients themselves or nominated caregivers.

At the time of this review, most patients in Ireland received healthcare-administered outpatient parenteral antimicrobial therapy, but there had been some progress in advancing self-administration. Self-administration increases the capacity of the programme when used in appropriate candidates, and should be further explored by hospitals. This review identified a number of programmes led by infectious diseases physicians which had effectively moved this model of care forward, and much can be learnt from the approach taken in these hospitals.

Overall, this review found that significant progress has been made nationally since 2010 in providing access to publically-funded outpatient antimicrobial therapy services. HIQA notes

that at the time of the review, the service had its geographic limitations, with non-availability in distant rural areas a feature due to resource limitations. In order to overcome this and increase uptake of the service, further development of the self-administration of outpatient antimicrobial therapy in suitable candidates should be explored where clinically appropriate.

4.7 Conclusion

Chapter 2 of this report highlighted the need to improve national assurance and risk management of infection prevention and control and antimicrobial stewardship. Key to improvement in this area is enhancing national surveillance as described. This HIQA review has identified that significant progress has been made in Ireland in relation to monitoring antimicrobial consumption in hospitals. A good system has been established to provide benchmarked data back to individual hospitals on a regular basis. The work conducted in this area is to be commended.

In addition, national systems for monitoring alert pathogens in invasive isolates are in place, and over time allow for useful benchmarking with other European countries who are collecting similar data. While progress has been made in these areas, significant gaps in the monitoring of non-invasive infection and colonization for alert pathogens, including for example multidrug resistant Gram-negative organisms, exists. As a consequence, national visibility of the emergence and spread of new or problematic multidrug-resistant pathogens is not comprehensive and requires significant improvement.

There is great potential for information and communication technology to underpin antimicrobial stewardship activities in hospitals. Ireland falls behind many healthcare systems in this regard from the perspective of the availability of electronic prescribing systems, harmonized electronic laboratory systems and indeed a wider electronic health record. Recent progress in this area through the publication of an eHealth strategy is to be welcomed, and work to roll out electronic prescribing in the community, allied to a new laboratory information system, are important developments both from an antimicrobial stewardship perspective, and in a wider context.

As has been highlighted throughout this report so far, there is a significant need for an overarching national plan to be developed to further progress and improve the Irish approach to infection prevention and control and antimicrobial stewardship in public acute hospitals, including of surveillance and assurance mechanisms. Likewise, this plan needs to recognize the significant role that information and communication technology can play in improving both this and other areas of the health service.

The Irish public acute hospital system has made significant progress on rolling out outpatient antimicrobial therapy since 2010. Further expansion of this service should be targeted at improved audit and assurance mechanisms, and towards moving into geographic areas that are not currently provided for. Increased use of self-administered outpatient antimicrobial therapy in suitable candidates may aid in improving capacity in this regard.

Chapter 5 — Antimicrobial stewardship in individual hospitals

Summary of key findings

- Good progress has been made in many Irish hospitals to implement best practice in antimicrobial stewardship. Where progress has been made, this has been enabled by the presence of:
  - an appropriate complement of well-trained and well-led specialist staff, working as a team
  - a support framework which includes good laboratory, information technology, surveillance and clinical pharmacy resources, and
  - appropriate governance arrangements with effective senior management support.
- Notable success has been identified in higher performing hospitals in the development of:
  - regularly reviewed evidence-based empiric prescribing[‡] guidelines
  - protected antimicrobial prescribing rights for key strategic antimicrobial agents
  - point-of-care interventions
  - good collaboration between hospitals to make best use of resources, and
  - the integration of antimicrobial stewardship programmes, with wider medication safety and risk management programmes.
- In contrast to those hospitals leading the way on antimicrobial stewardship, performance in other hospitals is hindered in direct proportion to the lack of those various factors outlined above.
- A small number of hospitals had no antimicrobial stewardship programme in place. This is a significant patient safety concern, and is not in compliance with National Standards.

[‡] **Empiric antimicrobial therapy**: antimicrobial therapy given for an anticipated and likely cause of infection based upon probability, but where the causative organism has not yet been identified through microbiological testing.

5.1 Introduction

The following chapter focuses on HIQA's collective findings in relation to the implementation of antimicrobial stewardship in individual hospitals. The presentation of findings in this chapter follows the same structure as outlined in the antimicrobial stewardship self-assessment tool used by the hospitals to provide information to HIQA (see Appendix 2). The essential elements for implementing antimicrobial stewardship in individual hospitals is initially described. The chapter then provides a collective overview of HIQA's findings related to the implementation of additional antimicrobial stewardship elements.

5.2 Essential structural and organizational elements of antimicrobial stewardship

Individual hospitals were asked to define the nature of their antimicrobial stewardship programme from a structural and organizational point of view in the antimicrobial self-assessment tool. Findings (see Figure 14 later in this chapter) were further explored at interview during announced inspections in a sample of public hospitals.

HIQA reviewed governance arrangements in hospitals with respect to antimicrobial stewardship, including oversight by relevant committees, and identification of key personnel in the organization with responsibility for governance and technical leadership of the stewardship programme.

5.2.1 Overall executive accountability

The Infection Prevention and Control Standards state that a hospital's chief executive officer or equivalent should hold overall accountability and responsibility for implementing and monitoring the Standards. Such a requirement reflects both the seriousness of the risk posed by antimicrobial resistance and Healthcare Associated Infection, and the complex multidisciplinary hospital-wide approach required for managing this risk.

Hospitals were asked to identify the person with overall executive responsibility and accountability for antimicrobial stewardship in their organization. The responses outlined that:

- 69% of hospitals identified the most senior hospital manager
- 13% of hospitals identified a named clinical director
- 9% of hospitals identified a senior hospital manager such as a deputy chief executive officer, a chief operating officer or a director of nursing.

The question was not answered in 9% of self-assessments. Follow-up announced inspection in a proportion of those hospitals that did not answer this question identified

that responsibility for overall ownership was poorly defined. Hospitals should ensure that clear accountability arrangements are in place and communicated to all staff.

5.2.2 Leadership of antimicrobial stewardship programmes

Current Standards and guidelines state that an antimicrobial stewardship programme should be led by a consultant clinical microbiologist or an infectious diseases consultant. This is required so that antimicrobial stewardship programmes are led by personnel with the required clinical expertise to effectively lead such a programme. Hospitals were asked in the HIQA self-assessment tool to identify the person or persons who direct the local antimicrobial stewardship programme. Hospitals reported that:

- in 90% of hospitals with a programme reported to be in place (41 hospitals), the programme was led by a consultant microbiologist
- in the remaining 10% of responding hospitals, three programmes were led by an infectious diseases physician, whereas in one hospital the programme was jointly led by a consultant medical microbiologist and an infectious diseases physician.

Although HIQA found that all established antimicrobial stewardship programmes had appropriate leadership, it was of concern, that in one hospital, the programme was led by a temporary rather than permanent staff member. This hospital had relied on the contribution of a series of temporary position holders over a period of time. This had led to difficulties in the hospital's ability to plan for the future with confidence, and had led to interruptions in the programme.

Another hospital described past difficulties in recruiting and retaining a consultant microbiologist, but also reported that it had been more successful in recent times in employing a permanent member of staff to lead the programme. However, this meant that its antimicrobial stewardship programme was significantly less developed when compared to other similar hospitals.

5.2.3 Antimicrobial stewardship programme implementation

National Standards and guidelines state that hospitals should have an antimicrobial stewardship programme in place which reflects the size of the organization and the complexity and type of patients treated in the facility. Hospitals were asked to state if there was a defined antimicrobial stewardship programme in place at their hospital. The responses from hospitals showed that:

- 41 hospitals (84%) reported that they had a defined antimicrobial stewardship programme in place
- eight hospitals (16%) stated that they did not have a defined programme in place.

Although some hospitals stated that they did not have a defined programme in place, HIQA established that they had implemented some measures which would indicate that a basic level of protection to patients was being afforded from an antimicrobial stewardship perspective. However, a statement of a belief that their programmes were not clearly defined indicated a potential deficiency in programme coherence and effectiveness. Contrary to requirements laid out in the Standards and current national guidelines, four acute hospitals did not have any form of antimicrobial stewardship programme in place. This is of significant concern to the Authority.

One hospital reported in the self-assessment that it did not have a defined antimicrobial stewardship programme that was led by a named consultant microbiologist or infectious diseases consultant. This was in spite of employing such specialist staff. Further exploration of this issue during an announced inspection at this hospital revealed that while there were a number of effective stewardship activities in place, which included core activities such as ready access to clinical expertise and well developed guidelines, there was no defined antimicrobial stewardship programme. In this instance, between the time of submission of the self-assessment and the time of HIQA's announced inspection, the hospital had formalized arrangements to lead and govern an antimicrobial stewardship programme.

Another hospital reported that it did not have the necessary specialist staff to implement an antimicrobial stewardship programme. However, recruitment of specialist staff to implement such a programme had been successfully addressed during the course of this review.

HIQA asked hospitals if they had a dedicated budget assigned for antimicrobial stewardship. Only a very small number of hospitals stated that their antimicrobial stewardship programmes had dedicated resources allocated to it. In most hospitals resources were drawn from central funds.

5.2.4 Hospital drugs and therapeutics committees

National Standards and guidelines recommend that all acute hospitals should have a multidisciplinary drugs and therapeutics committee. Larger hospitals require their own individual committees, whereas regional committees are appropriate for smaller hospitals. Larger hospitals may decide to have a designated antimicrobial stewardship committee as a subcommittee of a drugs and therapeutics committee. Committees in larger hospitals should meet at least four times a year.

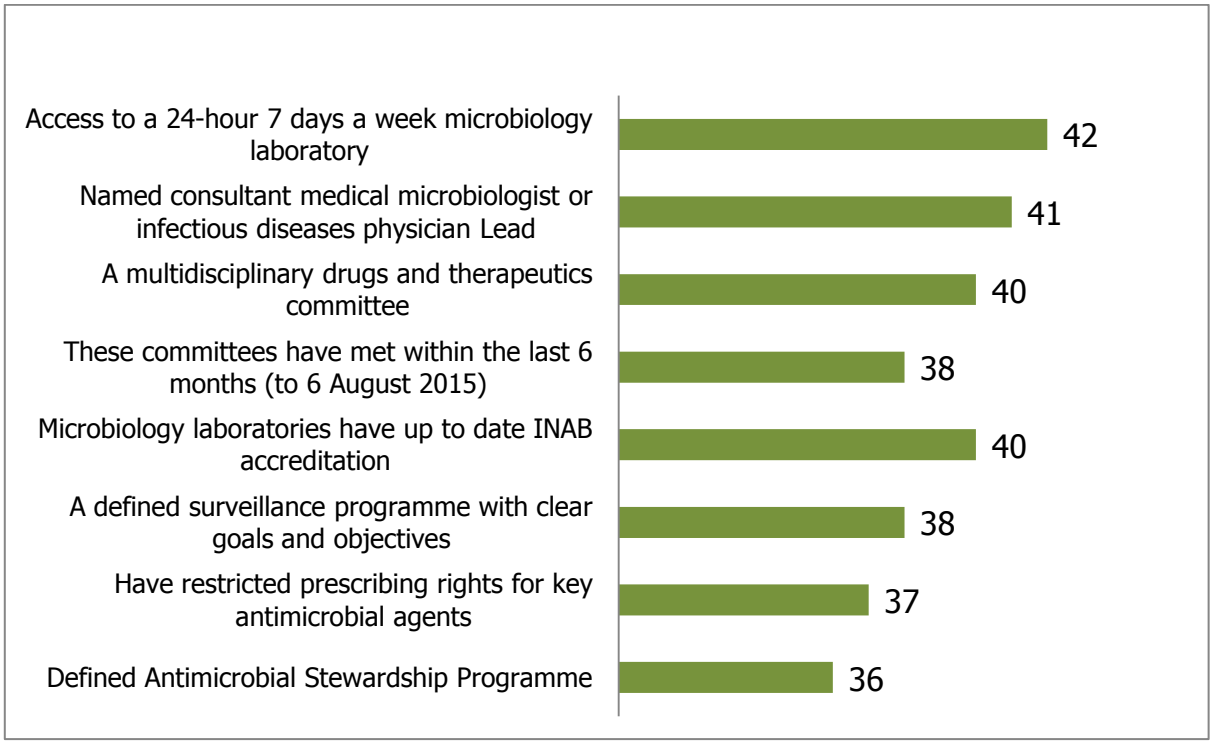
HIQA found that five hospitals lacked a drugs and therapeutics committee. Responses indicated that in one case it was intended to reconvene a dormant committee, albeit a defined time frame for this was not expressed in the response received. In another case, a

hospital described a situation whereby an antimicrobial stewardship committee was in place, but was not active.

Seven hospitals stated that they had active drugs and therapeutics committees, but the evidence from their self-assessment responses indicated that these committees did not meet as often as they should have. One hospital had two separate drugs and therapeutics committees relating to different specialities; however, only one of these committees appeared to have formalized lines of reporting. This was highlighted as a concern to the hospital by HIQA during this review, and subsequently addressed by the hospital.

HIQA's announced inspections confirmed the need for better routine functioning of drugs and therapeutics committees in some hospitals. While a number of hospitals were able to demonstrate the reinstatement of drugs and therapeutics committees in the time between self-assessment completion and announced inspection, HIQA has concerns that such a process may have occurred in response to regulatory scrutiny rather than through wider hospital governance expectations.

Figure 14. Self-assessment responses identifying the presence of essential structural and organizational antimicrobial stewardship elements (out of 45 responses)



The lack of well-functioning drugs and therapeutics committees in hospitals is a significant deficiency, both for antimicrobial stewardship governance and medication safety more generally. It is critically important that antimicrobial stewardship programmes are appropriately embedded into the wider governance structures for medication usage, and that there are close reporting links to the hospital infection prevention and control

committee or equivalent. Failure to ensure such an arrangement presents a risk of poor programme alignment, and underdeveloped or unclear processes for risk escalation and management where needed.

It also presents the risk that the antimicrobial stewardship programme may remain confined to the efforts of those individuals specifically tasked with advancing antimicrobial stewardship in their respective hospitals, rather than all antimicrobial prescribers and other relevant staff who have an equally important role to play. As a consequence, programme effectiveness in achieving sustained change management is hindered. This represented one of the more significant findings from this review.

5.2.5 Programme priorities

Hospitals were asked to outline the top three priorities for their antimicrobial stewardship programmes for 2015 as part of the self-assessment. Responses were varied, which was reflective of the various individual needs of each programme, and their relative degree of development. Most of the priorities listed were task oriented, and included the identification or a need for updating prescribing guidelines, improved education and training for staff, or targeted audit.

Some programmes had identified particular patient populations or medication-specific areas for focused improvement efforts, while many hospitals cited the need, as a matter of priority, to ensure good practice with respect to using the ultra-broad-spectrum antimicrobial, meropenem.

A number of hospitals identified, as a priority for 2015, that they needed to change their programme governance arrangements and reporting lines. Others intended to improve collaboration and to formalize working arrangements with other hospitals in their group. A minority of hospitals also cited process or outcome-related targets among their priorities for the year; for example, some identified as a priority a requirement to reduce antimicrobial consumption or cost by a percentage value, or a targeted reduction, or maintenance of low *Clostridium difficile* infection rates.

5.2.6 Microbiology laboratory services

National Standards recommend that there should be access to an accredited clinical microbiology laboratory with appropriately trained and qualified staff, on a 24-hour basis. This is necessary in order to ensure that the microbiology laboratory operates in line with international quality control standards. Accreditation of the microbiology lab by an independent external assessor also provides assurance to senior managers that this service is operating in line with best practice criteria.

Five hospitals reported that their microbiology laboratory did not have up-to-date accreditation from the Irish National Accreditation Board. One microbiology laboratory was not eligible for accreditation due to a lack of required 24-hour microbiology cover. Three hospitals reported that they did not have on-site access to a 24-hour, seven-day-a-week microbiology laboratory, but had made alternative arrangements for clinical specimen processing outside of normal working hours.

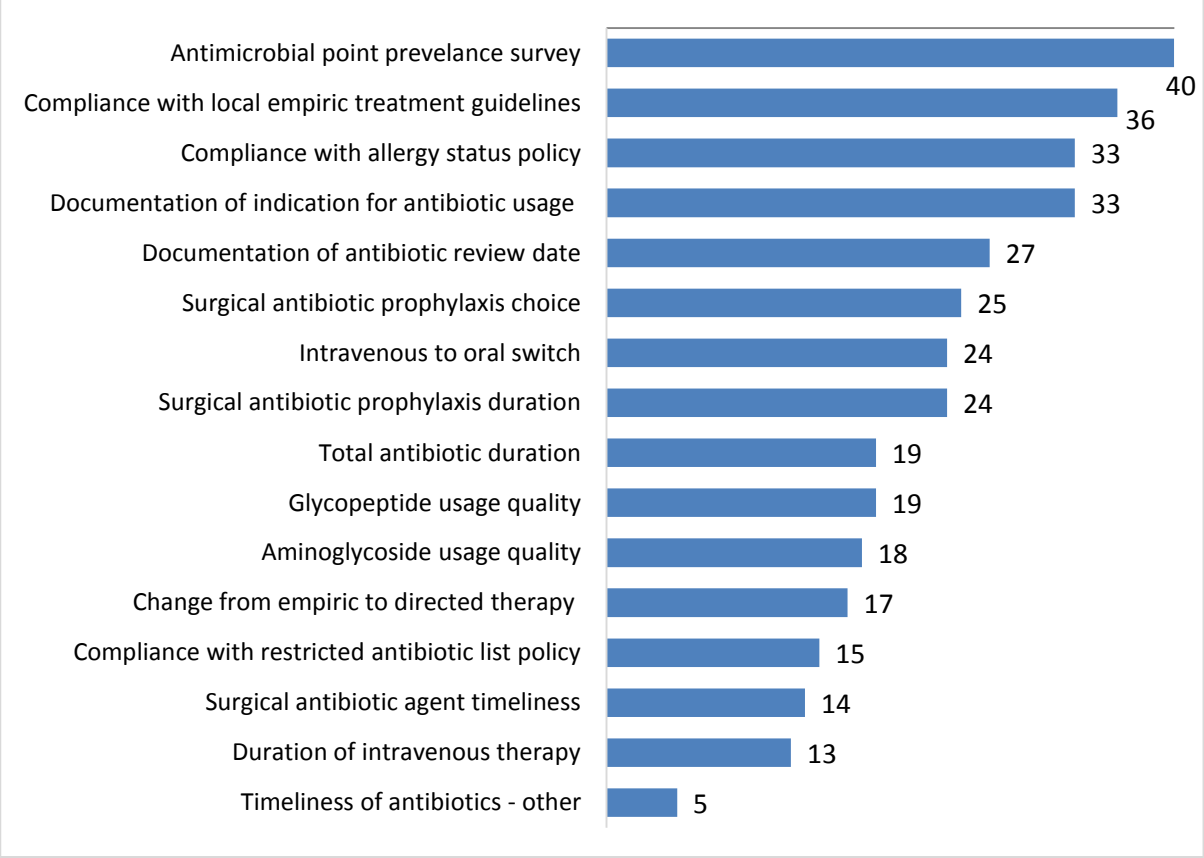
5.3 Essential audit and surveillance elements

5.3.1 Audit

A key component of any antimicrobial stewardship programme is the effective identification and management of risk associated with antimicrobial use. An active approach to risk management is critical, while a key component of any governance framework is planned audit, with reciprocal improvement where required.

In evaluating essential antimicrobial stewardship elements for all acute hospitals, HIQA and its External Advisory Group determined that a critical component of any antimicrobial stewardship programme is the presence of a planned and ongoing programme of audit of antimicrobial usage. As a result, hospitals were asked to provide evidence of audit, and specifically their three most recently completed antimicrobial-related audits (see Figure 15).

Figure 15. Number of hospitals conducting identified clinical audits over the previous three years



A high proportion of hospitals reported having conducted audit targeted at usage of particular antimicrobial agents, with a high number of hospitals auditing usage of the ultra-broad-spectrum antimicrobials, meropenem and or vancomycin. Other areas of audit cited included a review of prescribing practice in the use of the patient drug chart, and performance surrounding the use of outpatient parenteral (intravenous) antimicrobial therapy (OPAT) services.

Some hospitals reported conducting audit into particular aspects of the antimicrobial stewardship programme such as the efficacy of stewardship interventions, including clinical ward rounds. Some reported auditing performance in managing particular clinical conditions such as sepsis or *Clostridium difficile* infection. Others highlighted recent audit into medication process-related issues such as time to drug administration following prescription. This is of particular relevance in the case of infections such as meningitis, pneumonia or sepsis where rapid treatment with appropriate antimicrobials correlates with better treatment outcomes. Others audited performance relative to hospital policy in ensuring a timely and appropriate switch from intravenous to oral antimicrobials. Timely

switching to oral antimicrobials has been shown to be safer and more tolerable for patients, and more cost and time efficient for hospitals.

As with any effective governance assurance mechanism, it is critical that audit findings are effectively acted upon, and that the information identified is reported appropriately within the hospital. In doing so, effective sharing of findings may be a first step towards ensuring that any identified risks are properly managed and mitigated. Alternatively, where good performance is identified, appropriate reporting ensures that those responsible for governance may be suitably assured.

It was evident in some hospitals that such assurance mechanisms were well developed. However, in others, and particularly in those without active drugs and therapeutics committees, such assurance was not in evidence. This needs to be addressed. Finally, given the significant body of audit work that has occurred and is ongoing in hospitals as identified during this review, it is important that opportunities to share learning between hospitals are fully availed of in the interest of efficiency and collective improvement.

5.3.2 The National Antimicrobial Prescribing Point Prevalence Study

Most Irish hospitals participate in an annual National Point Prevalence study, which is centrally coordinated by the National Antimicrobial Stewardship in Hospitals Committee, a sub-committee of the Healthcare Associated Infection and Antimicrobial Resistance Clinical Programme Clinical Advisory Group. The study is supported by the Health Protection Surveillance Centre (HPSC). This point prevalence study aims to take an annual snapshot of antimicrobial prescribing practices, including specific quality measures, on a given day across Irish hospitals to allow for benchmarking.

During the review, HIQA identified multiple examples of hospitals using this data for the purpose of assurance, and to inform local improvement efforts. The coordination of such audit — and indeed the widespread degree of involvement nationally across the acute hospital system — is a very positive initiative, and compares favourably from an international perspective.

Hospitals were generally positive about being involved in this process. A small number of specialized staff spoken with highlighted that there may be some additional value in considering a more focused national audit which looks to measure, benchmark and then collectively improve a defined quality parameter, rather than taking a more general approach to annual measurement. This may be worthy of further consideration.

5.4 Essential microbiological and infection rate surveillance requirements

Chapter 3 of this report explored the national picture in relation to surveillance of relevant outcome measures such as infection rates, and alert pathogen bloodstream infection and antimicrobial resistance rates. Allied to national oversight of such data, it is important that each hospital and hospital group has the ability to closely track and respond to antimicrobial resistance or infection trends in their own organizations.

Antimicrobial resistance is an evolving process, and all acute hospitals need to have systems in place to monitor antimicrobial resistance rates over time. Such monitoring both identifies trends that may be negatively influenced by hospitals' predominant pattern of antimicrobial use, and ensures that antimicrobial usage is planned well in order to address the main antimicrobial resistance patterns emerging in individual hospitals, and in defined high-risk patient populations.

In evaluating what is considered essential in microbiological surveillance, HIQA and its External Advisory Group took the view that while the absolute requirements of each hospital's approach to surveillance should remain individualized and focused on its patient population, all hospitals should have a programme of active microbiological surveillance in place. In particular, it was identified that an essential component of surveillance for most hospitals should include real-time monitoring of *Clostridium difficile* infection rates. The self-assessment tool therefore asked hospitals how their programmes monitored organisms of concern.

5.5 *Clostridium difficile* infection surveillance

Effective antimicrobial stewardship programmes have been associated with reduced *Clostridium difficile* infection rates, which can cause serious illness or death in at-risk patients. *Clostridium difficile* infection is associated with antimicrobial usage. Close monitoring of the incidence of hospital-acquired *Clostridium difficile* infection is therefore an important marker for antimicrobial stewardship programmes. With the exception of a very small number of hospitals,[♦] all acute hospitals should have an active programme of *Clostridium difficile* infection surveillance in place that allows for benchmarking against other hospitals, and also enables timely intervention should an increase be detected.

The HSE has a national performance measure related to *Clostridium difficile* infection whereby all public hospitals are required to report their incidence of *Clostridium difficile* infection every three months to the HPSC. Current national guidelines for *Clostridium*

[♦] It is acknowledged that in a small number of specialist hospitals (such as stand-alone paediatric and maternity hospitals), the risk associated with *Clostridium difficile* would be lower. In such cases, it was felt by the external advisory group that surveillance resources may have been more appropriately channelled towards other higher risk areas, but that such an approach would include provision for background monitoring of this risk.

difficile management[79] recommend additional surveillance in respect of this infection. In addition, hospitals are encouraged to participate in an enhanced, but voluntary, surveillance programme which provides additional data around importance measures such as the recurrence rate.

All but one hospital reported that they provided *Clostridium difficile* infection rate data to the HPSC every three months. One acute general hospital did not engage in either national reporting or local enhanced surveillance for *Clostridium difficile* infection. Two other hospitals reported that they did not participate in enhanced *Clostridium difficile* infection surveillance at local level, but the hospitals in question were either a paediatric hospital or a maternity hospital. *Clostridium difficile* infection is of lower risk in both of these settings.

Local monitoring of *Clostridium difficile* rates on a more frequent basis than national monitoring requirements of every three months was reported by 82% of respondents. Notwithstanding that some of these hospitals were maternity or paediatric hospitals, the lack of more frequent real-time monitoring of *Clostridium difficile* infection rates in nearly one in five hospitals surveyed requires further review. All hospitals need to ensure that they have a very keen awareness of the incidence of *Clostridium difficile* infection in their institution on a daily and weekly basis, so that should problems arise, controls may be rapidly enacted.

5.6 Additional pathogen-specific surveillance

HIQA explored the extent to which hospitals undertook additional pathogen-specific surveillance other than *Clostridium difficile* infection rates. Many hospitals reported that they routinely conducted root-cause analyses where Meticillin-Resistant *Staphylococcus aureus* (MRSA) bloodstream infection or devices-related infection had been identified. Less commonly, some hospitals had begun to undertake root-cause analyses for infection caused by extended spectrum beta lactamase (ESBL) producing Gram-negative organisms,[¥] or in the case of surgical site infection.

Extensive variation was identified across hospitals with respect to the nature of each hospital's surveillance programme. This would be expected given the differing risk profiles associated with different patient populations — maternity services, for example, would have different surveillance needs to a service caring for older people.

It was also identified by HIQA, however, that the extent of surveillance was also significantly dictated by the degree of surveillance resources available, underlying

[¥] Extended-spectrum beta-lactamase (ESBL) producing Gram-negative organisms: ESBLs are enzymes produced by bacteria that provide resistance to a number of different types of commonly used antimicrobials.

laboratory and information and communication technology infrastructure, and the experience, training and work time allocation provided to surveillance scientists. The degree to which hospitals' governance systems expected the availability of such data also impacted upon the relative availability of data in some hospitals. More could be done to enhance the collective approach to reporting in hospitals in this regard.

5.7 Antimicrobial consumption surveillance

Chapter 3 outlined the work that has been done nationally to establish a method for the standardized monitoring and benchmarking of antimicrobial consumption in Irish hospitals.

HIQA found that at local level, many hospitals used antimicrobial surveillance data to inform assurance processes in their hospital. HIQA identified a number of examples where available benchmarked data had been used to inform improvements. In particular, a number of antimicrobial stewardship teams had used antimicrobial consumption data to advocate for the introduction of restricted prescribing rights for certain antimicrobials where they identified higher antimicrobial usage in comparison to other hospitals.

5.8 Essential antimicrobial stewardship initiatives

Good antimicrobial stewardship programmes aim to implement and translate international best practice into local implementation. A number of key antimicrobial stewardship initiatives in hospitals were deemed essential by HIQA and it's External Advisory Group. These included:

- empiric antimicrobial prescribing guidelines
- intelligent reporting of microbiological laboratory reports
- the presence of key policy documents around
  - management of patients with allergy to penicillin
  - safe administration of intravenous medicines
  - intravenous to oral antimicrobial conversion
  - dose optimization and therapeutic drug monitoring for antimicrobials with a narrow therapeutic index
- ongoing education and training for prescribers and other clinical staff involved in the medication usage process.

5.8.1 Empiric antimicrobial prescribing guidelines

Empiric antimicrobial therapy is given for an anticipated and likely cause of infection based upon probability, but where the causative organism has not yet been confirmed.

The development of comprehensive and up-to-date antimicrobial prescribing guidelines, that are both evidence-based and match the needs of the hospital's patient population, should represent a key intervention for all stewardship programmes.[44;80;81] These guidelines need to also take into account the local microbiological resistance patterns, and should be designed to reduce the potential for the incidence of *Clostridium difficile* infection and other multidrug resistant organisms through a design which directs astute choice of antimicrobial agent used.

HIQA identified that all hospitals had comprehensive, evidence-based antimicrobial guidelines from which to draw upon. Indeed, many hospitals had moved to transform these guidelines to make them compatible with modern technology through the development of smartphone apps or mobile websites. The body of work completed in this area has been significant over the last number of years, is typically of a high quality, and is to be commended.

In most hospitals, these guidelines had been specifically designed for the patient population treated in that particular centre. However, a minority of hospitals were using empiric guidelines that had been adopted from other hospitals. During announced inspections, HIQA identified on more than one occasion a situation whereby guidelines had been adopted from another hospital without first ensuring compatibility with local microbiological resistance patterns.

HIQA highlighted concerns in relation to this practice to hospital management during the inspections, and in each instance the hospitals were able to provide assurances following cross referencing against local laboratory data that the guidelines in use were indeed compatible. It is important that such checks are always conducted prior to adopting a guideline, and conducting such verification should be a priority for those responsible for the governance of medication usage in all hospitals.

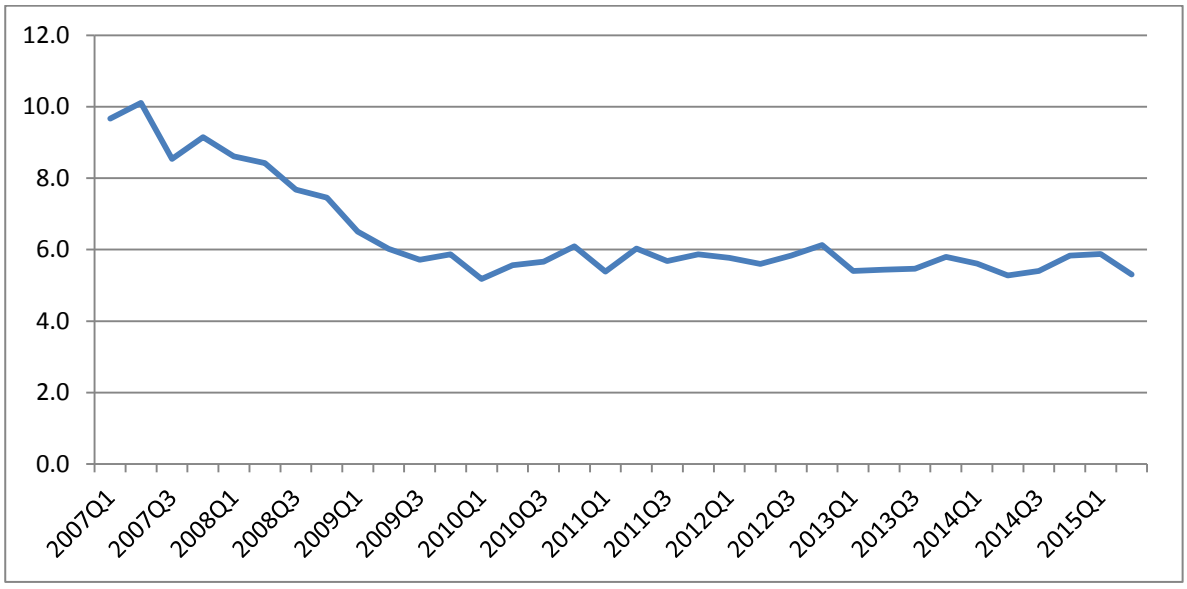
The design of empiric antimicrobial prescribing guidelines is extremely important for stewardship programmes, not only because it acts to promote best practice in antimicrobial agent selection for individual patients, but because it also allows hospitals to significantly influence the overall pattern of antimicrobial usage. Through careful antimicrobial selection by agent-class and infection type, a predominant pattern of antimicrobial usage can be dictated by a stewardship programme.

This is particularly important from the perspective of seeking to control and reduce the incidence of *Clostridium difficile* infection.[82-84] This may be achieved by designing

guidelines to reduce, where possible, using agents which are more likely to promote *Clostridium difficile* infection (such as clindamycin, cephalosporins, co-amoxiclav and the fluoroquinolone antimicrobial class which includes ciprofloxacin), through substitution with those agents which are less likely to promote *Clostridium difficile* infection.[81] Through the review of documentation, interviews with staff and evaluation of the design of empiric antimicrobial guidelines in hospitals throughout this review, it is apparent that guideline development in most hospitals has been designed to influence the predominant pattern of prescribing across Irish hospitals, that is to say, a move away from clindamycin, fluoroquinolones and cephalosporin usage in particular.

Cumulatively, it can be seen from evaluation of antimicrobial prescribing patterns that there has been a significant decline in the overall volume of fluoroquinolone used nationally at a time when overall antimicrobial usage volume has marginally increased. This finding is shown in Figure 16.

Figure 16. Total volume of fluoroquinolone usage in public acute hospitals per quarter in defined daily doses per 100 bed days from the start of 2007 until 2015



The overall incidence of *Clostridium difficile* infection in Irish hospitals has generally declined in recent years. This decrease has occurred at a time when the sensitivity of testing for the infection has increased. This increased sensitivity has in fact been attributed to higher *Clostridium difficile* infection detection rates in some hospitals internationally.[85] While numerous factors influence the incidence of this infection, it is possible that the effort expended in Irish hospitals to reduce *Clostridium difficile* infection rates through antimicrobial stewardship may have helped reduce its incidence.

Despite a cumulative reduction in *Clostridium difficile* infection across Ireland, analysis of national data shows a significant and persistently higher incidence of *Clostridium difficile* in a small number of Irish hospitals. HIQA notes that in some cases, this ongoing higher incidence had been preceded by a significant outbreak. The subsequent ongoing higher rates of *Clostridium difficile* infection experienced in these hospitals highlight the difficulty in managing the problem once it emerges in a hospital setting, and reinforces the importance of infection prevention and control.

In one hospital, this HIQA review process identified the presence of an historical problem in managing *Clostridium difficile* infection rates in a situation where its antimicrobial stewardship activities were severely hampered by the ongoing lack of a permanent consultant microbiologist position. This hospital had since permanently appointed a consultant microbiologist, and antimicrobial stewardship had begun to progress. However, this was at a significantly less advanced stage than peer hospitals.

5.8.2 Other antimicrobial prescribing policies and procedures

Most hospitals had policies and procedures on safe administration of intravenous antimicrobials, managing the risk of antimicrobial allergy, and the promotion of timely and appropriate conversion from intravenous to oral antimicrobials. In addition, all hospitals reported that they had policies or procedures in place for managing antimicrobials that have a narrow therapeutic index[§] — which is in line with good practice.[(81)]

Hospitals should act to ensure the universal availability of such guidance, particularly where there are gaps in guidance. Not all hospitals reported the routine use of interpretative comments of microbiological laboratory reports as recommended in national guidelines. However, most hospitals reported that they added comments where indicated, rather than routinely including them.

5.9 Non-specialist staff education, training and support

Good practice in relation to the prudent usage of antimicrobials relies upon good decision-making from those involved in the antimicrobial usage process. A key component of antimicrobial stewardship programmes involves the effective education and training of non-specialist staff employed within a hospital to get best use out of the antimicrobials available.

[§] Antibiotics with a narrow therapeutic index are so called because the difference between a therapeutic dose and a toxic dose is small. Usage of these medicines requires special care in dosing and monitoring (often through specialist blood tests, and monitoring of other measures such as the patient's kidney function) to ensure that treatment is effective while minimizing the risk of side effects. Commonly used antimicrobials with a narrow therapeutic index include vancomycin and gentamicin.

During this review, HIQA identified a number of different measures that had been enacted by hospitals to promote education and training of general staff. Many hospitals used presentations from specialist staff for relevant staff during their induction, at clinical staff educational meetings or in more formal educational meetings such as speciality team or departmental journal club meetings.

Some hospitals also reported more personalized feedback to staff in the clinical environment, either through intervention and feedback during stewardship rounds, to planned bedside training of more junior staff. These types of interventions were more common in those hospitals which were relatively better resourced from a specialist staffing point of view.

In those hospitals with more limited resources, innovative ways to ensure all staff received some degree of ongoing training and education were required at the time of the review. Greater use of e-learning opportunities potentially provide an efficient way to bridge this gap. HIQA is aware that e-learning programmes targeted at non-consultant hospital doctors (NCHDs) have been embedded into postgraduate training programmes. However, it was identified during announced inspections that there may be greater potential for uptake of these e-learning programmes by NCHDs. This should be reviewed, and indeed broadened to include hospital consultants.

Conversely, the albeit small sample of more junior medical staff spoken with by HIQA during this review, who had recently been educated in Irish universities, consistently expressed satisfaction with undergraduate training on antimicrobial usage and indeed antimicrobial stewardship. It was communicated that these staff felt that the training provided had been useful in preparing them for clinical practice — this finding is encouraging and a potential avenue for further study.

Finally, ensuring that patients are well informed about antimicrobial therapy is an important component of any educational programme aimed at ensuring good practice in antimicrobial usage. HIQA identified that a number of hospitals had devised educational tools for patients on this issue and wider medication-related information. These included information leaflets and booklets designed to help with medication reconciliation at points of transition of care. There is further additional scope for further development in this regard nationally, especially at the point of discharge from hospital.

5.9.1 European Antibiotic Awareness Day

Every November, the HSE and individual hospitals collectively promote the need for prudent antimicrobial use, as part of European Antibiotic Awareness Day. This pan-European event, which is coordinated internationally by the European Centre for Disease Prevention and Control, aims to raise awareness amongst healthcare professionals and the

general public as to the current and future challenges that lie ahead with respect to antimicrobial resistance, and for the need to use antimicrobials prudently.

HIQA was able to identify during the review how this event was widely observed and promoted in the inspected hospitals and nationally, and it is a very good example of collective working and collaboration across the entire community of healthcare professionals, and others working in this field to promote the same message.

5.10 Additional findings

In addition to the essential elements of antimicrobial stewardship, HIQA reviewed progress made by hospitals in implementing other best practice arrangements with respect to stewardship. Announced inspections allowed HIQA to further explore potential for further progression of antimicrobial stewardship across the acute hospital system.

5.10.1 Point-of-care intervention

Direct feedback to prescribers in the clinical environment by specialist trained staff in relation to antimicrobial usage is a critically important component of antimicrobial stewardship programmes. Such intervention, which recent Australian antimicrobial stewardship guidelines[80] refer to as 'point-of-care intervention', may include:

- expert staff proactively reviewing the appropriateness and choice of antimicrobials with prescribers
- expert intervention to allow for streamlining of therapy based upon laboratory results
- dose optimization
- conversion from intravenous to oral therapy
- therapeutic drug monitoring
- or timely discontinuation of antimicrobials when they are no longer required.

Highly effective antimicrobial stewardship programmes aim to empower all prescribers by ensuring that they have sufficient expertise, knowledge, and access to information to deal with the majority of clinical scenarios independently of expert advice. Ready access to high-quality, up-to-date empiric guidelines — coupled with effective education and training, and feedback on performance through audit — are critical parts of such an approach.

Most antimicrobial prescribing in hospitals follows a relatively predictable pattern, and can usually be readily guided by protocol. However, in a minority of cases, treatment will be more complex. In this situation, ready and early access to specialist expertise, in the form of consultant microbiologists, infectious diseases physicians and antimicrobial pharmacists, can significantly aid in the decision-making process with respect to antimicrobial usage.

In hospitals where adequate access to these individuals and a wider stewardship team are present, better antimicrobial stewardship performance can be expected. Chapter 3 highlighted the variance that exists across the public acute hospital system in Ireland in relation to the availability of these specialist staff. Announced inspection showed that in better resourced hospitals, the extent of patient bedside review, on-the-ward interaction with other clinical staff, and proactive intervention were much higher. As a consequence, the level of awareness about antimicrobial stewardship, and the degree of support for more junior prescribers in particular, was greater.

Antimicrobial stewardship activities in higher performing hospitals include the stewardship team regularly and proactively working with key clinical teams that care for patients at high risk of infection. These patient cohorts include critically ill patients, patients with cystic fibrosis, or those undergoing treatment for cancer. In some hospitals which had sufficient resources, such intervention extended beyond the Monday to Friday working week, with active bedside intervention at weekends. Better resourced programmes were also more able to rapidly address identified risks through structured quality improvement initiatives.

This review found that in hospitals with less specialist staff, less point-of-care intervention was achievable. In particular, inspected Model 3 hospitals — which had one or less whole-time equivalent consultant microbiologists allocated to them, and typically no infectious diseases physician — fared poorly in this regard. The relative lack of resources in these hospitals curtailed the ability of microbiologists to provide a proactive service, with intervention largely provided through telephone consultation rather than bedside review. Indeed the lack of such a resource was often further compounded by a relative lack of other supports such as general clinical pharmacy or surveillance resources.

In a small number of hospitals, resources were so limited that on-site consultant microbiologist availability was largely non-existent, with advice only provided remotely by telephone. This situation does not provide best practice protection for patients. In most cases, this happened in Model 2 hospitals. In such a situation, HIQA found that in a small number of instances this risk was partly mitigated through effective formalized working arrangements between off-site specialist staff and local link staff including senior clinicians, and an effective contribution on site from clinical pharmacists and infection prevention and control nurses.

Such a situation was also identified in a small number of Model 3 hospitals. However, HIQA is of the view that this is a particularly inappropriate arrangement for a Model 3 hospital.

Most hospitals had an antimicrobial pharmacist in position, even in those hospitals which did not have an on-site consultant microbiologist. In such a situation, the pharmacist's role

became even more important, as they needed to become the on-site leader for antimicrobial stewardship, especially in relation to point-of-care intervention. HIQA saw antimicrobial pharmacists carrying out much positive work in these circumstances.

Likewise, in some smaller Model 2 hospitals, both generalist clinical pharmacists and infection control nurses were providing a daily critical function in advancing antimicrobial stewardship. However, in this situation, there is a risk that the lack of a consultant microbiologist or infectious disease physician to lead the programme may result in an inferior approach to moving the programme along. Multidisciplinary antimicrobial stewardship teams are the best arrangement, and should be pursued in all hospitals.

In practical terms, better resourced hospitals — from a clinical pharmacy perspective — are generally organized so that every inpatient has their medication regimen clinically reviewed on a regular basis.[72] This is to ensure quality and safety in the usage of medicines, and intervention to effect improvement or indeed prevent patient harm where necessary. As the degree of relative resource is reduced in hospitals, their ability to provide such a proactive service decreases, meaning that in some hospitals, some patients do not receive clinical pharmacist services.

At its extreme, some Irish hospitals had no clinical pharmacy services in place at the time of this review.

In well-developed antimicrobial stewardship systems, clinical pharmacy services act as the first point of quality assurance for antimicrobial prescribing. Such intervention can include:

- identification and modification of prescribing error
- advice on best dosage and treatment duration
- incentives for timely conversion from intravenous to oral therapy
- education and training for more junior prescribing staff.

Extensive clinical pharmacy services also provide an important surveillance and triage function for antimicrobial stewardship teams in identifying complex cases in need of specialist intervention. This is an especially useful function in light of a general lack of electronic prescribing in Irish hospitals, which instead rely on paper-based prescribing systems. Clinical pharmacy services also play an important role in acting to support the adoption of hospital policy in relation to prescribing, for example, in promoting adherence to empiric prescribing guidelines, and in monitoring and supporting key antimicrobial prescribing policies and initiatives. Hospitals without clinical pharmacy services neither receive these, nor other wider medication safety benefits.

5.10.2 Protection of key strategic antimicrobial agents

A core high-impact antimicrobial stewardship intervention recommended in many international guidelines are additional controls targeted at ensuring high-quality usage of key strategic antimicrobials. In practical terms, such an approach usually occurs in one of two ways.[81] Some hospitals have adopted an approach which requires expert prior approval for using certain key antimicrobials, in what has been referred to by some authors as a 'front-end strategy'.

Alternatively, others have adopted what has been referred to as a 'back-end strategy'. In this case, there are no immediate controls in place to limit prescribing by generalist staff, but there is prospective expert quality assurance review in the days after therapy being started. Such an approach — which is known also as 'concurrent review with feedback' — aims to be more persuasive rather restrictive.

It benefits from being less labour intensive and is potentially more acceptable to prescribing clinicians. However, a key weakness is the potential for a delay in review, which can result in a patient receiving a significant number of doses of a broad-spectrum agent before intervention, should it be required. In such a scenario it can be potentially difficult for the prescribing clinician to alter therapy in the middle of a course of treatment where the patient is improving, even if a comparable outcome might be achieved through using a less broad-spectrum agent.

Before the development of national standards and guidelines for antimicrobial stewardship, such controls over key strategic antimicrobials would have been uncommon in most Irish hospitals. The SARI guidelines for Antimicrobial Stewardship in Hospitals clearly outline a recommendation for the introduction of such systems, in line with international best practice. As a consequence, this review looked to further explore progress nationally in this area.

HIQA found, with the exception of a small number of hospitals, that the majority of hospitals described and could demonstrate that a system, whereby additional controls around the prescribing rights for key strategic antimicrobial agents, was in place.

Some hospitals relied on a purely persuasive approach to retrospective expert intervention in the prescribing of a large group of antimicrobials. Others have introduced a more rigorous system, with an enforced requirement to seek expert advice during pharmacy department opening hours for a smaller number of agents, with supply being withheld save for a first dose if needed, until such time as expert consultation has happened.

It was also observed that in some hospitals, with long-standing and better resourced antimicrobial stewardship programmes, a culture of expert consultation was embedded. In these hospitals, there was a legacy approach to requiring expert consultation prior to

prescribing such agents, and this had resulted in non-specialists routinely consulting their specialist colleagues for advice before prescribing them, due to their lack of experience in the independent prescribing of such agents.

Finally, in hospitals without stewardship programmes in place, no such system of control applied to the use of key strategic antimicrobial agents.

During this HIQA review, the relevant HSE National Clinical Director wrote to all hospitals to advise that such a system of controls and restrictions should be universally applied. Arising from this review, measures had since been enacted in hospitals that previously did not have such a system in place. If implemented correctly and safely, the increased adoption of such controls has the potential to be an important step for embedding a culture of antimicrobial stewardship nationally to protect the usefulness of key strategic antimicrobials.

However, HIQA identified that in some instances, despite the very best efforts of all staff involved, the hospital had been unable to sustain such a programme, largely due to a reported shortage in clinical pharmacy staff. In other instances, the programme extended to all clinical areas with staff reporting an onerous workload in order to implement the system. The effectiveness and sustainability of these programmes need be routinely reviewed. Where capacity issues emerge, the targeted application of prescribing rights to certain clinical teams, accompanied by regular audit, may be a more sustainable alternative arrangement.

5.11 Medication safety programmes

Extensive international research shows that use of medicines is regularly cited as a leading cause of error in hospital patients.[86-89] It is estimated that 1–2% of all prescriptions written contain an error, with 5–15% of these resulting in moderate to severe patient harm. Given the volume of prescribing that occurs in Ireland, this amounts to a significant burden of harm nationally. In an Irish context, extrapolation from published information indicates that:

- 26% of people aged 50 years or over use five or more medicines daily[90]
- 20% of readmissions to hospital within a year of discharge are medicines-related[91]
- 8% of all emergency hospital admissions are medicines-related[92]
- 8% of incidents reported to the Clinical Indemnity Scheme are medicines-related[93]
- 6% of hospital discharge prescriptions have a potentially severe medication prescribing error.[94]

Antimicrobial stewardship is a medication safety initiative. Many of the medicines most commonly associated with adverse incidents or errors in practice include antimicrobials such as penicillin, gentamicin, vancomycin and the antifungal amphotericin. During this

review, HIQA looked at how each antimicrobial stewardship programme linked into the wider hospital structure to support medication safety and risk management more generally.

HIQA found that a small number of hospitals had worked proactively to establish well-defined medication safety programmes. These included setting up a medication incident or near-miss reporting programme, overseen by a designated person who coordinated the collation and analysis of data generated from this process. The programmes then aimed to mitigate risk identified through in-house reporting and structured quality improvement efforts. More established programmes in larger hospitals were generally managed by designated full-time or part-time medication safety officers. In smaller hospitals, this role generally fell to pharmacy department managerial staff.

HIQA identified that in some instances, medication safety programmes worked closely with antimicrobial stewardship programmes and the wider risk management structures within the organization. This is an example of good practice where there was pooling of expertise and resource between initiatives, and good communication across functions. In other hospitals, there was greater scope for collaboration between established in-house programmes, and this should be reviewed by hospitals.

HIQA found some hospitals had established effective medication incident reporting systems. Typically these systems were overseen by medication safety officers. In one hospital inspected, an electronic reporting system was in place which automatically reported the incident to relevant staff in the hospital for immediate mitigation. In established reporting systems, most reports were made by nurses. However, these systems also benefitted significantly from high reporting rates from clinical pharmacists and pharmacy technicians. Crucially, doctors also strongly supported established systems, and while they tended to report less frequently, they usually reported more serious incidents rather than near misses.

However, it was clear from speaking with front-line staff that many hospitals had yet to fully embed a culture of openness in reporting errors and near misses. Setting up such programmes will help to foster such a culture.[95] Such an initiative would need to be effectively supported by senior leaders and key opinion formers in each hospital, particularly among clinical staff. There is much to be learnt from the more advanced systems in place in Irish hospitals and internationally.

5.12 The role for greater collaboration and quality improvement

Despite a widespread variation in the nature and resources given to antimicrobial stewardship in Irish hospitals, this review has identified that most hospitals have such stewardship programmes in place. It was evident throughout the review, however, that

overall, most of these programmes operate in relative isolation rather than in cooperation with other hospitals.

A small number of hospitals indicated that there were close and embedded working relationships among a network of hospitals in their area. This formalized relationship had developed due to shared consultant microbiologist positions across hospital sites, and a central shared lab. From a stewardship perspective, this arrangement allowed each hospital in the network to contribute to shared empiric guideline development efforts, and allowed collective learning across sites. Working in this way made best use of limited resources.

In other parts of the country, less formalized but nevertheless helpful shared working was evident — particularly with guideline development. Again, this is to be commended. It is important, however, that there is local governance oversight of such arrangements and that all resulting documents are approved by each hospital's governance oversight committees. On more than one occasion, HIQA inspectors found externally developed guidance, which had been adopted locally, had not been approved by local governance committees. This was significant because it meant an appropriate review of the relevance locally of such guidelines had not happened. In all instances, HIQA escalated its concerns about this situation to hospital managers during the inspection so that the hospital could mitigate the associated risk.

At the time of this review, the Irish acute hospital system is in the process of ongoing organizational change, with each of the 49 acute hospitals transferring into one of seven hospital groups, each with its own defined management structure. If successful, these changes have significant potential to yield collective benefit across each hospital within each group. The potential for greater collaboration on antimicrobial stewardship between hospitals in each group is one such area where both hospitals and patients might benefit significantly.

In at least one hospital group, HIQA found efforts to organize stewardship cooperation and collaboration along hospital group lines were at an advanced stage. This involved setting up a hospital-group antimicrobial stewardship committee with input from all hospitals. It aimed to share collective knowledge and experience across hospitals, particularly from those working in the tertiary Model 4 hospital in the hospital group which had a well-established stewardship programme. This was aided by newly appointed consultant microbiologists working across the hospital sites within the group. Such an approach may be of particular benefit for smaller hospitals where microbiologists are working on their own. Good cooperation was also identified between specialist paediatric hospitals, again aided by the presence of joint consultant microbiologist appointments.

However, such an arrangement was as of yet uncommon in most hospital groups. Additionally, in some instances, existing collaboration that has developed across hospitals (in relation to joint staff appointments across different hospitals not in the same hospital group, close working relationships and in some cases centralised labs) does not correspond with the new alignment of hospitals into groups.

It is important that any realignment of arrangements that occurs along hospital group lines is done in a well-planned way where these existing arrangements exist.

5.12.1 Informal professional supports

While formalized working relationships between hospitals remains the exception currently in Ireland, this review identified the presence of well established informal professional networks that have developed between specialist staff across the country. These networks support individuals working in relative isolation, are effectively used to share experience and ideas and to aid in communication. Good inter-professional working relationships were also identified within hospitals, and at national level, and a strong community of antimicrobial stewardship practitioners has evolved.

There may be greater potential for more formalized multidisciplinary working nationally, similar to practice in other countries.[96] Indeed, while there is good information sharing between professional groups, there is greater potential for multidisciplinary information sharing and learning nationally. Also, the potential for increased deployment of infection prevention and control nurses, and indeed other nursing input, into antimicrobial stewardship efforts is increasingly being recognized internationally. Greater nursing involvement with information sharing and ongoing collaboration should also be considered.

5.12.2 Improvement collaboratives

While HIQA identified the existing presence of some collaboration and cooperation between hospitals during this review, there is much more potential for this to yield benefits, especially within the framework of hospital groups.

HIQA notes that efforts at a national level have been advanced to try to collectively address problems associated with gentamicin usage through the formation of a gentamicin collaborative improvement project.[97] This project aimed to apply quality improvement methods advocated, amongst others, by the Institute for Healthcare Improvement to try to collectively fix a commonly encountered problem across multiple hospital sites. Furthermore, under this project, efforts have also been made to agree and approve a proposed standardized dosing guideline for gentamicin for use among adult and paediatric patients nationally.

In addition, the potential for applying similar improvement efforts, using such a methodology, were at the time of this review being explored by the HSE in an attempt to introduce an antimicrobial prescribing care bundle across hospitals. Ongoing efforts in this regard represent a welcome development, which warrants further exploration across the Irish healthcare system. On a more fundamental level, it is recommended that individual hospitals look to engage with their peer hospitals in working to address similar improvement priorities.

5.13 Conclusions

This review has identified that good progress has been made at an individual hospital level to implement evidence-based best practice, where the following elements are in place:

- an appropriate complement of well-trained and well-led specialist staff, who are working as a team
- working within a wider framework which included good laboratory, information technology, surveillance and clinical pharmacy resources
- and overseen by appropriate and effective governance arrangements, including effective senior management supports.

Notable areas of success observed by HIQA during this review included progress in developing and embedding comprehensive empiric prescribing guidelines, and introducing key policy initiatives such as restricted prescribing rights and expert point-of-care intervention. More recent progress at the time of this review in advancing improved collaboration between hospitals also shows significant promise in the goal of achieving best antimicrobial stewardship practice.

However, as each of the key elements outlined above becomes diminished in hospitals, the ability of their antimicrobial stewardship programmes to work well is reduced accordingly. This review highlighted that while stewardship activities of some description were in place in most hospitals, a small number had no programme in place at all. This is despite national standards and guidelines dating back to 2009 mandating that all public acute hospitals should have such programmes in place. From both a local and national perspective, this critical gap in patient safety defences is of significant concern and needs to be addressed.

6. Overall conclusions

This review aimed to evaluate the national provision for antimicrobial stewardship in each public acute hospital in Ireland, and also took a higher-level view with an examination of national structures that have been put in place to support local implementation. At the time of this HIQA review, a critical finding was that there was no up-to-date national strategic plan in place to guide the Health Service Executive (HSE), or indeed other relevant national groups, in collectively addressing the key strategic national and global risk of increasing antimicrobial resistance.

More recently, the Irish Government has commenced planning a national action plan to address antimicrobial resistance. This initiative, which has been spearheaded by the Council of the EU under the Dutch Presidency,[8] requires all member states to formulate a national action plan in this area by mid-2017. Council of the EU requirements state that this plan should adopt a 'one-health' approach. This means that all of the players involved in the antimicrobial usage and development process, including healthcare, agricultural and veterinary stakeholders, are required to come together to contribute to the formulation and implementation of a national plan in this area.

It is important that as part of this process, the strategic requirements within the health and social care sectors in this area are considered and included in the action plan, and that the findings and recommendations contained within this report be acted on.

Over the past 15 years, much progress has been made in the acute hospital system in Ireland at an individual hospital level to build an infrastructure to develop and enhance antimicrobial stewardship. Significant credit for this progress is due to the dedicated professionals working in this field who have worked diligently to advance practice over this time. Recognition should also be paid to those who have provided leadership, and advocated to enhance practice and investment in this area.

However, the nature of the risk presented by antimicrobial resistance is ever evolving, and the gap between emergent resistance and remaining treatment options continues to narrow.

At the start of this review, the national structures to support antimicrobial stewardship and infection prevention and control within the HSE lacked coordination. However, in early 2016, the HSE identified a named person responsible for coordinating and managing its national antimicrobial stewardship programme. Changes to the national approach to leadership and governance in this area through the establishment of a new national task force may address these concerns, although it was too early to establish at the time of this review how effective these new arrangements were.

Nonetheless, it should be recognized that this new task force has been established in an environment where there are already many contributory groups and complex reporting structures in place. Clarity with respect to where this task force and other parallel groups fit in the new construct should be fully defined, clearly articulated and evaluated on a regular basis.

Additional investment will be required to fully develop the necessary systems and infrastructure to ensure universal good practice across the Irish health system in relation to both antimicrobial stewardship and infection prevention and control. Key areas for investment will include increased staffing in some areas, and an improvement in surveillance and measurement systems in others. Much can also be achieved within current resources through the establishment of a more organized approach to leadership, governance and management at a national level.

While much has been achieved, the task at hand in building the required infrastructure to fully address this problem across the acute hospital system remains incomplete. Moreover, the development achieved in much of the acute hospital system has not been attained to the same required level in non-acute care settings. The ongoing existence of such gaps in antimicrobial stewardship and infection prevention and control provision is of significance for the whole health service, as antimicrobial resistance is a system-wide issue, and any system is only as good as its weakest link.

Therefore, it is of critical importance that national HSE efforts in this area are re-energized to address any outstanding deficiencies. This is required so that the Irish health service is as well prepared as it can be for the new resistance challenges that have begun to emerge, and which may be anticipated into the future. Immediate action is required now, as failure to fully address this threat across the health system in the short term will result in major repercussions for Irish people who rely on our health services for years to come.

Appendix 1 — Methodology

This section of the report summarises how the Health Information and Quality Authority (HIQA) carried out this review. This national quality assurance review started following consultation with an external expert advisory group, and it consisted of three phases.

Phase one was a process of self-assessment, whereby all 49 public acute hospitals in Ireland were asked to complete and return an antimicrobial stewardship self-assessment tool to HIQA (see Appendix 2). This self-assessment tool — in the form of a questionnaire — was developed with the help of the external Expert Advisory Group, and was informed by relevant national standards and guidelines, and international best practice. It was also developed following feedback from three hospitals that had tested a draft self-assessment tool on behalf of HIQA. The self-assessment tool was circulated to each hospital in an interactive PDF (portable document format), with hospitals being required to complete the self-assessment tool and return it to HIQA within 28 working days of receipt.

Hospitals were also asked to provide additional documentation to allow for a further evaluation of practice at each site. This included a copy of each hospital's antimicrobial stewardship plan for 2015, and a copy of its most recent set of antimicrobial prescribing guidelines.

Phase two of the review included announced inspections by HIQA in a sample of 14 out of the 49 public acute hospitals to verify findings and gain a better understanding of the implementation of antimicrobial stewardship programmes at a local level. Further documentation, relevant to antimicrobial stewardship in each hospital, was requested and reviewed in advance of the inspection.

The 14 hospitals were inspected by HIQA between October 2015 and January 2016. These announced inspections took place over one working day and consisted of a series of group interviews and a visit to each hospital's pharmacy department and clinical areas to observe various important aspects of antimicrobial usage.

Phase three of the review involved interviews by HIQA with key senior figures within the Health Service Executive (HSE) and other key leadership figures to examine national governance and operational management of Healthcare Associated Infection, antimicrobial resistance and antimicrobial stewardship. These interviews further explored the management and governance of antimicrobial stewardship at a national level.

In undertaking this review, HIQA wanted to find out how antimicrobial stewardship programmes were being provided in Irish hospitals through assessment against the *National Standards for the Prevention and Control of Healthcare Associated Infection* (referred to in this report as the Infection Prevention and Control Standards),[2] and the

SARI (A Strategy for the Control of Antimicrobial Resistance in Ireland) *Guidelines for Antimicrobial Stewardship in Irish Hospitals*.

As effective antimicrobial stewardship in hospitals requires a coordinated approach across each organization, the *National Standards for Safer Better Healthcare,* which are of relevance to all health and social care services, were also considered in formulating the approach to this review.

HIQA was also guided by other relevant national and international standards, guidelines, recommendations and published literature. This included reference to a number of the recently published National Clinical Guidelines produced by the National Clinical Effectiveness Committee which are of relevance to antimicrobial stewardship programmes, as follows:

- National Clinical Guideline No. 2 — Prevention and Control Methicillin-Resistant *Staphylococcus aureus* (MRSA) — December 2013[(98)]
- National Clinical Guideline No. 3 — Surveillance, Diagnosis and Management of *Clostridium difficile* Infection in Ireland — June 2014[(99)]
- National Clinical Guideline No. 6 — Sepsis Management — November 2014.[(100)]

To further assist with this work, an expert advisory group was formed. The Expert Advisory Group supported HIQA in relation to the monitoring review, including the content and composition of the self-assessment tool for hospitals. The Expert Advisory Group membership included patient representation, alongside people with relevant expertise from across the Irish health service (see Appendix 3 for membership of the Expert Advisory Group).

Antimicrobial stewardship self-assessment tool

The antimicrobial self-assessment tool was divided into two sections, Sections A and B:

- **Section A** requested information related to essential elements that HIQA, aided by the External Advisory Group, identified as both necessary and achievable for all acute hospitals regardless of their size or resource allocation. These essential elements were selected in line with specifications outlined in both the *National Standards for the Prevention and Control of Healthcare Associated Infection*,[2] and the SARI *Guidelines for Antimicrobial Stewardship in Irish Hospitals*.[24] It should be noted that it was expected that in most hospitals, the extent of the hospitals' antimicrobial stewardship programmes would significantly exceed that covered in this section of the self-assessment tool.

- **Section B** requested further detailed information in relation to specific aspects of each hospital's antimicrobial stewardship programme beyond those listed in section A. This section was broken down under the headings of:
  - governance
  - workforce
  - and additional antimicrobial stewardship programme components.

This section was designed to gather data to inform HIQA in relation to planning phase two of the review.

The questions within the self-assessment tool were informed by:

- international best practice
- relevant guidelines
- similar work conducted in other countries[80;101-106]
- the expert advisory group, and were shaped by the:
  - *National Standards for the Prevention and Control of Healthcare Associated Infection*
  - SARI *Guidelines for Antimicrobial Stewardship in Irish Hospitals.*

Questions in the self-assessment tool were aligned to the overarching themes contained in the *National Standards for Safer Better Healthcare*. These themes are illustrated in the chart below.

Themes in the *National Standards for Safer Better Healthcare*

1. Person-centred Care and Support
2. Effective Care and Support
3. Safe Care and Support
4. Better Health and Wellbeing
5. Leadership, Governance and Management
6. Workforce
7. Use of Resources
8. Use of Information

Finally, each hospital was required to complete a declaration form to verify at senior hospital manager level that the information contained within the response was accurate.

Announced inspection

Announced inspections were conducted in a sample of 14 hospitals. Hospitals were selected based on a series of criteria agreed with HIQA's External Advisory Group and ranged from large tertiary academic teaching hospitals, to smaller specialist and general hospitals.

Two hospitals from each of Ireland's seven hospital groups were selected and the sample included statutory hospitals (run directly by the HSE) and voluntary hospitals (funded by the HSE under service-level agreements, but run and governed by independent organizations).

HIQA's announced inspections consisted of structured interviews and observation in a number of hospital areas on the day of the inspection. Interviews were held in hospitals with the following staff groups:

- group one: a consultant microbiologist or consultant infectious diseases physician (antimicrobial stewardship programme lead), the antimicrobial pharmacist, and a surveillance scientist
- group two: the chief pharmacist, the medication safety coordinator, the head of quality and safety, and the head of risk management
- group three: a medical registrar, a staff nurse and a surgical intern or equivalents
- group four: the chief executive officer, the chairperson of the drugs and therapeutics committee, and a clinical director.

Authorized persons from HIQA also spent time examining the structures and processes in place in each hospital which underpinned antimicrobial prescribing practices. This included a review of a selection of antimicrobial prescriptions, methods of access to information and specialist advice, antimicrobial storage and supply processes, and adverse-incident reporting systems.

In addition, in hospitals that had reported the presence of a policy and practice of protected access to particular named antimicrobials, observation included a review of the function of this system in practice. This involved the randomized identification of a patient prescribed and administered a restricted antimicrobial under local policy, examination of documents and discussion with staff to explore the application of this policy in practice.

Review of national governance and supporting structures

The interrelationship between hospitals and other healthcare providers means that the effective management of antimicrobial stewardship requires both local and national

coordination and oversight. Consequently, HIQA, as part of this review, also assessed the national governance arrangements and supports for antimicrobial stewardship activities across the public acute hospital system.

This assessment included a request for information from the HSE to determine the arrangements in place at the time of the review for corporate responsibility for antimicrobial stewardship, and associated schemes of delegation of authority and responsibility for the national management of this issue.

This was also accompanied by interviews with key individuals who held positions of responsibility for the national coordination of antimicrobial stewardship and wider infection prevention and control activities in Ireland, who were identified for HIQA by the HSE. This group included staff in national HSE roles, alongside key technical national leaders and management within the hospital groups.

As a result of the findings emerging in the early stage of this element of the review, HIQA broadened its focus to include national leadership, governance and management of both infection prevention and control and antimicrobial stewardship alongside each other.

HIQA took this decision as many of the HSE structures and contributory groups that were in place to advance these areas of practice were common for these two interlinked areas. Furthermore, potential areas for improvement of national leadership, governance and management were relevant to both infection prevention and control and antimicrobial stewardship.

Appendix 2 — HIQA antimicrobial stewardship self-assessment tool

Section A - Antimicrobial Stewardship Essential Elements

Essential Structural and Organisational Elements			
A.1.01	Is there a defined antimicrobial stewardship programme in place at your hospital?	Yes ◯	No ◯
A.1.02	If yes, please list the programmes proposed top three objectives for 2015:		
A.1.03	Which member of the senior management team in your hospital is corporately responsible for oversight of antimicrobial stewardship?		
A.1.04	Does the hospital have a defined budget (in excess of monies allocated to fund staff posts) allocated to the antimicrobial stewardship programme at your hospital?	Yes ◯	No ◯
A.1.05	Does the hospital have a named Consultant Medical Microbiologist or Infectious Diseases Physician who is responsible for leading the Antimicrobial Stewardship programme?	Yes ◯	No ◯
A.1.06	If yes, please state this person's job title below.		
A.1.07	Does the hospital have a multidisciplinary Drugs and Therapeutics Committee in place?	Yes ◯	No ◯
A.1.08	If yes, please insert the date of the last meeting in the box below.		
A.1.09	Please provide the job title of the Chair of the Drugs and Therapeutics Committee.		
A.1.10	How often does the Drugs and Therapeutics Committee meet? (Tick one option only) ◯ Monthly ◯ Every other month ◯ Quarterly ◯ Twice Yearly Other (please specify)		

A.1.11	Does the hospital also have an Antimicrobial Stewardship Committee (Antimicrobial Advisory Committee or equivalent) accountable to the Drugs and Therapeutics Committee? (Note it is acknowledged that some hospitals may not be of a sufficient size to warrant this additional committee)	Yes ○	No ○
A.1.12	If yes please insert the date of the last meeting		
A.1.13	Does your hospital participate in a regional antimicrobial stewardship committee or equivalent?	Yes ○	No ○
A.1.14	If yes, please list the other hospitals involved with this committee		
A.1.15	Does the antimicrobial stewardship programme have formal links to the wider medicines safety programme and/or risk management programme in your hospital? (e.g. formal reporting lines, dual membership of committees etc)	Yes ○	No ○
A.1.16	Are adverse incident reports related to antimicrobial usage fed back to the antimicrobial stewardship committee or the Drugs and Therapeutics Committee?	Yes ○	No ○
A.1.17	Does the hospital have access to a 24-hour 7 days a week microbiology laboratory?	Yes ○	No ○
A.1.18	Does this microbiology laboratory have up to date INAB accreditation?	Yes ○	No ○
A.1.19	Does your hospitals clinical governance framework allow for restricted prescribing rights for key antimicrobial agents (for example Microbiologist or ID Physician only use) as deemed clinically necessary?	Yes ○	No ○
A.1.20	Does the hospital have a defined and documented surveillance programme, with clear goals and objectives that are reviewed on an annual basis?	Yes ○	No ○
A.1.21	Are there local guidelines to ensure that commercial promotion of antimicrobials and interactions between prescribers and the pharmaceutical industry are carried out in an ethical manner, and approved by the hospital's drugs and therapeutics committee?	Yes ○	No ○
Please insert additional comment or clarification below related to this section of the tool, with reference to the question number where relevant			

Essential Workforce Elements (Applicable to all Hospitals)			
A.2.01	Is there 24-hour access 7 days a week to a Consultant Medical Microbiologist at your hospital?	Yes ○	No ○
A.2.02	Does your hospital have a Clinical Pharmacist who, as at least part of their role, contributes to the delivery of the hospitals antimicrobial stewardship programme?	Yes ○	No ○
A.2.03	Does your hospital have named individual/individuals with responsibility and allocated time for coordinating the surveillance programme? (note surveillance programme in this context refers to disease/pathogen specific surveillance or infection surveillance, including device related or surgical site infection)	Yes ○	No ○
Please insert additional comment or clarification below related to this section of the tool, with reference to the question number where relevant			

Essential Audit and Surveillance Elements			
A.3.01	Does your hospital have a programme of audit of antimicrobial usage practice in place?	Yes ○	No ○
A.3.02	Please list the last three antimicrobial stewardship related audits conducted at your hospital, with the date that the audit was conducted in each case.		
A.3.03	For these audits, please specify to which groups of staff the findings were disseminated to (tick all that apply)		

	Audit 1	Audit 2	Audit 3
Antimicrobial Stewardship Team	☐	☐	☐
Antimicrobial Stewardship Committee	☐	☐	☐
Drugs and Therapeutics Committee	☐	☐	☐
Hospital Senior Management Team	☐	☐	☐
Prescribers involved	☐	☐	☐
Potential antibiotic prescribers	☐	☐	☐

A.3.04	Are local antibiograms, with pathogen and condition-specific susceptibility data regularly updated and reviewed by relevant personnel at your hospital?	Yes ○	No ○

A.3.05	Are multidisciplinary root cause analysis exercises conducted for all incidences of: ☐ Hospital acquired *Clostridium difficile* ☐ Severe *Clostridium difficile* ☐ *Clostridium difficile* cases associated with clusters/outbreaks ☐ Not at all		
A.3.06	Please outline what infections other than *Clostridium difficile*, if any, are subject to root cause analysis at your hospital		
A.3.07	Does your hospital undertake routine surveillance of *Clostridium difficile* infection rate per 10,000 bed days used?	Yes ○	No ○
A.3.08	Does your hospital record and monitor the incidence of *Clostridium difficile* infection cases in-house in real time, for example by using run charts or statistical process control charts?	Yes ○	No ○
A.3.09	Does your hospital take part in the enhanced *Clostridium difficile* surveillance programme conducted by the Health Protection Surveillance Centre?	Yes ○	No ○

A.3.10 Please indicate which pathogen specific routine surveillance (not including EARS-Net or Clostridium difficile) that is currently ongoing in your hospital, including the organisational level (local, regional, national or international) that this data is reported to and compared at. Please tick all that apply.

Pathogen name, (and either infection or colonisation)	Reported Locally	Reported Regionally	Reported Nationally	Reported Internationally
MRSA Colonisation	☐	☐	☐	☐
MRSA Infection	☐	☐	☐	☐
VRE Colonisation	☐	☐	☐	☐
VRE Infection	☐	☐	☐	☐
MDR* Enterobacteriaceae colonisation	☐	☐	☐	☐
MDR Enterobacteriaceae infection	☐	☐	☐	☐
Multidrug Resistant Acinetobacter Sp. colonisation	☐	☐	☐	☐
MDR Acinetobacter Sp. infection	☐	☐	☐	☐
MDR Pseudomonas Sp. colonisation	☐	☐	☐	☐
MDR Pseudomonas Sp. infection	☐	☐	☐	☐
	☐	☐	☐	☐
	☐	☐	☐	☐
	☐	☐	☐	☐
	☐	☐	☐	☐

*MDR=Multidrug Resistant

A.3.11	Please insert any additional information relating to question A.3.9 below.

Please insert additional comment or clarification below related to this section of the tool, with reference to the question number where relevant

Key Stewardship Interventions			
A.4.01	Are local/regional empiric evidence based antimicrobial prescribing guidelines, designed for use in the majority patient population in place at your hospital?	Yes ○	No ○
A.4.02	Please state when these guidelines are last reviewed and/or updated.		
A.4.03	Does your microbiology laboratory report antimicrobial susceptibilities in a restrictive manner?	Yes ○	No ○
A.4.04	Do reports routinely include interpretive comments to guide prescribers in deciding whether or not antimicrobial therapy is required or what drug to prescribe if an antibiotic is needed?	Yes ○	No ○
A.4.05	Does your hospital have a policy or guideline that includes advice for managing patients with antimicrobial allergies?	Yes ○	No ○
A.4.06	Does your hospital have a policy or guidance document to advise staff on safe administration of IV antimicrobials?	Yes ○	No ○
A.4.07	Does your hospital have a written policy or guideline document outlining expected practice in promoting optimal parenteral to oral conversion?	Yes ○	No ○
A.4.08	Does your hospital have guidance on dosing optimisation and therapeutic drug monitoring for antimicrobials with a narrow therapeutic index (e.g. aminoglycosides, glycopeptides)?	Yes ○	No ○
A.4.09	Is there an ongoing education programme for prudent antimicrobial use and improving antibiotic prescribing for each of the following categories of staff (tick all that apply) ☐ Non-consultant Hospital Doctors ☐ Medical Consultants ☐ Nurse Prescribers ☐ Non-prescribing nurses ☐ Clinical Pharmacists Other (please specify)		

A.4.10	Please outline the supports (eg financial support, protected study time) afforded to antimicrobial stewardship team members to promote their ongoing training and education.
Please insert additional comment or clarification below related to this section of the tool, with reference to the question number where relevant	
Please outline what barriers, if any, limit your hospital's ability to provide any of the essential elements listed in section A above	

Section B - Additional Questions Related to Your Antimicrobial Stewardship Programme

B1. Governance

B.1.01	Does an annual review of the antimicrobial stewardship programme take place?		Yes ○	No ○
B.1.02	Is an annual work plan for the antimicrobial stewardship programme produced following this review?		Yes ○	No ○
B.1.03	Is the antimicrobial stewardship programme specifically listed as an area of focus in the hospitals service plan?	Yes ○	No ○	N/A ○
B.1.04	Is the antimicrobial stewardship programme specifically listed as an area of focus in your hospital groups' service plan?		Yes ○	No ○
B.1.05	Is antimicrobial stewardship included within the hospital's infection control strategy/annual work plan?		Yes ○	No ○
B.1.06	Is antimicrobial stewardship a standing item on the Drugs and Therapeutics Committee's agenda?		Yes ○	No ○
B.1.07	List membership (by roles) of the Drugs and Therapeutics committee			
B.1.08	Does the Antimicrobial Stewardship Committee have minutes or an action list?	Yes ○	No ○	N/A ○
B.1.09	List membership (by roles) of the Antimicrobial Stewardship Committee			
B.1.10	Does your hospital hold any joint Drugs and Therapeutics meetings with any other hospital?		Yes ○	No ○
B.1.11	If yes please list the hospitals:			
B.1.12	Does your hospital hold any joint antimicrobial stewardship meetings with any other hospital?		Yes ○	No ○
B.1.13	If yes please list the hospitals:			

B.1.14	List membership (by role/speciality but not individual name) and number of contracted hours per week dedicated to this role for each member of the antimicrobial stewardship team.		
B.1.15	Is the hospitals superintendent pharmacist routinely located at this hospital site?	Yes ○	No ○
B.1.16	If not then please outline which hospital they are predominantly based at		
B.1.17	Please outline what formal links currently exist in relation to antimicrobial stewardship between your hospital and other hospitals in your hospital group		

Role	Number of hours per week

Please insert additional comment or clarification below related to this section of the tool, with reference to the question number where relevant

B2. Workforce

Staff Deployment

B.2.01 How many Medical Microbiologists are employed by the hospital?

Role	Whole Time Equivalents Currently in Position
Consultants	
Registrars	
SHOs	

B.2.02 How many Infectious Disease Physicians are employed by the hospital?

Role	Whole Time Equivalents Currently in Position
Consultants	
Registrars	
SHOs	

B.2.03 How many Clinical Pharmacists with dedicated responsibility for antimicrobial stewardship (antimicrobial pharmacists) are employed by the hospital?

Job Title of each Clinical Pharmacist Assigned to Stewardship Activities	Whole Time Equivalents Currently in Position	Protected hours per week dedicated to antimicrobial stewardship activities

B.2.04 Overall number of Clinical Pharmacists

Whole Time Equivalents Currently in Position	Number of individuals employed to make up this Whole Time Equivalent	What is the estimated total cumulative number of hours per week that this workforce is engaged in ward/clinic/other clinical pharmacy work?

B.2.05 How many laboratory-based designated surveillance scientists are employed by the hospital? Please detail the number of hours per week that is spent on surveillance activities

Job Title	Whole Time Equivalents Currently in Position	Protected hours per week that are spent on surveillance activities

B.2.06 Number of Infection Control Nurses (Whole Time Equivalent)?

Job Title	Grade	Whole Time Equivalents Currently in Position

B.2.07 How many Infection Surveillance Nurses are employed at your hospital?

Job Title	Whole Time Equivalents Currently in Position	Protected hours per week that are spent on surveillance activities

B.2.08 How many nurses are employed by your hospital to assist with facilitating outpatient parenteral antimicrobial therapy (OPAT)?

Job Title	Whole Time Equivalents Currently in Position

B.2.09 How many hours per week of administrative support are routinely provided to assist the antimicrobial stewardship programme at your hospital?

B.2.10 Are any of the designated staff members listed above currently redeployed to other duties? Yes ○ No ○

B.2.11	Have any of these staff ever been redeployed to other duties within the past 5 years?	Yes ○	No ○
B.2.12	Have all staff that had been redeployed now returned to antimicrobial stewardship duties?	Yes ○	No ○
B.2.13	If staff are redeployed please outline which staff members either have been or are currently affected by position, and the number of hours a week of time typically lost to antimicrobial stewardship activities per staff member		
B.2.14	Has the workforce outlined above ever increased during especially busy periods (e.g. during an outbreak, or as a result of a particular issue requiring further resources)	Yes ○	No ○
B.2.15	Please specify any currently unfilled vacancies in your hospital for any of the positions outlined above.		

Please insert additional comment or clarification below related to this section of the tool, with reference to the question number where relevant

B3. Additional Stewardship Programme Component Parts

Provision of Information to Patients and the Public			
B.3.01	What patient education materials relevant to antimicrobial resistance and use are available to the general public and patients in your hospital: ☐ Materials from the HSE's Public information campaign on antibiotics – antibiotics don't work on colds and flus ☐ Leaflets ☐ Posters ☐ Information on hospital's website Other (please specify)		
B.3.02	Please outline what challenges, if any, you have encountered in providing educational material to the general public and patients in your hospital		
B.3.03	Please outline any other measures your hospital has enacted to involve patients in your antimicrobial stewardship programme		
Prescribing of Antimicrobials and Stewardship Interventions			
B.3.04	Do your antimicrobial prescribing guidelines include a list that stipulates which antimicrobials are restricted (approval of a specialist is required) or permitted for specific conditions?	Yes ○	No ○
B.3.05	If yes how often is this list reviewed?		
B.3.06	If antimicrobials are restricted, please outline how this is achieved (please tick all that apply) ☐ Restricted agents need approval by microbiologist or infectious diseases physician before release from the pharmacy ☐ Restricted agents can only be prescribed by consultants ☐ Restricted agents can only be prescribed by specified consultants/teams ☐ Restricted agents may be prescribed by any staff member, and an initial supply will be provided, but there will be documented antimicrobial stewardship team review within 24-72 hours Other (please specify)		

B.3.07	Please list the restricted antimicrobial agents at your hospital by generic name, with the criteria for their restriction in each case		
B.3.08	Please describe how you monitor compliance with the restriction measures:		
B.3.09	Are antimicrobial stewardship ward rounds conducted in your hospital?	Yes ○	No ○
B.3.10	If yes, how often do they occur?		
B.3.11	How many times a week do Microbiologists or ID Physicians conduct ICU ward rounds? (tick only one option) ○ 5 days per week ○ Every other day ○ Once a week ○ NA (no ICU) Other (please specify)		
B.3.12	Is there a designated section on prescription charts for the prescribing of antimicrobials?	Yes ○	No ○
B.3.13	Does this include provision for an automatic stop date?	Yes ○	No ○
B.3.14	Is there information technology support for antimicrobial stewardship within your hospital?	Yes ○	No ○
B.3.15	If yes, please describe these supports:		
B.3.16	Does your hospital have an electronic prescribing system?	Yes ○	No ○
B.3.17	If yes please list areas where available: ☐ ICU ☐ Entire hospital ☐ Other patient population group		
B.3.18	Does your hospital share guidelines and policies related to antimicrobial use with any other hospital?	Yes ○	No ○
B.3.19	If yes please list the hospitals that you share guidelines with:		

B.3.20	Does the antibiotic prescribing policy in your hospital require antibiotic prescribers to record the indication for antibiotics, on either the drug kardex or elsewhere in the patient's medical records at the time of prescribing the drug?	Yes ○	No ○
B.3.21	Is this audited?	Yes ○	No ○
B.3.22	Does the antibiotic prescribing policy in your hospital include a requirement for duration of therapy to be documented, on either the drug kardex or elsewhere in the patient's medical records at the time of prescribing the drug?	Yes ○	No ○
B.3.23	Is this audited?	Yes ○	No ○
B.3.24	Does your hospital provide any supports to non-acute hospital service providers (e.g. GPs, Nursing Homes)	Yes ○	No ○
B.3.25	If other supports are provided, please specify below		
Please insert additional comment or clarification below related to this section of the tool, with reference to the question number where relevant			

Local Prescribing Guidelines	
B.3.26	In what format(s) are your guidelines available (tick all that apply): ☐ Printed booklet ☐ Online document ☐ Smartphone/Tablet app ☐ Mobile website Other (please specify)
Please insert additional comment or clarification below related to this section of the tool, with reference to the question number where relevant	

Surveillance and Additional Laboratory Services			
B.3.27	Please give three examples of how pathogen/disease specific or infection surveillance data has been used to advance the antimicrobial stewardship programme in your hospital.		
B.3.28	Does your hospital participate in enhanced EARS-NET surveillance?	Yes ○	No ○
B.2.29	Please list the pathogens for which you actively screen and the various clinical settings where screening takes place (e.g. unit, patient population)?		
B.3.30	Is pathogen/disease specific or infection surveillance data reported to senior management in the Hospital?	Yes ○	No ○
B.3.31	If yes, how is this surveillance data reported and acted upon?		
B.3.32	Does your hospital report quarterly antimicrobial consumption data to the Health Protection Surveillance Centre?	Yes ○	No ○
B.3.33	If yes, please outline which individuals and groups review the reports that are returned from the Health Protection Surveillance Centre?		
B.3.34	Do you have an additional system for antimicrobial consumption surveillance in place in your hospital to supplement reports provided by the Health Protection Surveillance Centre?	Yes ○	No ○
B.3.35	Please explain how antimicrobial consumption data has been used to inform improvement in practice locally		

B.3.36	Please outline to which clinical staffing groups antibiotic consumption data is routinely fed back (tick all that apply) ☐ Individual Prescribers ☐ Individual Medical/Surgical Teams ☐ Relevant Consultants ☐ Clinical Departments ☐ Clinical Directorates ☐ All Prescribers Other (please specify)		
B.3.37	If risks are identified from surveillance or antimicrobial consumption data how is this risk escalated in your hospital?		
B.3.38	Is there a surgical site infection (SSI) surveillance programme in place at your hospital?	Yes ○	No ○
B.3.39	If there is a SSI surveillance programme in place, please list the surgical specialities included in this programme		
B.3.40	Is there regular surveillance of healthcare associated invasive medical device infections including (tick all that apply) ☐ Hospital acquired central venous catheter related infection ☐ Hospital acquired peripheral venous catheter related infection ☐ Hospital acquired catheter associated urinary tract infection ☐ Hospital acquired bloodstream infection other than catheter related ☐ Ventilator associated pneumonia (VAP) Other (please specify)		
B.3.41	Is relevant surveillance data routinely reported to and reviewed by (tick all that apply) ☐ The Antimicrobial Stewardship Team ☐ The Antimicrobial Stewardship Committee ☐ The Drugs and Therapeutics Committee ☐ The Infection Prevention Control Committee ☐ The Hospital Senior Management Team Other (please specify)		

Please insert additional comment or clarification below related to this section of the tool, with reference to the question number where relevant

B.3.45	Please list any antimicrobial stewardship quality improvement initiatives that have been conducted/completed in the last two years.

Please insert additional comment or clarification below related to this section of the tool, with reference to the question number where relevant

Outpatient Parenteral Antimicrobial Therapy			
B.3.46	Does your hospital utilise an outpatient parenteral antimicrobial therapy (OPAT) services?	Yes ○	No ○
B.3.47	Please outline what system is in place in your hospital to ensure that patients who are potential candidates for OPAT are clinically reviewed to determine an appropriate treatment regimen before discharge from hospital:		
B.3.48	Does this clinical review always require input from medical microbiologists or infectious disease physicians?	Yes ○	No ○

Clinical Pathways			
B.3.49	Do you have written clinical pathways for specific infections?	Yes ○	No ○
B.3.50	If you do have written clinical pathways for infection, please outline which infection types these refer to:		
Please insert additional comment or clarification below related to this section of the tool, with reference to the question number where relevant			

Education and Training			
B.3.51	Are the principles of prudent antimicrobial prescribing included in induction training for all relevant staff?	Yes ○	No ○
B.3.52	What education interventions are in place to promote appropriate antibiotic use in your hospital(please tick all that are in place) : ☐ Printed materials ☐ Regular presentations ☐ Electronic educational materials ☐ Reminders to individual prescribers ☐ Educational aids to guide prescribers at the point of prescribing. e.g. clinical algorithms for the diagnosis of infection ☐ Awareness days ☐ Online training programmes Other (please specify)		
Please insert additional comment or clarification below related to this section of the tool, with reference to the question number where relevant			

Section C - Additional Required Documentation

Please provide the following additional documentary information alongside this completed self-assessment tool in electronic format to the Authority at qualityandsafety@hiqa.ie. Please tick yes if available and supplied, or no if unavailable.

List of documents required (if available)		
Declaration to be completed by the hospital Chief Executive Officer/General Manager, and the Hospital Group Chief Executive Officer	Yes ○	No ○
A copy of your hospital's Antimicrobial Stewardship Programme Plan for 2015 or most recent available.	Yes ○	No ○
A copy of your hospital's most recent assessment report of the antimicrobial stewardship programme if available.	Yes ○	No ○
A copy of your hospital's most recent empiric antimicrobial prescribing guidelines.	Yes ○	No ○
Your hospital's Standard Operating Procedure for use in the event of a *Clostridium difficile* outbreak.	Yes ○	No ○
A copy of an organogram clearly showing the lines of communication and cooperation between your hospital's Drugs and Therapeutics Committee/Antimicrobial Stewardship Team, the Infection Prevention and Control Team, the Pharmacy Department, the Risk Management Team/Department and your hospital's senior Management Team.	Yes ○	No ○

Appendix 3 — Expert Advisory Group membership

Name	Organization
Chairperson — Mary Dunnion	Director of Regulation, HIQA
Project Lead — Sean Egan	Acting Head of Healthcare, Healthcare Regulation, HIQA
Dr Eibhlin Connolly	Deputy Chief Medical Officer, Department of Health — nominated on behalf of the Chief Medical Officer
Dr Robert Cunney	Consultant Microbiologist, Children's University Hospital Temple Street, and Clinical Lead, HSE Healthcare Associated Infection and Antimicrobial Resistance Clinical Programme — nominated on behalf of the HSE National Quality Improvement Division
Dr Eoin Feeney - for 2016	Consultant Infectious Diseases Physician, St Vincent's University Hospital, Dublin — nominated on behalf of the Infectious Disease Society of Ireland
Karen Logan	Surveillance Scientist, University Hospital Sligo — nominated on behalf of the Surveillance Scientists Association of Ireland
Catherine Mannion	Antimicrobial Pharmacist, St Luke's Hospital, Kilkenny — nominated on behalf of the Hospital Pharmacists Association of Ireland, and the Irish Antimicrobial Pharmacists Group
Mr Paul McCormick	Consultant Colorectal and General Surgeon, St James's Hospital, Dublin – Nominated on behalf of the Royal College of Surgeons in Ireland
Stephen McMahon	Irish Patients' Association
Mary McKenna	Assistant Director of Nursing, HSE Healthcare Associated Infection and Antimicrobial Resistance Clinical Programme — nominated on behalf of the Office of Nursing and Midwifery, HSE
Dr Busi Mooka — for 2015	Consultant Infectious Diseases Physician, University Hospital Limerick — nominated on behalf of the Infectious Diseases Society of Ireland
Dr Eoghan O'Neill	Consultant Microbiologist, Connolly Hospital, Blanchardstown – Chairperson, National Antimicrobial Stewardship in Hospitals Committee

Professor Edmund Smyth	Consultant Microbiologist, Beaumont Hospital, Dublin — nominated on behalf of the Irish Society of Clinical Microbiologists
Margaret Swords	Chief Operating Officer, Royal College of Surgeons in Ireland Hospital Group — nominated on behalf of the HSE Acute Hospitals Division
Dr Catherine Wall	Consultant Nephrologist, Tallaght Hospital, Dublin — nominated on behalf of the Royal College of Physicians of Ireland
Further additional supports were provided by HIQA staff	

Appendix 4 — Governance: description of national leadership, governance and management structures for infection prevention and control and antimicrobial stewardship

This review identified that there are a number of key contributory groups which play a role nationally with respect to antimicrobial stewardship and infection prevention and control. The following section outlines the role of these different groups, and relationship with each other as they existed at the start of the review.

Department of Health

While the Health Service Executive (HSE) is responsible for the operational management of the prevention and control of Healthcare Associated Infection and antimicrobial resistance, in the absence of a stand-alone HSE board, governance oversight of how the HSE exercises these functions lies with the Minister for Health and the Department of Health.

To supplement this formal reporting function, the Department also contributes to wider cross-governmental efforts to address the threat of emergent antimicrobial resistance, and oversees creating national clinical guidelines, some of which are of direct relevance to this area.

National Interdepartmental Antimicrobial Resistance Consultative Committee

The Irish Government has, in line with EU requirements, established a National Interdepartmental Antimicrobial Resistance Consultative Committee, which is a joint initiative between the Department of Health and the Department of Agriculture, Food and the Marine.

The committee was set up in November 2014, and is jointly chaired by the Chief Medical Officer of the Department of Health and the Chief Veterinary Officer of the Department of Agriculture, Food and the Marine. It met twice during 2015. The Committee aims to increase public and professional awareness of the need for prudent use of antimicrobials in the treatment of human and animal diseases, in the context of a 'one-health' approach.

This committee also aims to provide guidance as to how best to ensure that the matter of antimicrobial resistance is addressed holistically and in a coordinated way across both sectors at a national level, in a setting where challenges faced by both sectors are understood by all.

The committee aim to provide guidance as to how best to encourage, coordinate and support existing and planned work on the antimicrobial resistance threat, including research activities. It also aims to provide commentary and advice, which will serve to inform future evidence-based intersectoral policy decisions and actions in relation to antimicrobial resistance.

National Clinical Effectiveness Committee

The National Clinical Effectiveness Committee (NCEC) was established by the Minister for Health in September 2010. At the time of this review, the Committee has published 14 national clinical practice guidelines. The Minister has directed that these published national clinical effectiveness guidelines are to be implemented in Irish public acute hospitals. Three of these guidelines relate to antimicrobial resistance and Healthcare Associated Infections and include guidelines for the management of *Clostridium difficile* and the prevention and control of Meticillin-Resistant *Staphylococcus aureus* (MRSA) and sepsis.

Health Service Executive (HSE)

Nationally, the HSE comprises a directorate structure known as the Health Service Directorate. This directorate is led by the Director General of the HSE who reports directly to the Minister for Health.

The directorate comprises national HSE directors with responsibility for operational services including acute hospitals, social care, primary care, health and wellbeing, mental health and quality improvement. In addition, the directorate also includes the HSE's Deputy Director General and its Chief Financial Officer positions. The organizational structure is shown in Figure 1 on the following page.

Non-acute HSE service areas, including primary care, social care, health and wellbeing and mental healthcare, are delivered by community healthcare organizations. Each such organization is headed up by a chief officer who reports to four national HSE directors in relation to social care, primary care, health and wellbeing, and mental health.

The HSE's Health and Wellbeing Division

Two sections of the HSE's Health and Wellbeing Division are relevant to this review: the Health Protection Surveillance Centre (HPSC) and Public Health (of which there are eight departments of public health).

Both sections have a role to play in infection prevention and control and antimicrobial stewardship through a framework of infectious disease laws and regulations.

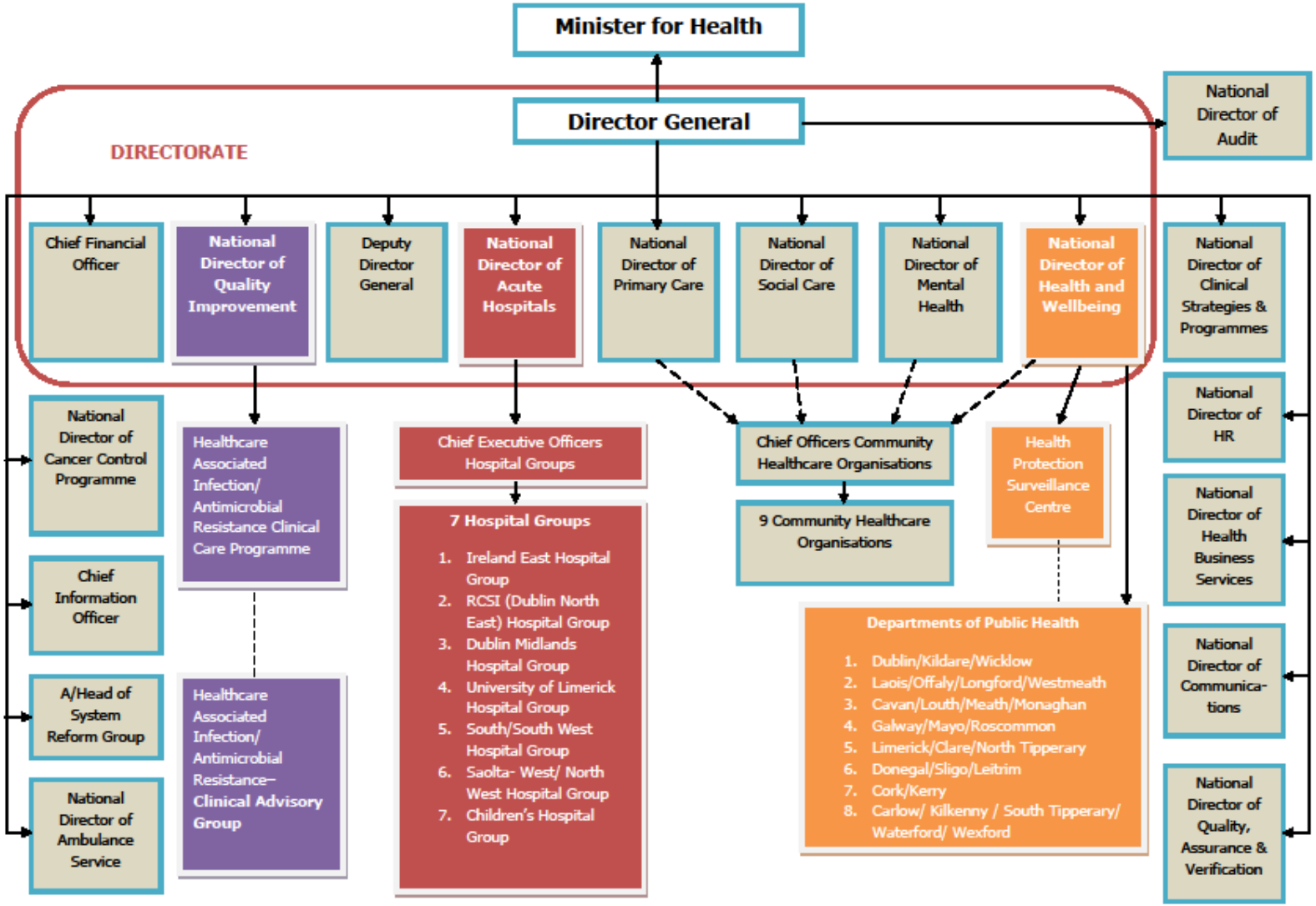
Health Protection Surveillance Centre

The Health Protection Surveillance Centre (HPSC) is the national communicable disease surveillance resource of the Irish health service, and reports directly into the National Health and Wellbeing Division of the HSE. It was initially established to report data into a European-wide network of national antimicrobial resistance surveillance systems.

The HPSC is legally responsible for collating and reporting data into the HSE which is relevant to communicable diseases. Data is submitted to the HPSC by public health departments and hospital laboratories across Ireland. It also has roles and responsibilities in relation to emergency planning, international health regulations, operational support, policy development, research, training and providing public information.

The HPSC has played an important role in promoting the development of national standards and guidelines about infection prevention and control, antimicrobial stewardship and antimicrobial resistance.

Chart 1. HSE organizational structure, as it relates to antimicrobial stewardship and infection prevention and control at the start of this review. Source: HSE



The national Healthcare Associated Infection and Antimicrobial Resistance Clinical Programme

The HSE's national clinical programmes were established in 2010 as a joint initiative between the HSE and the Forum of Irish Postgraduate Medical Training Bodies with the objective of improving the quality of care that the HSE delivers. A national HSE clinical programme for Healthcare Associated Infection and antimicrobial resistance was set up in 2010. The programme has focused on three main areas for improvement, namely: hand hygiene performance, antimicrobial stewardship and the prevention of invasive-device related infection. HIQA was informed during this review that the Healthcare Associated Infection and Antimicrobial Resistance Programme is a supportive and advisory forum only, and does not have the authority or operational responsibility to implement its recommendations.

Royal College of Physicians of Ireland Clinical Advisory Group for Healthcare Associated Infection and Antimicrobial Resistance

The Royal College of Physicians of Ireland (RCPI) Clinical Advisory Group for Healthcare Associated Infection and Antimicrobial Resistance was set up in September 2011 to provide expert advice to the HSE's clinical programme described immediately above. This advisory group took over the functions of the original SARI (A Strategy for the Control of Antimicrobial Resistance in Ireland) National Committee which had been initially established to oversee the implementation of the SARI strategy in 2001.

Multidisciplinary membership of this committee includes clinical microbiologists, pharmacists, surveillance scientists, infection prevention and control nurses, an endoscopy/decontamination lead and representatives from the Department of Health and the Department of Agriculture, Food and the Marine.

Terms of reference for this group include:

- providing expert advice to the HSE on developing infection prevention and control strategies and to indicate priority areas for intervention
- advising on developing national surveillance and quality indicators
- developing national guidelines, staff information and education
- providing expert advice to the Department of Health on national policy
- formally coordinating national efforts between relevant different bodies, including the veterinary colleges.

Although funded by the HSE, it was reported to HIQA during this review that the Clinical Advisory Group reports into the Faculty of Pathology in the Royal College of Physicians of Ireland. Similar to the Healthcare Associated Infection and Antimicrobial Resistance Clinical Programme, the Clinical Advisory Group serves in an advisory capacity only and does not

have the authority or operational responsibility to effect the implementation of its recommendations.

National Antimicrobial Stewardship in Hospitals Committee

The National Antimicrobial Stewardship in Hospitals Committee is a subcommittee of the above RCPI's Healthcare Associated Infection and antimicrobial resistance clinical advisory group. This committee is accountable to the HSE National Director of Quality Improvement and the aforementioned RCPI clinical advisory group. The function and responsibility of the Committee is to provide expertise and advice on all aspects of antimicrobial prescribing in hospitals and to review and update national guidance in relation to antimicrobial stewardship.

The Committee has played an important role in coordinating an annual antimicrobial prescribing point-prevalence study across acute hospitals. It has also overseen the development of national surveillance systems for antimicrobial use in hospitals. However, similar to the both the HSE's clinical programme and the RCPI's clinical advisory group, this Committee acts in an advisory capacity only and does not have the authority or operational responsibility to secure the implementation of its recommendations.

Appendix 5 — The Gram-negative resistance threat explained

What are Gram-negative bacteria?

The term Gram-negative bacteria refers to a collection of bacterial species which when submitted to a test with exposes them to a particular staining dye (Crystal Violet stain, also known as the Gram stain), do not absorb the stain. Bacterial species that do absorb such a stain are known as Gram-positive bacteria, and this absorption into their cell wall makes it easier to see them under a microscope.

Which bacterial species fall into the Gram-negative category, and what types of infections do these cause?

The term Gram-negative bacteria covers a whole series of bacterial species. In practical terms, the most common species that can cause infection include *Escherichia coli* (*E. coli*), *Klebsiella pneumoniae*, *Pseudomonas aeruginosa* and *Salmonella Species*. In contrast, Meticillin-Resistant *Staphylococcus aureus* (MRSA) is a Gram-positive bacterial species. Gram-negative bacteria may be found in the environment, in soil, or as human or animal colonising bowel flora. Every human bowel contains millions of bacteria (including Gram-negative bacteria) which usually live harmlessly in that environment.

Gram-negative bacteria most commonly cause urinary tract infection, abdominal infection, respiratory infection and bloodstream infection. Gram-negative infections commonly occur in hospitalized patients, or those who have weak immune systems, and infection may occur through the transfer of the patient's own bacterial flora from their bowel to parts of the body that would normally be sterile, due to illness or medical intervention (such as an intravenous line insertion, urinary catheterisation, or surgical procedures). Poor environmental hygiene and poor hand hygiene may also aid in the transmission of Gram-negative bacteria to patients from the environment, or indeed from other patients accommodated in the clinical area.

Why is there concern about antimicrobial resistance to Gram-negative bacteria in particular?

Gram-negative infection is the most common bacterial cause of sepsis or septic shock in hospitalized patients. As a consequence, severe infection may result in rapid patient deterioration, and it is especially important that antimicrobials initially chosen to treat the infection are given quickly, and are effective in treating the likely infecting bacteria — there may be little leeway to further strengthen the antimicrobial regimen chosen if the first choice option does not work.

Unfortunately, resistance amongst Gram-negative species has evolved significantly over the past 15 years, and efforts to discover new antimicrobials to treat this grouping of

bacteria have been relatively ineffective. In the most resistant strains that have begun to emerge, clinicians have increasingly needed to rely on using older less established antimicrobials that historically fell out of favour, but have needed to be revived through necessity as they are the only antimicrobials left which retain activity against the bacteria in question.

What are beta-lactamases?

The most commonly used antimicrobials in Irish hospitals fall into two related classes, known as either penicillins or cephalosporins. These antimicrobial classes are collectively known as 'Beta-lactam' antimicrobial, because as part of their chemical composition they share a common structure known as a beta-lactam ring. Over time, following the introduction of these new antimicrobials, bacteria began to evolve a mechanism to stop them from working, by developing the capability to produce a chemical called an enzyme which could attack and dismantle the commonly shared beta-lactam ring. Such an enzyme is known as a beta-lactamase. Bacteria with the ability to produce beta-lactamases are resistant to the effects of penicillins such as benzylpenicillin and amoxicillin.

In clinical practice, it would not be uncommon to encounter bacteria which produce beta-lactamases. To counter this evolution, scientists designed new antimicrobial combinations to overcome the beta-lactamases. The antimicrobial co-amoxiclav (a combination of amoxicillin and clavulanic acid) contains a medicine designed to stop the beta-lactamase from working — clavulanic acid — a so called beta-lactamase inhibitor. Many of the cephalosporins have been further refined through a series of generations from first-generation to now a fifth-generation to overcome evolving resistance as it emerges.

What are extended-spectrum beta-lactamases and carbapenemase producers?

Bacterial species continually evolve to overcome and thrive in their environment. With the introduction of new antimicrobials, bacteria found ways to overcome these new innovations. One such development has seen certain bacterial strains evolving to produce what are known as extended-spectrum beta-lactamases (ESBLs). These are like standard beta-lactamases, but they can prevent a wider range of more recently developed antimicrobials from working, including second and third-generation cephalosporins.

The gold standard treatment option for patients infected with ESBL producers is an antimicrobial called meropenem. This antimicrobial is ultra-broad-spectrum, and it belongs to a class of antimicrobials called carbapenems. Historically, this antimicrobial was rarely used in Ireland, and kept in reserve for very sick patients. However, Irish hospitals now need to routinely use this medicine due to the increased incidence of ESBL producing bacteria found in sicker patients.

Greater use of meropenem has begun to see limited instances of the emergence of resistance to this drug — some strains of Gram-negative bacteria have evolved to produce

chemicals which disable meropenem and other carbapenem antimicrobials from working. These chemicals are known as carbapenemases. Treatment options for carbapenemase producing bacteria are limited to a handful of antimicrobial choices which are often less effective than meropenem, and sometimes more toxic. In addition, the level of experience in using some of these antimicrobials to treat infection in certain parts of the body is limited.

Resistance mechanism transmission

Beta-lactamases, extended-spectrum beta-lactamases and carbapenemases present an additional challenge from an infection control perspective as these mechanisms may be readily spread between different bacterial species. This means that when and where they emerge they can often spread very quickly. Also, unlike with MRSA, patients who are colonized with bacteria in their bowel that have the ability to produce these chemicals cannot be treated to eradicate the colonization (a process known as decolonization).

How common are the bacteria that produce these mechanisms?

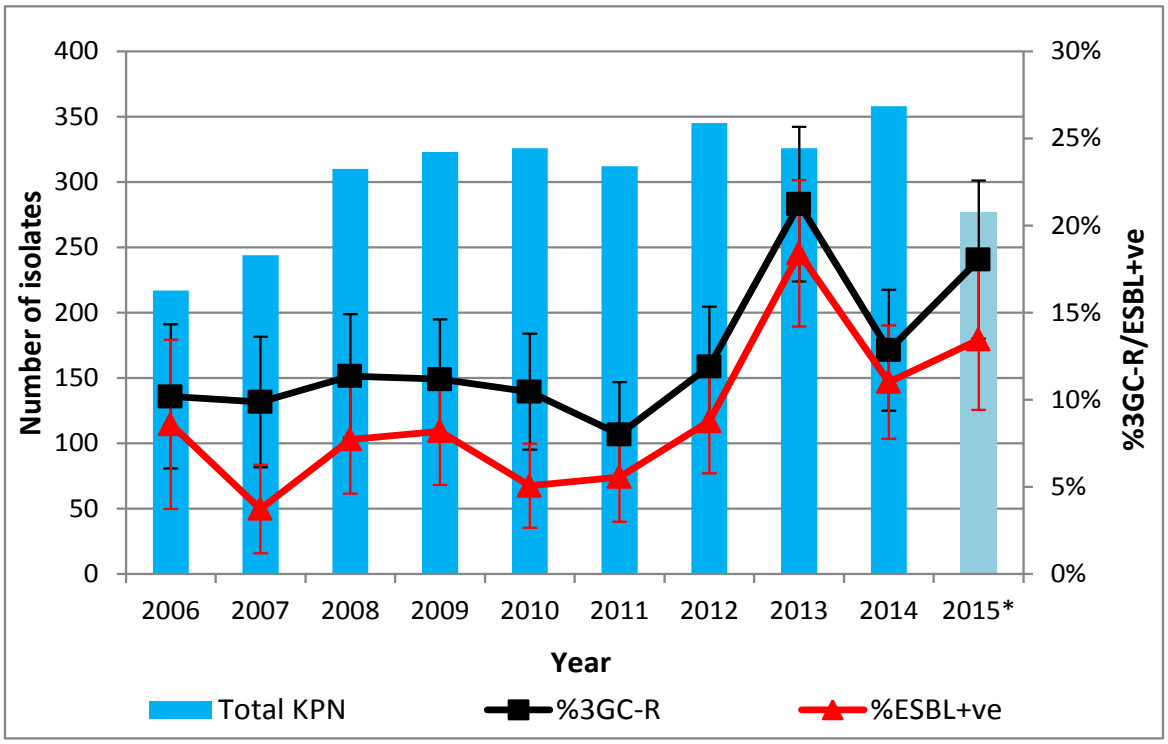
Standard beta-lactamase producing bacteria are commonly found in practice in Ireland. Ten years ago, extended spectrum beta-lactamase (ESBL) producers were very uncommon in Ireland. However, there has been a significant increase in their detection over the last decade.

In 2013, a national outbreak of the Gram-negative ESBL producing bacteria *Klebsiella pneumoniae* was identified in Ireland. Chart 2 below, which is taken from the HPSC website, outlines the percentage detection of ESBL producers relative to non-ESBL producers amongst blood-stream isolates processed in Irish laboratories. In excess of 10% of all isolates were ESBL producers in these tests, and for every patient colonized with an ESBL producing organism which results in the development of a bloodstream infection, a much wider proportion of the population will remain colonized (and therefore in a position to transmit the bacteria), but uninfected.

In 2012, the Royal College of Physicians of Ireland Clinical Advisory Group on Healthcare Associated Infection, in Association with the HSE's Quality and Patient Safety Division, published guidelines for the prevention and control of multidrug-resistant organisms (MDRO) excluding MRSA in the healthcare setting.

These guidelines included recommendations on which patients should be screened to identify who is colonized with, for example, multidrug-resistant Gram-negative organisms (such as ESBL and carbapenemase producing organisms). The guidelines also outlined management measures where detection occurred. This review by HIQA has identified that these guidelines have not been routinely implemented in hospitals. As a consequence, the full burden of colonization with these multidrug resistant organisms in Ireland is currently not known.

Chart 2. The annual trend of *Klebsiella pneumoniae* (KPN) isolated from blood cultures in Irish hospitals, with the percentage incidence rate of third-generation Cephalosporin resistance (%3GC-R), and the percentage of ESBL production in these isolates. *2015 rates to Q3 of 2015 only. Data source: www.hpsc.ie.

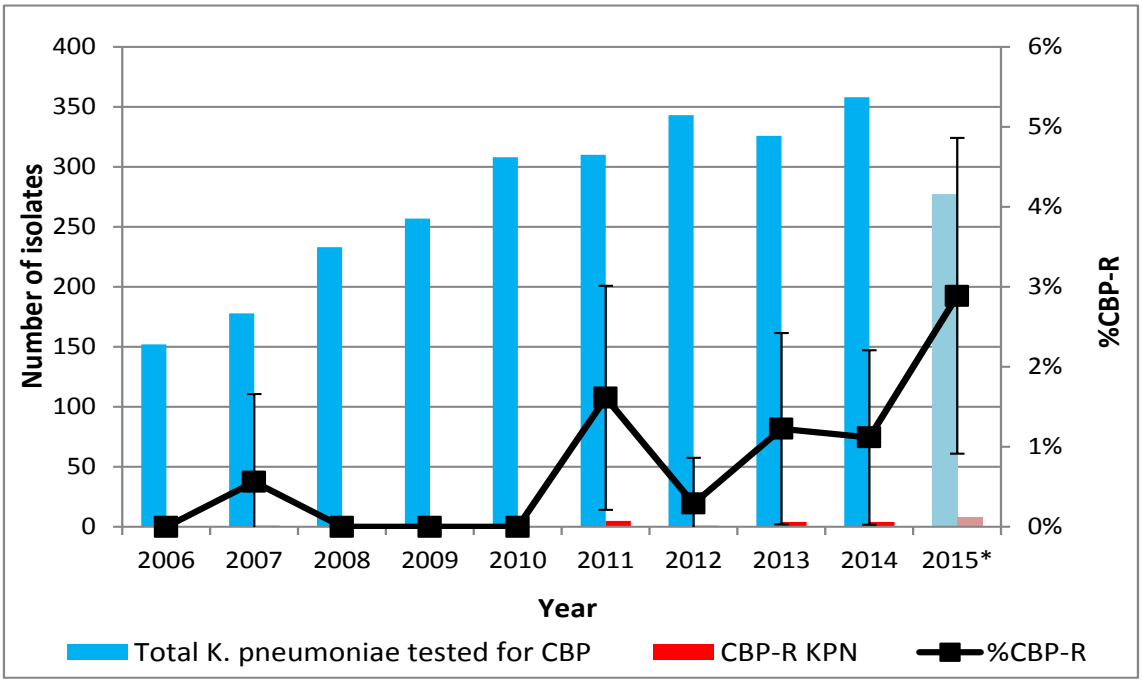


Carbapenemase producing Gram-negative bacteria remain relatively uncommon in Ireland. However, there has been an ongoing outbreak in the Mid-West Region of the country including the University Hospital Limerick. Experience internationally has demonstrated that failure to contain such outbreaks effectively can result in rapid proliferation of what is a highly clinically significant resistance problem.

Chart 3 outlines the national rate of detection of carbapenem resistance in *Klebsiella pneumoniae* bloodstream isolates in Ireland up to and including the third quarter of 2015. The map shown below it (Chart 4) outlines the percentage detection rate of carbapenemase producing Gram-negative bacteria in bloodstream isolates in 2014 across Europe. It can be seen from this map that while the incidence in Ireland remains on the relatively low end of the spectrum, the incidence is much higher in some southern European countries — in Greece for example, more than 50% of bloodstream isolates tested are resistant to carbapenems.

This phenomenon has occurred over a relatively short time period, and results in a significant number of additional deaths in the country annually relative to pre-carbapenem resistant times. It would be expected that the incidence of mortality associated with such resistance would be relatively high.

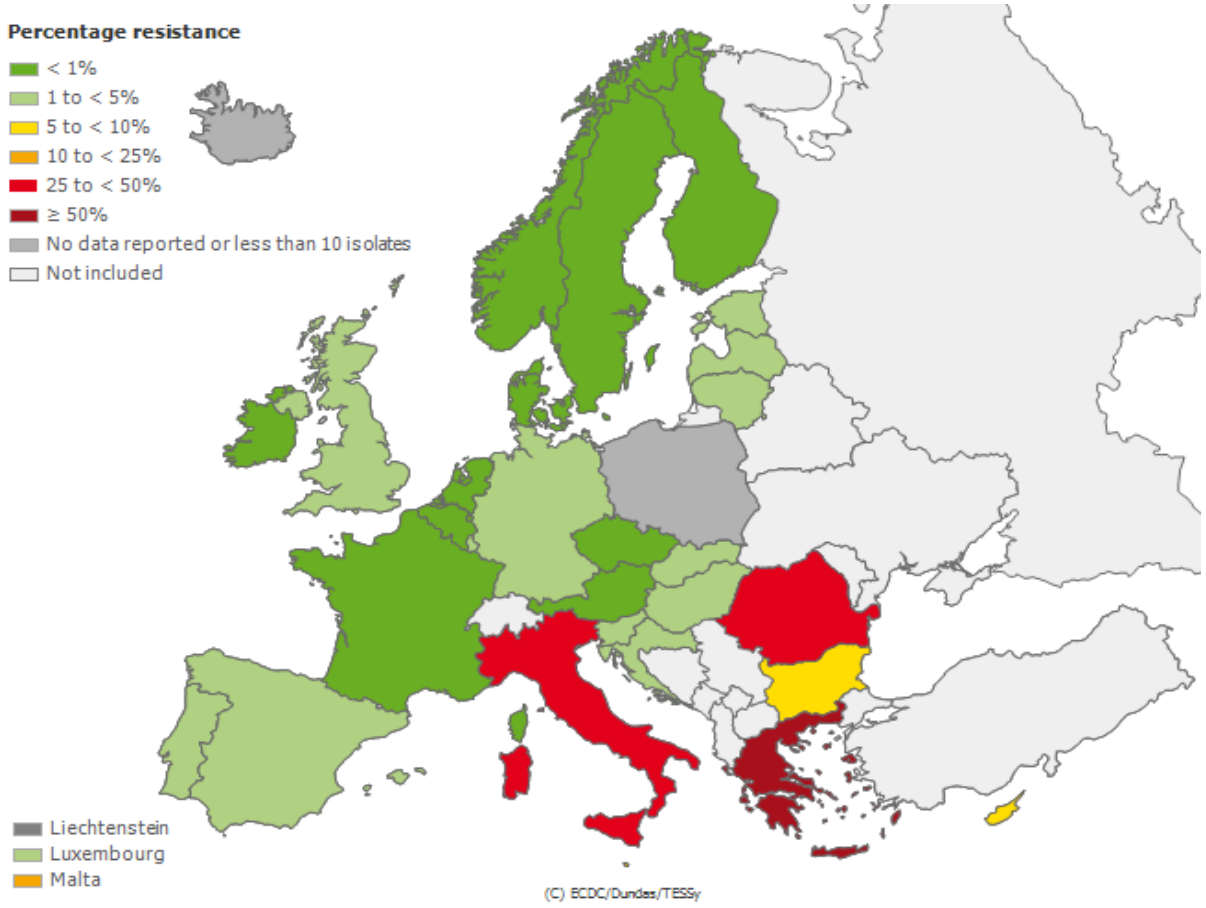
Chart 3. The annual trend of *Klebsiella pneumoniae* (KPN) isolated from blood cultures in Irish hospitals, with the percentage incidence rate of carbapenem resistance (%CBP-R) as the percentage tested for this resistance mechanism. *2015 rates to Q3 of 2015 only. Data source: www.hpsc.ie.



Given the experience of emergent Gram-negative resistance elsewhere in Europe, it is imperative that the recommendations of this report and other national guidelines of relevance are fully enacted in the short term.

Failure to implement these recommendations and guidelines presents the risk that such resistance will become endemic in Ireland, as it has in many southern European countries. Such a situation will result in increased patient mortality, increased morbidity, and much higher treatment costs than might otherwise occur in preventing such a situation from occurring.

Chart 4. The percentage distribution of carbapenem resistance in *Klebsiella pneumoniae* bacteria in EARS-Net reporting European Countries in 2014. Available from http://ecdc.europa.eu/en/healthtopics/antimicrobial_resistance/database/Pages/database.aspx.



Appendix 6 – List of public acute hospitals in Ireland by group, the 2010 HSE acute medicine programme hospital model type,[107] and governance status

In Ireland, acute hospitals have recently been organised into seven hospital groups on an administrative basis. These groups contain a variety of different hospitals which were classified in 2010 by the Health Service Executive's (HSE's) Acute Medicine Programme by way of hospital model type, which was defined by the level of the services provided.

In addition, public acute hospitals in Ireland are governed and funded in two ways. Statutory hospitals are directly governed and funded by the HSE. Alternatively, voluntary hospitals are so called due to their historical formation independently from the State by voluntary organisations. These hospitals retain their own independent boards and internal governance structures. They are part funded through allocation by the Irish Government and provide services as outlined in service level agreements. They report on performance via the hospital group structure and accountability framework to the HSE.

Children's Hospital Group

Name	Model	Voluntary or Statutory
Children's University Hospital, Temple Street, Dublin	Specialist paediatric	Voluntary
Our Lady's Children's Hospital, Crumlin, Dublin	Specialist paediatric	Voluntary

Dublin Midland Hospital Group

Name	Model	Voluntary or Statutory
Coombe Women and Infants University Hospital, Dublin	Specialist maternity	Voluntary
Midland Regional Hospital, Portlaoise	3	Statutory
Midland Regional Hospital Tullamore	3	Statutory
Naas General Hospital	3	Statutory
St James's Hospital, Dublin	4	Voluntary
St Luke's Hospital, Rathgar, Dublin	Specialist oncology/ radiotherapy	Voluntary
The Adelaide and Meath Hospital, Dublin, Incorporating the National Children's Hospital	4	Voluntary

Ireland East Hospital Group

Name	Model	Voluntary or Statutory
Cappagh National Orthopaedic Hospital, Dublin	Specialist orthopaedic	Voluntary
Mater Misericordiae University Hospital, Dublin	4	Voluntary
Midland Regional Hospital Mullingar	3	Statutory
National Maternity Hospital, Holles Street, Dublin	Specialist maternity	Voluntary
Our Lady's Hospital Navan	3	Statutory
Royal Victoria Eye and Eye Hospital, Dublin	Specialist eye and ear	Voluntary
St Columcille's Hospital, Loughlinstown, Dublin	2	Statutory
St Luke's General Hospital Kilkenny	3	Statutory
St Michael's Hospital, Dun Laoghaire	2	Voluntary
St Vincent's University Hospital, Dublin	4	Voluntary
Wexford General Hospital	3	Statutory

Royal College of Surgeons in Ireland (RCSI) Hospital Group

Name	Model	Voluntary or Statutory
Beaumont Hospital, Dublin	4	Voluntary
Cavan General Hospital	3	Statutory
Connolly Hospital, Dublin	3	Statutory
Louth County Hospital	2	Statutory
Monaghan General Hospital	Combined with Cavan	Statutory
Our Lady of Lourdes Hospital, Drogheda	3	Statutory
Rotunda Maternity Hospital, Dublin	Specialist maternity	Voluntary

Saolta Hospital Group

Name	Model	Voluntary or Statutory
Letterkenny General Hospital	3	Statutory
Mayo General Hospital	3	Statutory
Portiuncula Hospital	3	Statutory
Roscommon Hospital	2	Statutory
Sligo General Hospital	3	Statutory
University Hospital Galway, (incorporating Merlin Park Hospital)	4	Statutory

South/South West Hospital Group

Name	Model	Voluntary or Statutory
Bantry General Hospital	2	Statutory
Cork University Hospital	4	Statutory
Cork University Maternity Hospital	Specialist maternity	Statutory
Kerry General Hospital	3	Statutory
Lourdes Orthopaedic Kilcreene, Co Kilkenny	Specialist orthopaedic	Statutory
Mallow General Hospital	2	Statutory
Mercy University Hospital, Cork	3	Voluntary
South Infirmary Victoria University Hospital, Cork	2	Voluntary
South Tipperary General Hospital, Clonmel	3	Statutory
Waterford Regional Hospital	4	Statutory

University of Limerick Hospitals Group

Name	Model	Voluntary or Statutory
Croom Hospital, Co Limerick	Specialist orthopaedic	Statutory
Ennis Hospital	2	Statutory
Nenagh Hospital	2	Statutory
St John's Hospital, Limerick	2	Voluntary
University Hospital Limerick (Dooradoyle)	4	Statutory
University Maternity Hospital, Limerick	Specialist maternity	Statutory

Glossary of terms used in this report

Accountability: being answerable to another person or organization for decisions, behaviour and any consequences.
Adverse event: an incident that results in harm to a patient.
Antibiogram: the result of laboratory testing for the susceptibility of a strain of bacteria to different antimicrobials. This information can be collated to guide antimicrobial prescribing practice.
Antibiotic: a substance that kills or inhibits the growth of bacteria. See also entry on **Antimicrobial.**
Antimicrobial: a substance that kills or inhibits the growth of micro-organisms such as bacteria, viruses or fungi (an antibiotic is a type of antimicrobial). The term antimicrobial is used throughout this report except where the term antibiotic is specifically mentioned such as in references to academic literature or to describe a specific occurrence such as an educational event containing the word 'antibiotic' in the title. See also entry on **antibiotic**.
Antimicrobial resistance: when a microbe becomes more or fully resistant to antimicrobials which previously could treat infection caused by microbe/s. This broader term also covers antibiotic resistance, which applies to bacteria and antibiotics.
Antimicrobial stewardship: describes a system or collection of measures introduced into a healthcare setting which aim to improve the quality of antimicrobial usage across a patient population, to optimize outcomes, reduce adverse events, minimize the emergence of antimicrobial resistance and reduce treatment costs.
Assurance: is being sure or certain about systems, processes and procedures and standing over business objectives. It involves monitoring risk and implementing controls to mitigate that risk.
Audit: a quality improvement process that seeks to improve service-user care and outcomes through systematic review of care against explicit criteria and the implementation of change.
Bacteraemia: a bacterial infection of the blood or lymph system.
Benchmarking: a continuous process of measuring and comparing care and services with similar service providers.

Broad-spectrum antimicrobial: an antimicrobial that acts against a wide range of disease-causing bacteria, in contrast to a **narrow-spectrum antimicrobial**, which is effective against specific families of bacteria.
Carbapenemase-producing Enterobacteriaceae: are Gram-negative bacteria that possess the ability to produce an enzyme which can breakdown and therefore prevent carbapenem antimicrobials, such as meropenem, from working. Possession of this resistance mechanism is significant as carbapenem antimicrobials are considered a 'drug of last resort' for Gram-negative bacterial infections.
Care bundle: a structured way of improving the process of care and patient/service-user outcomes. They are groupings of evidence-based best practices with respect to a disease process that improve care.
Care pathway: a multidisciplinary care plan that outlines the main clinical interventions undertaken by different healthcare professionals in the care of patients with a specific condition or set of symptoms.
Clinical guidelines: systematically developed statements to assist healthcare professionals and patients' decisions about appropriate healthcare for specific circumstances.
Clinical (medical) microbiologist: a person who studies the science of the isolation and identification of microorganisms that cause disease in humans and applies this knowledge to treat, control and prevent infections in humans.
Clinical pharmacist: qualified pharmacist who develops and promotes the rational, safe and appropriate use of medicines.
Clinician/clinical staff: health professionals engaged in the care of hospital patients and service users.
Clostridium difficile: is a bacterium that lives harmlessly in the colon of a certain proportion of the population. In some patients, overgrowth of *Clostridium difficile* in the bowel and subsequent toxin production by this increased population causes inflammation of the colon, known as colitis. Broad-spectrum antimicrobial usage may promote the overgrowth of *Clostridium difficile*, as other bacteria in the bowel may be removed due to the antibiotics, thereby upsetting the natural ecological balance in the bowel. People who have other illnesses or conditions requiring prolonged use of antimicrobials, and the elderly, are at greater risk of acquiring this disease. The consequences range from diarrhoea, up to and including bowel perforation or death in a small proportion of patients.

Colonization/colonized: when micro-organism(s) are living on or in a person without causing disease.
Communicable disease: a disease caused by a micro-organism that can be passed from a person, animal or the environment to another susceptible individual. Also known as infectious disease.
Consultant: a hospital consultant is a registered medical practitioner in hospital practice who, by reason of his or her training, skill and experience in a designated specialty, is consulted by other registered medical practitioners and assumes full clinical responsibility for patients in his or her care or that aspect of care on which he or she has been consulted, without supervision in professional matters by any other person.
Drugs and therapeutics committee: a multidisciplinary group of people from within and outside a hospital or group of hospitals, which reports to senior management. The committee is responsible for expert governance oversight and review of the service to ensure safe and effective use of medicines in the hospital(s) in question.
Empiric antimicrobial therapy: antimicrobial therapy given for an anticipated and likely cause of infection based upon probability, but where the causative organism has not yet been identified through microbiological testing.
***Enterococci* :** part of the normal intestinal bacteria of humans and animals. These bacteria can cause serious infection in a normally sterile site such as the bloodstream. Over time *Enterococci* have developed resistance to antimicrobials which makes some infections more difficult to treat.
Epidemiology: the study of factors affecting the health and illness of populations.
Extended-spectrum beta-lactamase (ESBL) producing Gram-negative organisms: enzymes produced by bacteria that provide resistance to a number of different types of commonly used antimicrobials. This ESBL enzyme breaks down the antimicrobials' structure. This limits the treatment options for ESBL producing bacteria — with carbapenem antimicrobials such as meropenem representing the gold standard treatment option.
Gentamicin: antimicrobial used to treat several types of serious bacterial infections. Gentamicin can cause inner ear problems and kidney problems so the dose required should be monitored by blood testing, also known as therapeutic drug monitoring. This makes the medicine more difficult to use effectively and safely than many conventional antimicrobials, and therefore a regular target for improvement efforts.

Governance: in healthcare, an integration of corporate and clinical governance; the systems, processes and behaviours by which services lead, direct and control their functions in order to achieve their objectives, including the quality and safety of services for patients.
Gram-negative bacteria: a type of bacteria that cause infections including pneumonia, bloodstream infections, wound or surgical site infections, and meningitis in healthcare settings. Gram-negative bacteria are becoming increasingly resistant to antimicrobials.
Hand hygiene: a general term referring to any action of hand cleansing.
Healthcare Associated Infections: infections that are acquired as a result of healthcare interventions.
Health Protection Surveillance Centre (HPSC): specialist organization which is responsible for surveillance of communicable disease and other functions in Ireland. It is part of the Health Service Executive (HSE).
Infection prevention and control: the discipline and practice of preventing and controlling the spread of infection and infectious diseases in a healthcare organization.
Infection prevention and control committee: a multidisciplinary group of people from within and outside a hospital or group of hospitals, which reports to senior management. The committee is responsible for expert governance oversight and review of the service to prevent and control infection in the hospital(s) in question.
Infectious disease: a disease that can be spread from one person to another, also called communicable disease.
Infectious diseases physician: in this report refers to consultant grade medical doctors who specialise in the prevention, diagnosis and management of communicable disease.
Invasive infection: when **micro-organisms** invade parts of the body that are normally free from micro-organisms. For example, pneumococcal bacteria can invade the bloodstream, causing bacteraemia, and the tissues and fluids surrounding the brain and spinal cord, causing meningitis.
***Klebsiella pneumonia* :** a Gram-negative bacterium that normally lives inside human intestines, where it doesn't cause disease. However, these bacteria can cause serious infection in the bloodstream and the lungs. An increase in antimicrobial-resistant strains of these bacteria has made some infections more difficult to treat.
Key performance indicator (KPI): see **Performance indicator**.

Medication management: the clinical, cost-effective and safe use of medicines to ensure that service users get the maximum benefit from the medicines they need, while at the same time minimizing potential harm.
Medication safety: aims to reduce medication-related harm and improve patient safety.
Meropenem: an ultra-broad-spectrum antimicrobial belonging to a class of antimicrobial known as carbapenems. It may be used to treat a wide range of infection types. It is an important antimicrobial as it remains the gold standard treatment for serious infection caused by extended-spectrum beta-lactamase (ESBL) producing Gram-negative organisms. Treatment options for Gram-negative organisms resistant to meropenem are very limited in number, generally less effective and can be toxic.
Meticillin-Resistant *Staphylococcus aureus* (MRSA): strains of *Staphylococcus aureus* resistant to one or more antimicrobial classes including penicillins.
Microbiology: the branch of biology that deals with micro-organisms and their effects on other living organisms.
Model 1, 2, 3 and 4 hospitals: in 2010, the HSE's National Acute Medicine Programme described four generic acute hospital models (Model 1, 2, 3 and 4). Their purpose was to define the level of service that can be safely provided at acute hospitals within the constraints of available facilities, staff, resources and local factors. Below are broad descriptions of the type of care usually provided in these hospitals. **Model 1 hospitals** are community and or district hospitals that do not have surgery, emergency care, acute medicine (other than a select group of low-risk patients) or critical care. **Model 2 hospitals** can provide the majority of hospital activity including extended day surgery, selected acute medicine, local injuries, a large range of diagnostic services, including endoscopy, laboratory medicine, point-of-care testing, radiology (computed tomography [CT], ultrasound and plain-film X-ray), specialist rehabilitation medicine and palliative care. **Model 3 hospitals** admit all types of patients with any degree of seriousness or severity of illness or injury; provide 24-seven acute surgery, acute medicine, and critical care. **Model 4 hospitals** are tertiary hospitals and are similar to Model 3 hospitals, but also provide tertiary care and, in certain locations, supra-regional care.

Multidisciplinary: an approach to the planning of treatment and the delivery of care for a patient or service user by a team of healthcare professionals who work together to provide integrated care.
Multiple drug resistance: resistance to two or more antimicrobials from different antimicrobial classes.
National clinical guidelines: a suite of guidelines that meet specific quality assurance criteria and have been mandated by the designated national body, the National Clinical Effectiveness Committee.
Outbreak of infection: usually two or more related cases of the same infection or where the number of infections is more than would normally be expected.
Outbreak management team/committee: a multidisciplinary group of people from within and outside the service, responsible for the management of outbreaks, which reports to senior management.
Performance indicator: specific and measurable elements of practice that can be used to assess quality and safety of care (may also be called key performance indicator).
Performance management and or **performance monitoring:** a process which includes activities that ensure that goals are consistently being met in an effective and efficient manner. Performance management can, for example, focus on the performance of an organization, a department, service, or the processes to deliver a service.
Point-of-care: the place where the three elements of care come together: the patient, the healthcare worker and the care or treatment involving contact with the patient or his or her surroundings.
Prophylaxis: the administration of medication or treatment to prevent an event. For example, the administration of an antimicrobial before surgery in order to reduce the risk of infection as a consequence of the procedure.
Risk management: the systematic identification, evaluation and management of risk. It is a continuous process with the aim of reducing risk to an organization and individuals.
Risk register: a risk register is a risk management tool. It acts as a central repository for all risks identified by an organization and, for each risk, includes information such as risk probability, impact, controls and risk owner.
Risk: in healthcare, the likelihood of an adverse event or outcome.
Specialist hospital: in this report refers to stand-alone paediatric, orthopaedic and

maternity hospitals.
Strategy/strategic plan: a focused guide which outlines future direction for an organization through the development of targets to achieve strategic goals. It generally projects a medium- to long-term vision (three to five years) and enables the development of an operational plan, aligned to identified needs.
Surveillance: the systematic collection and evaluation of data on all aspects of a disease which are relevant to its prevention and control.
Surveillance scientist: in this report refers to a healthcare worker, usually a medical laboratory scientist who collates and analyses microbiology laboratory results.
Terms of reference: a set of terms that describe the purpose and structure of a project, committee or meeting.
Tertiary hospital: a hospital in which the clinical services are more specialised that those provided in other types of acute hospital, for example, neurosurgery, oncology, transplant services.
Transmission: the spread of infection or infectious disease from one person to another or a plasmid from one bacterium to another.
Vancomycin: broad-spectrum antimicrobial that has activity (amongst other bacteria) against Meticillin-Resistant strains of *Staphylococcus aureus*. It is generally reserved for the treatment of serious drug resistant Gram-positive infections. Vancomycin dosing should be patient-specific based upon a patient's weight and kidney function, and can cause side effects. Therefore, the dose required should be monitored by blood testing, also known as therapeutic drug monitoring. This makes the medicine more difficult to use effectively and safely than many conventional antimicrobials, and therefore a regular target for improvement efforts.
Whole-time equivalent (WTE): one whole-time equivalent employee is an employee who works the total number of standardized hours possible for their grade. WTEs are not the same as staff numbers as many staff work reduced hours, for example, two nurses working 19.5 hours per week each would be one WTE as full-time hours for nursing staff are currently 39 hours per week.
Workforce: the people who work in, for, or with the service provider. This includes individuals that are employed, self-employed, temporary, volunteers, contracted or anyone who is responsible or accountable to the organization when providing a service to the service user or patient.

References

(1) Valencia R, Arroyo LA, Conde M, Aldana JM, Torres MJ, Fernández-Cuenca F, et al. Nosocomial outbreak of infection with pan-drug-resistant Acinetobacter baumannii in a tertiary care university hospital. *Infection Control & Hospital Epidemiology.* 2009; 30(3): pp.257-63.

(2) Falagas M, Bliziotti I. Pandrug-resistant Gram-negative bacteria: the dawn of the post-antibiotic era? *International Journal of Antimicrobial Agents.* 2007; 29(6): pp.630-6. Available online from: http://www.sciencedirect.com/science/article/pii/S0924857907000192.

(3) World Health Organization. *Antimicrobial resistance, global report on surveillance*. 2014.

(4) HM Government, Welcome Trust. *Review on Antimicrobial Resistance - Tackling drug-resistant infections globally*. 2014. Available online from: http://amr-review.org/sites/default/files/AMR%20Review%20Paper%20-%20Tackling%20a%20crisis%20for%20the%20health%20and%20wealth%20of%20nations_1.pdf.

(5) Dellit TH, Owens RC, McGowan JE, Gerding DN, Weinstein RA, Burke JP, et al. Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America Guidelines for Developing an Institutional Program to Enhance Antimicrobial Stewardship. *Clinical Infectious Diseases.* 2007; 44(2): pp.159-77. Available online from: http://cid.oxfordjournals.org/content/44/2/159.full.

(6) Davey P, Brown E, Charani E, Fenelon L, Gould IM, Holmes A, et al. Interventions to improve antibiotic prescribing practices for hospital inpatients. *Cochrane Library.* 2013; Available online from: http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD003543.pub3/full.

(7) Health Information and Quality Authority. *National Standards for the Prevention and Control of Healthcare Associated Infections*. Dublin: Health Information and Quality Authority; 2009. Available online from: http://www.hiqa.ie/publication/national-standards-prevention-and-control-healthcare-associated-infections.

(8) Council of the EU. *Council conclusions on the next steps under a One Health approach to combat antimicrobial resistance*. Press Release . 2016. Available online from: http://www.consilium.europa.eu/en/press/press-releases/2016/06/17-epsco-conclusions-antimicrobial-resistance/.

(9) Pogue JM, Marchaim D, Kaye D, Kaye KS. Revisiting "older" antimicrobials in an era of multidrug resistance. *Pharmacotherapy: The Journal of Human Pharmacology and Drug Therapy.* 2011; 31(9): pp.912-21.

(10) Boucher HW, Talbot GH, Bradley JS, Edwards JE, Gilbert D, Rice LB, et al. Bad Bugs, No Drugs: No ESKAPE! An Update from the Infectious Diseases Society of

America. *Clinical Infectious Diseases.* 2009; 48(1): pp.1-12. Available online from: http://cid.oxfordjournals.org/content/48/1/1.long.

(11) Piddock LJV. The crisis of no new antibiotics - what is the way forward? *The Lancet Infectious Diseases.* 2011; 12(3): pp.249-53.

(12) Pok HCJ, Lopez-Mayor JF. Post-operative wound infection: a prospective study of determinant factors and prevention. *Surgery.* 1969; 66(1): pp.97-103.

(13) Hill C, Flamet R, Mazas F, Evrgard J. Prophylactic cefazolin versus placebo in total hip replacement. Report of a multicentre double-blind randomised trial. *The Lancet.* 1987; 329(8537): p.860.

(14) Smaill F HG. Antibiotic prophylaxis for cesarean section. *The Cochrane Library (Oxford)*. 2005.

(15) Fleming A. *Nobel lecture*. 1945. Available online from: http://www.nobelprize.org/nobel_prizes/medicine/laureates/1945/fleming-lecture.pdf.

(16) Tufts Center for the Study of Drug Development. *Briefing: Cost of Developing a New Drug*. Boston: 2014. Available online from: http://csdd.tufts.edu/files/uploads/Tufts_CSDD_briefing_on_RD_cost_study_-_Nov_18,_2014..pdf.

(17) Fishbach MA, Walsh CT. Antibiotics for emerging pathogens. *Science.* 2009; 325(5944): pp.1089-93. Available online from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2802854/.

(18) Spellberg B, Blaser M, Guidos RJ, Boucher HW, Bradley JS, Eisenstein BI, et al. Combating antimicrobial resistance: policy recommendations to save lives. *Clinical Infectious Diseases* 52[Supple 5], p.S397-S428. 2011.

(19) World Health Organization. *Global Action Plan on Antimicrobial Resistance*. 2015.

(20) The White House. *National Strategy For Combating Antibiotic Resistant Bacteria*. Washington: The White House; 2014. Available online from: https://www.whitehouse.gov/sites/default/files/docs/carb_national_strategy.pdf

(21) HM Government, Wellcome Trust, The Review on Antimicrobial Resistance. *Tackling a global health crisis: initial steps.* 2015. Available online from: http://amr-review.org/sites/default/files/Report-52.15.pdf.

(22) The Federal Government (Germany). *DART 2020. Fighting antibiotic resistance for the good of both humans and animals*. 2015. Available online from: http://www.bmg.bund.de/fileadmin/dateien/Publikationen/Ministerium/Broschueren/BMG_DART_2020_Bericht_en.pdf

(23) Federal Ministry of Health (Germany). *G7 Germany 2015: Combating antimicrobial resistance. Examples of best-practices of the G7 countries*. 2015. Available online

from: http://www.bmg.bund.de/fileadmin/dateien/Downloads/G/G7-Ges.Minister_2015/Best-Practices-Broschuere_G7.pdf

(24) Department of the Taoiseach. *National Risk Assessment 2014*. 2014. Dublin. Available online from: http://www.taoiseach.gov.ie/eng/Publications/Publications_2014/National_Risk_Assessment_report_2014.pdf.

(25) Department of the Taoiseach. *Draft National Risk Assessment 2015*. 2015. Dublin. Available online from: http://www.taoiseach.gov.ie/eng/Publications/Publications_2015/2015_05_15_Draft_NRA_.pdf.

(26) Department of the Taoiseach. *Draft National Risk Assessment 2016 - Overview of Strategic Risks*. 2016. Available online from: http://www.taoiseach.gov.ie/eng/Publications/Publications_2016/Draft_National_Risk_Assessment_for_2016_.pdf

(27) European Centre for Disease Prevention and Control, European Medicines Agency. *The bacterial challenge: time to react*. Stockholm: European Centre for Disease Prevention and Control; 2009. Available online from: http://ecdc.europa.eu/en/publications/Publications/0909_TER_The_Bacterial_Challenge_Time_to_React.pdf

(28) Centers for Disease Control and Prevention. *Antibiotic resistance threats in the United States, 2013*. 2013. Available online from: http://www.cdc.gov/drugresistance/pdf/ar-threats-2013-508.pdf

(29) Morris D, Boyle F, Morris C, Condon I, Delannoy-Viellard AS, Power L, et al. Inter-hospital outbreak of Klebsiella pneumoniae producing KPC-2 carbapenemase in Ireland. *Journal of Antimicrobial Chemotherapy.* 2012; 67(10): pp.2367-72.

(30) Wrenn C, O'Brien D, Keating D, Roche C, Rose L, Ronayne A, et al. Investigation of the first outbreak of OXA-48-producing Klebsiella pneumoniae in Ireland. *Journal of Hospital Infection.* 2014; 87(1): pp.41-6. Available online from: http://www.sciencedirect.com/science/article/pii/S0195670114000838?np=y.

(31) Liu L, Wang Y, Walsh T, Yi L, Zhang R, Spencer J, et al. Emergence of plasmid-mediated colistin resistance mechanism MCR-1 in animals and human beings in China: a microbiological and molecular biological study. *The Lancet Infectious Diseases* 2016; 16[2], pp.161-8.

(32) Webb H, Granier S, Marault M, Millemann Y, den Bakker H, Nightingale K, et al. Dissemination of the MCR-1 colistin resistance gene. *The Lancet Infectious Diseases* 2016; 16[2], pp.144-5.

(33) Mc Gann P, Snesnid E, Maybank R, Corey B, Ong A, Clifford R, et al. Escherichia coli harbouring mcr-1 and bla CTX-M on a novel IncF plasmid: first report of mcr-1 in the USA. *Antimicrobial Agents and Chemotherapy* 2016; [doi:10.1128].

(34) Generating Antibiotic Incentives Now Act of 2010.2010. Available online from: https://www.congress.gov/bill/111th-congress/house-bill/6331?q={%22search%22%3A[%22\%22hr6331\%22%22]}&resultIndex=2.

(35) Transatlantic Taskforce on Antimicrobial Resistance. *Transatlantic Taskforce on Antimicrobial Resistance, 2011. Recommendations for future collaboration between the U.S. and E.U.* 2014. Available online from: http://www.cdc.gov/drugresistance/pdf/tatfar-progress_report_2014.pdf.

(36) Butler MS, Blaskovich MA, Cooper MA. Antibiotics in the clinical pipeline in 2013. *Journal of Antibiotics.* 2013; 66(10): pp.571-91.

(37) HM Government. *UK 5 Year Antimicrobial Resistance (AMR) Strategy 2013-2018, Annual Progress Report and Implementation Plan, 2014*. 2014. Available online from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/385733/UK_AMR_annual_report.pdf.

(38) NHS Scotland. *Scottish Management of Antimicrobial Resistance Action Plan 2014-2018 (ScotMarap 2)*. 2014. Available online from: http://www.gov.scot/Publications/2014/07/9192.

(39) *DANMAP: Danish Integrated Antimicrobial Resistance Monitoring and Research Programme. 2012*. 2012. Available online from: http://www.danmap.org/Downloads/The%20Danish%20approach.aspx.

(40) Public Health Agency of Sweden. *Swedish work on containment of antibiotic resistance. Tools, methods and experiences.* Public Health Agency of Sweden; 2014.

(41) Centers for Disease Control and Prevention. *National strategy for the control of antibiotic resistance. 2014. USA*.

(42) World Health Organisation. *Worldwide countries situation analysis: response to antimicrobial resistance*. 2015. Available online from: http://www.who.int/drugresistance/documents/situationanalysis/en/.

(43) SARI. *A Strategy for the Control of Antimicrobial Resistance in Ireland*. 2001. Available online from: http://www.hpsc.ie/A-Z/MicrobiologyAntimicrobialResistance/StrategyforthecontrolofAntimicrobialResistanceinIrelandSARI/KeyDocuments/File,1070,en.pdf.

(44) Health Service Executive, Health Protection Surveillance Centre, SARI Hospital Antimicrobial Stewardship Working Group. *Guidelines for Antimicrobial Stewardship in Hospitals in Ireland*. Dublin: Health Service Executive Health Protection Surveillance Centre; 2009. Available online from: https://www.hpsc.ie/A-Z/MicrobiologyAntimicrobialResistance/InfectionControlandHAI/Guidelines/File,4116,en.pdf.

(45) Health Service Executive. *Guidelines for antibiotic prescribing in primary care*. 2014. Available online from: http://www.antibioticprescribing.ie/.

(46) Health Information and Quality Authority. *Overview of HIQA unannounced infection prevention and control inspections 2015*. 2016. Available online from: https://www.hiqa.ie/publications/overview-hiqa-unannounced-infection-prevention-and-control-inspections-2015.

(47) Tricker B. *Corporate Governance: Principles, policies and practices.* Oxford: Oxford University Press; 2009.

(48) Higgins J R and Department of Health. *The Establishment of Hospital Groups as a transition to Independent Hospital Trusts. A report for the Minister for Health, Dr James Reilly TD*. Dublin: Department of Health; 2013. Available online from: http://health.gov.ie/blog/publications/the-establishment-of-hospital-groups-as-a-transition-to-independent-hospital-trusts/.

(49) Health Service Executive. *National Service Plan 2015*. Health Service Executive; 2015. Available online from: http://www.hse.ie/eng/services/publications/corporate/sp2015.pdf.

(50) Health Service Executive. *National Service Plan 2016*. 2016. Available online from: https://www.hse.ie/eng/services/publications/serviceplans/nsp16.pdf

(51) Health Information and Quality Authority. *Guidance on Developing Key Performance Indicators and Minimum Data Sets to Monitor Healthcare Quality. Version 1.1*. Dublin: Health Information and Quality Authority; 2013. Available online from: http://www.hiqa.ie/publications/guidance-developing-key-performance-indicators-kpis-and-minimum-data-sets-monitor-healt.

(52) Health Protection Surveillance Centre. *Prevention of intravascular catheter-related infection in Ireland. SARI Prevention of intravascular catheter-related infection subcommittee*. 2009. Available online from: https://www.hpsc.ie/A-Z/MicrobiologyAntimicrobialResistance/InfectionControlandHAI/Guidelines/File,14834,en.pdf

(53) Health Protection Surveillance Centre obotSftCoASiIS. *SARI Implementation: Gap Analysis and Future Priorities*. 2008. Available online from: http://www.hpsc.ie/A-Z/MicrobiologyAntimicrobialResistance/StrategyforthecontrolofAntimicrobialResistanceinIrelandSARI/KeyDocuments/File,3101,en.pdf.

(54) Burns K, Foley M, Donlon S, Health Protection Surveillance Centre. *Health Protection Surveillance Centre, Point Prevalence Survey of Hospital Acquired Infections & Antimicrobial Use in European Acute Care Hospitals: May 2012 - Republic of Ireland National Report: November 2012.* Available online from: http://www.hpsc.ie/A-Z/MicrobiologyAntimicrobialResistance/InfectionControlandHAI/Surveillance/HospitalPointPrevalenceSurveys/2012/PPS2012ReportsforIreland/File,13788,en.pdf

(55) Health Protection Surveillance Centre. *EARS-Net Report, Quarter 1-4 2015*. 2016. Available online from: http://www.hpsc.ie/A-Z/MicrobiologyAntimicrobialResistance/EuropeanAntimicrobialResistanceSurveillanceSystemEARSS/EARSSSurveillanceReports/2015Reports/File,15214,en.pdf

(56) Royal College of Physicians of Ireland Clinical Advisory Group on Healthcare Associated Infections, Health Service Executive Quality and Patient Safety Directorate. *Guidelines for the prevention and control of multidrug resistant organisms (MDRO) excluding MRSA in the healthcare setting*. 2012. Available online from: http://www.hpsc.ie/A-Z/MicrobiologyAntimicrobialResistance/InfectionControlandHAI/Guidelines/File,12922,en.pdf

(57) Boucher HW, Talbot GH, Benjamin DK, Bradley J, Guidos RJ, Jones RN, et al. 10 × '20 Progress—Development of New Drugs Active Against Gram-Negative Bacilli: An Update From the Infectious Diseases Society of America. *Clinical Infectious Diseases.* 2013; Available online from: http://cid.oxfordjournals.org/content/early/2013/04/16/cid.cit152.full.

(58) Schwaber MJ, Lev B, Israeli A, Solter E, Smollan G, Rubinovitch B et al. Containment of a country-wide outbreak of carbapenem-resistant Klebsiella pneumoniae in Israeli Hospitals via a nationally implemented intervention. *Clinical Infectious Diseases* 2011; 52[7], pp.848-55.

(59) Health Service Executive. *Press Release - HSE welcomes HIQA report on overview of unannounced infection prevention and control inspections 2015*. 2016.

(60) OECD. *Public Servants as PArtners for Growth: Toward a Stronger, Leaner and More Equitable Workforce, OECD Publishing*. OECD Publishing; 2011. Available online from: http://www.oecd.org/gov/pem/publicservantsaspartnersforgrowth.htm.

(61) SARI. *Annual Report 2007*. 2007. Available online from: https://www.hpsc.ie/A-Z/MicrobiologyAntimicrobialResistance/StrategyforthecontrolofAntimicrobialResistanceinIrelandSARI/SARIAnnualReports/File,3202,en.pdf

(62) Department of Finance. *Press Release - Implementation of a moratorium on recruitment and promotions in the public sector*. 2009. Available online from: http://www.finance.gov.ie/news-centre/press-releases/implementation-moratorium-recruitment-and-promotions-public-service.

(63) Health Service Executive. *Employment census report - April 2016*. 2016. Available online from: https://www.hse.ie/eng/staff/Resources/Employment_Reports/Census-Report-April-2016-.pdf

(64) Royal College of Pathologists, Association of Medical Microbiologist. *Getting ahead of the Curve - a strategy for infectious disease: Recommendations on configuration of clinicaal and public health microbiology and virology services for the diagnosis, prevention and management of infection.* 2002.

(65) Hand K. Antibiotic pharmacists in the ascendancy. *Journal of Antimicrobial Chemotherapy* 2007; 60[Supple 1], p.i73-i76.

(66) Health Information and Quality Authority. *Report of the investigation into the safety, quality and standards of services provided by the Health Service Executive (HSE) to patients, including pregnant women, at risk of clinical deterioration, including those provided in University Hospital Galway (UHG), and as reflected in the care and treatment provided to Savita Halappanavar*. Dublin: Health Information and Quality Authority; 2013. Available online from: http://www.hiqa.ie/publications/patient-safety-investigation-report-services-university-hospital-galway-uhg-and-reflect.

(67) Murphy D, Carrico R, Warye K. Building the infection prevention system of tomorrow: Proceedings of the 2007 APIC futures summit. *American Journal of Infection Control* 2008; 36[4], pp.232-40.

(68) Stone P, Dick A, Pogorzelska H, Horan T, Furuya Y, Larson E. Staffing and structure of infection prevention and control programs. *American Journal of Infection Control* 2009; 37, pp.351-7.

(69) MacDougall C, Polk R. Antimicrobial stewardship programs in health care systems. *Clinical Microbiology Reviews.* 2005; 18 pp.638-56.

(70) Frontini R, Miharija-Gala T, Sykora J. EAHP Survey 2010 on hospital pharmacy in Europe: Part 1. General frame and staffing. *European Journal on Hospital Pharmacy* 2012; 19[4], pp.385-7.

(71) Society of Hospital Pharmacists of Australia. *Revised information on clinical pharmacist staffing levels*. 2011. Collingwood, Victoria, Society of Hospital Pharmacists of Australia.

(72) The Pharmaceutical Society of Ireland. *Baseline study of Hospital Pharmacy in Ireland Report 2012*. 2012.

(73) Health Information and Quality Authority. *National Standards for Safer Better Healthcare*. 2012. Available online from: http://www.hiqa.ie/standards/health/safer-better-healthcare.

(74) Department of Health Expert Advisory Committee on Antimicrobial Resistance and Healthcare Associated Infection, Public Health England. *Antimicrobial prescribing and stewardship competencies*. 133-155 Waterloo Road, Wellington House, London, SE1 8UG: Public Health England; 2013.

(75) Health Protection Surveillance Centre. *Public MicroB Reports*. 2016. Available online from: http://www.hpsc.ie/A-Z/MicrobiologyAntimicrobialResistance/EuropeanSurveillanceofAntimicrobialConsumptionESAC/PublicMicroBReports/.

(76) European Centre for Disease Prevention and Control. *European Surveillance of Antimicrobial Consumption Network (ESAC-Net)*. 2016. Available online from: http://ecdc.europa.eu/en/activities/surveillance/ESAC-Net/Pages/index.aspx.

(77) Beastall G. The Modernisation of Pathology and Laboratory Medicine in the UK: Networking into the Future. *The Clinical Biochemist Reviews.* 2008; 29(1): Available online from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2423316/.

(78) Gallagher DP, O'Reilly A, Fitzpatrick F, Slattery DM, Mallon PW, Fleming C, et al. *Out-patient parenteral antimicrobial therapy in Ireland: practice standards*. 2010. Available online from: http://www.idsociety.ie/wp-content/plugins/downloadmonitor/download.php?id=2.

(79) The National Clinical Effectiveness Committee. *Surveillance, Diagnosis and Management of Clostridium difficile Infection in Ireland National Clinical Guideline No. 3*. Department of Health; 2014. Available online from: http://health.gov.ie/wp-content/uploads/2015/01/National-Clinical-Guideline-No.-3-Clostridium-difficile.pdf

(80) Duguid M, Cruickshank ME. *Antimicrobial Stewardship in Australian Hospitals*. 2011. Sydney, Australian Commission on Safety and Quality in Healthcare. Available online from: http://www.safetyandquality.gov.au/wp-content/uploads/2011/01/Antimicrobial-stewardship-in-Australian-Hospitals-2011.pdf.

(81) Barlam TF, Cosgrove S, Abbo L, MacDougall C, Schuetz A, Septimus E, et al. Implementing an antimicrobial stewardship program: Guidelines by the Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America. *Clinical Infectious Diseases* 2016; 62[10], p.e51-e77.

(82) Khan R, Cheesbrough J. Impact of changes in antibiotic policy of *Clostridium difficile* - associated diarrhoea (CDAD) over a five-year period in a district general hospital. *Journal of Hospital Infections.* 2003; 54 pp.104-8.

(83) Chalmers JD, Al-Khairalla M, Short PM, Fardon TC, Winter JH. Proposed changes to management of lower respiratory tract infections in response to the *Clostridium difficile* epidemic. *Journal of Antimicrobial Chemotherapy.* 2010; 65 pp.608-18.

(84) Pepin J, Saheb N, Coulombe MA, Alary ME, Corriveau MP, Authier S et al. Emergency of fluoroquinolones at the predominant risk factor for *Clostridium difficile* - associated diarrhea - a cohort study during an epidemic in Quebec. *Clinical Infectious Diseases.* 2005; 41 pp.1254-60.

(85) Goldenberg SD, Price NM, Tucker D, Wade P, French GL. Mandatory reporting and improvements in diagnosing *Clostridium difficile* infection: an incompatible dichotomy? *Journal of Infection.* 2011; 62(5): pp.363-70.

(86) Leape LL, Brennan TA, Laird N, Lawthers AG, Localio AR, Barnes BA et al. The nature of adverse events in hospitalized patients. Results of the Harvard Medical Practice Study II. *New England Journal of Medicine.* 1991; 324(6): pp.377-84.

(87) Leape LL. *Error in medicine*. JAMA 1994; 272[23], pp.1851-7.

(88) Dean Franklin B, Vincent C, Schacter M, Barber N. The incidence of prescribing errors in hospital inpatients; an overview of the research methods*. Drug Safety.* 2005; 28(10): pp.891-900.

(89) Mc Dowell S, Ferner H, Ferner RE. The pathophysiology of medication errors: how and where they arise. *British Journal of Clinical Pharmacology.* 2009; 67(6): pp.605-13.

(90) The Irish Longitudinal Study on Ageing. *The over 50s in a changing Ireland - economic circumstances, health and well-being*. 2014.

(91) Davies E, Green C, Mottram D, Rowe P, Pirmohamed M. Emergency re-admissions to hospital due to adverse drug reactions within 1 year of the index admission. *British Journal of Clinical Pharmacology* 2010; 70, pp.749-55.

(92) Ahern F, Salm L, Lynch D, McCarthy S. Determining the frequency and preventability of adverse drug reaction-related admissions to an Irish University Hospital: a cross-sectional study. *Emergency Medicine Journal* 2014; 31[1], pp.24-9.

(93) Comptroller and Auditor General. *Report on the accounts of the public services*. 2012.

(94) Grimes T, Deasy E, Allen A, O'Byrne J, Delaney T, Barragry J, et al. Collaborative pharmaceutical care in an Irish hospital: uncontrolled before-after study. *BMJ Quality & Safety* 2014; 23, pp.574-83.

(95) Benn J, Koutantji M, Wallace L, Spurgeon P, Rejman M, Healey A et al. Feedback from incident reporting: information and action to improve patient safety. *Quality and Safety in Health Care.* 2009; 18 pp.11-21.

(96) Nathwani D, Sneddon J, Malcolm W, Wiuff C, Patton A, Hurding S et al. Scottish Antimicrobial Prescribing Group*. International Journal of Antimicrobial Agents.* 2011; 38(1): pp.16-26.

(97) *Royal College of Physicians of Ireland - Gentamicin Collaborative*. Royal College of Physicians of Ireland . 2014. Available online from: https://www.rcpi.ie/quality-improvement-programmes/national-quality-improvement-programme/gentamicin-improvement-guide/.

(98) Department of Health. *Prevention and Control Methicillin-Resistant Staphylococcus aureus (MRSA). National Clinical Guideline No. 2*. Dublin: Department of Health; 2013. Available online from: http://health.gov.ie/wp-content/uploads/2015/01/National-Clinical-Guideline-No.-2-MRSA1.pdf.

(99) Department of Health. *Surveillance, Diagnosis and Management of Clostridium difficile Infection in Ireland. National Clinical Guideline No. 3*. Dublin: Department of

Health; 2014. Available online from: http://health.gov.ie/wp-content/uploads/2015/01/National-Clinical-Guideline-No.-3-Clostridium-difficile.pdf.

(100) Department of Health. *Sepsis Management National Clinical Guideline No. 6*. Dublin: Department of Health; 2014. Available online from: http://health.gov.ie/wp-content/uploads/2015/06/Sepsis-Mgmt_Full-Report.pdf.

(101) Cooke J, Alexander K, Charani E, Hand K, Hills T, Howard P, et al. Antimicrobial Stewardship: an evidence-based, antimicrobial self-assessment toolkit (ASAT) for acute hospitals. *Journal of Antimicrobial Chemotherapy.* 2012; 65(12): pp.2669-73.

(102) Antimicrobial Stewardship Toolkit.Best practice from the GNYHA/UHF antimicrobial stewardship collaborative initiative. *Greater New York Hospital Association/ United Hospital Fund*. 2011. Available online from: http://www.shea-online.org/Portals/0/GNYHA_Antimicrobial_Stewardship_Toolkit_FINALv2%20Dec2011.pdf.

(103) Joint Commission International. *Antimicrobial Stewardship Toolkit*. 2015. Available online from: http://www.jointcommissioninternational.org/antimicrobial-stewardship-toolkit.

(104) Thompson I. *Antimicrobial Stewardship in New Zealand. Scoping Research*. Health Quality and Safety Commission New Zealand; 2013. Available online from: http://www.hqsc.govt.nz/assets/Infection-Prevention/PR/Antimicrobial-stewardship-report.pdf .

(105) Department of Health, Social Services and Public Safety. *Changing the Culture 2010. Strategy for Tackling Antimicrobial Resistance (STAR) 2012-2017*. Belfast: Department of Health,Social Services and Public Safety (Northern Ireland); 2010. Available online from: http://www.dhsspsni.gov.uk/star-doc.pdf .

(106) Nathwani D, Scottish Medicines Consortium (SMC) short life working group, Scottish Executive Health Department Healthcare Associated Infection Taskforce. Antimicrobial prescribing policy and practice in Scotland: recommendations for good antimicrobial practice in acute hospitals. *Journal of Antimicrobial Chemotherapy.* 2006; 57(6): pp.1189-96.

(107) Royal College of Physicians of Ireland, Irish Association of Directors of Nursing and Midwifery, Therapy Professions Committee, Health Service Executive, Quality and Clinical Care Directorate. *Report of the National Acute Medicine Programme*. Health Service Executive; 2010. Available online from: http://www.hse.ie/eng/about/Who/clinical/natclinprog/acutemedicineprogramme/report.pdf.

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