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# Antimicrobial stewardship in Ireland (2010–2021): a scoping review

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## Abstract

**Background** In 2009, the Strategy for the Control of Antimicrobial Resistance in Ireland (SARI) Hospital Antimicrobial Stewardship (AMS) Working Group published guidance on antimicrobial stewardship in hospitals. These were the first guidelines outlining the rationale for AMS in Irish hospitals and healthcare institutions. The aim of this scoping review is to evaluate the progress of AMS implementation in Ireland and align the findings with the 2009 SARI Hospital AMS Working Group guidance recommendations.

**Methods** Systematic searches were conducted in four electronic databases (PubMed, CINAHL, Embase, Web of Science) and five targeted websites for grey literature. Titles and abstracts were screened independently by two reviewers and all authors reviewed full-text publications. Studies were mapped into at least one of four predefined recommendations, (A) Structure and Organisation of Antimicrobial Stewardship, (B) Roles and Responsibilities for Prescribers, (C) Antimicrobial Stewardship Interventions and (D) Recommendations for non-acute Residential Healthcare Institutions. These recommendations will be used as a framework for the outcome of interest in this scoping review.

**Results** The search yielded 544 peer reviewed papers, of which 29 were included and 327 grey reports, of which 24 were included. Most articles (n=46) were mapped to categories A and C. Findings in category A highlight inadequate staffing and the need for greater investment in Information Technology (IT) to support AMS and infection prevention and control. Category C findings emphasise implementation challenges, including the need for hospital leadership to commit to improved availability of relevant resources, improving diagnostic capacity, and provision of education for prescribers, pharmacists, nurses, and patients.

**Conclusions** AMS implementation in Ireland has progressed over the past two decades, but significant challenges remain. Addressing resources including recruitment of staff and a defined budget, development of a structured national implementation plan with agreed annual targets, investing in IT and strengthening leadership commitment for all healthcare settings will be essential for future improvements.

**Keywords** Antimicrobial Stewardship, Ireland

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## Introduction

Over the past 30 years, the threat to human life from antimicrobial resistance (AMR) has increased significantly [1], compromising the effectiveness of these agents in preventing and treating infections [2] and threatening current advances and strategies in the management of human disease [3, 4]. The association between AMR and antibiotic usage is proven [5, 6] and a key approach to slowing down the development of resistance is the implementation of AMS intervention [7, 8]. These interventions aim to support the use of the correct antimicrobial, at the correct dose and appropriate duration, thus ensuring the best clinical outcome for the patient, whilst reducing the risks to patients from antimicrobial toxicity [9].

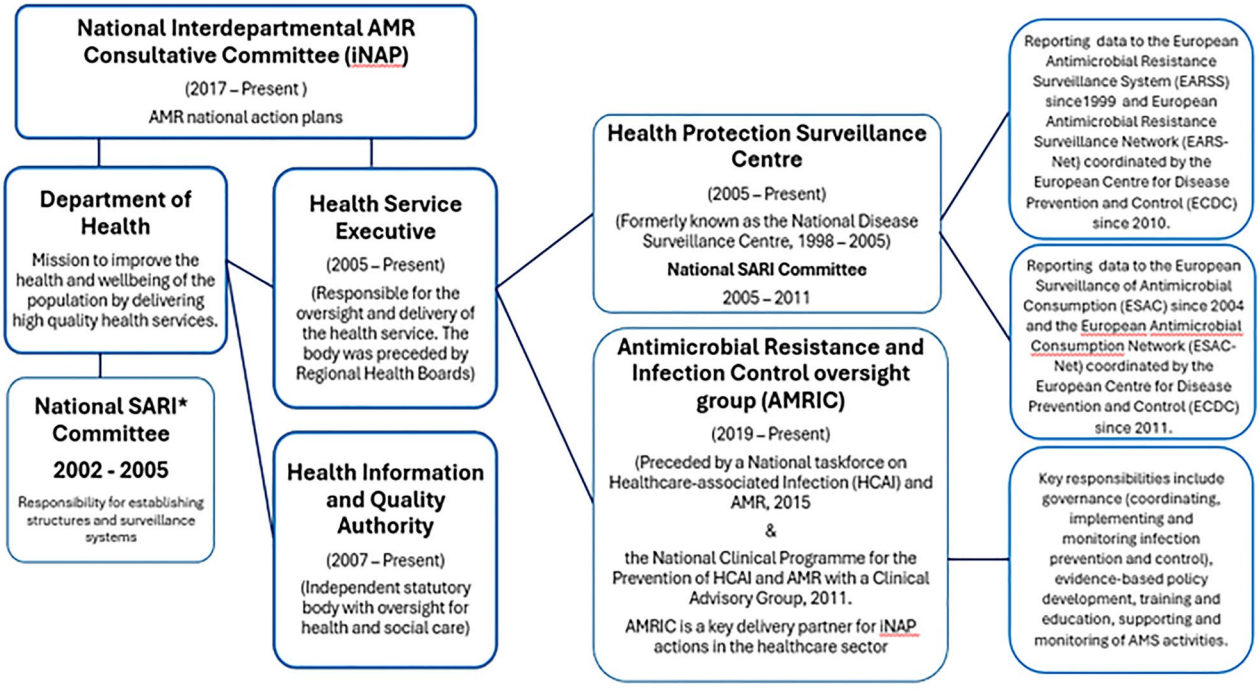
In the Republic of Ireland (ROI), a strategy to tackle the issue of AMR and stewardship by the Department of Health commenced in 1998 with the establishment of the National Disease Surveillance Centre (NDSC), with the primary goal of monitoring and controlling infectious diseases including AMR. The development of an AMR strategy in Ireland and the evolution of European wide programmes for its control became closely intertwined and following the adoption by the European Council of a resolution on AMR in 2001 [10]. The NDSC introduced Ireland's first national strategy to reduce the spread of AMR [11]. This strategy focussed on surveillance, infection prevention and control, prudent use of antibiotics and education and training.

In terms of surveillance prior to 2000, limited data were available on AMR in Ireland [12]. Recognition of this deficit drove early participation in the European Antimicrobial Resistance Surveillance System (EARSS) [13], which acted as a catalyst for the development of a national antimicrobial resistance surveillance programme [14]. This was subsequently followed by participation in the European Network for the monitoring of antimicrobial use both in hospitals and the community [15].

In 2005, following major organisational changes, and formation of the Health Service Executive (HSE), the Health Protection Surveillance Centre (HPSC) assumed a broader remit and established further links nationally with the European Centre for Disease Prevention and Control (ECDC) [16], Fig. 1.

### Health Service delivery in Ireland

Evolution of the ROI response to AMR continued with the launch of a National Clinical Programme for the Prevention of Healthcare Associated Infection (HCAI) and AMR in 2011 and the establishment of a clinical advisory group (CAG) on HCAI and AMR by the Royal College of Physicians Ireland (RCPI) [16]. This group were tasked with the role of advising on the National Strategy in both hospitals and the community. In 2015, the HSE introduced a national taskforce on HCAI and AMR, followed




*SARI: Strategy for the control of Antimicrobial Resistance in Ireland

**Fig. 1** Health Service delivery in Ireland in relation to AMR

in 2019 by the establishment of the HSE's Antimicrobial Resistance and Infection Control Division (AMRIC) whose remit includes AMR and Infection Prevention and Control (IPC) [17], Fig. 1.

Ireland does not have a universal health system instead it has a publicly funded system which includes social care systems and a private sector. The Department of Health led by the Minister of Health is responsible for policy and governance [18]. The HSE is responsible for the delivery of public health and social care services [19]. In 2020, Ireland had 50 acute public sector hospitals and 19 private hospitals, classified as model 1 – 4 based on increasing complexity and range of services with each successive level [20]. The Health Information and Quality Authority (HIQA) was established in 2007 [21] as an independent regulatory body responsible for overseeing health and social providers [22]. In 2020 there were 573 nursing homes in Ireland offering residential care of which approximately 70% were operated by for-profit providers [23]. Governance of long-term care facilities (LTCF) involves three key bodies: the Department of Health, the HSE and HIQA [24]. HIQA conducted a review of AMS in 2016 [25].

In 2009, the HPSC launched its first publication on AMS, "*Guidelines for Antimicrobial Stewardship in Hospitals in Ireland in 2009*" a national document outlining a systematic approach to AMS that could be taken by hospitals, community and primary care settings [26], these guidelines were developed based on international evidence-based practice. This national document provides a framework for implementing stewardship programmes across acute hospitals and long-term residential care facilities in Ireland. It aimed to promote rational antimicrobial use, support hospital leadership in establishing formal stewardship structures, and ensure appropriate prescribing practices. Key elements included recommendations to support implementation of dedicated stewardship programmes; develop and maintain prescribing guidelines; establish multidisciplinary teams with appropriate expertise; and monitor antibiotic use and resistance patterns to inform practice. The need to demonstrate stewardship performance and enhanced clinical pharmacy services to support effective stewardship was emphasised.

However, a preliminary review of the literature found few studies that examined progress made in Ireland over the past thirteen years in relation to those recommendations. Therefore, the aim of this scoping review is to document the progress in AMS implementation in Ireland and map these findings to the SARI 2009 recommendations [26]. The document is organized into four main categories, each defined by a recommendation heading: (A) Structure and Organisation of Antimicrobial Stewardship, (B) Roles and Responsibilities of Prescribers, (C) Antimicrobial Stewardship Interventions, and (D) Recommendations for Non-Acute Residential Healthcare Institutions [26].

**Table 1** Guidelines for antimicrobial stewardship in hospitals in Ireland 2009-Recommendations [26]

| | |
|---|---|
| A | Structure and Organisation of Antimicrobial Stewardship |
| B | Roles and Responsibilities for Prescribers |
| C | Antimicrobial Stewardship Interventions |
| D | Recommendations for Non-Acute Residential Healthcare Institutions |

## Methods

A scoping review methodology was chosen because it supports broad exploratory objectives, allowing for the identification of key concepts, types of evidence, research designs [27] and knowledge gaps [28] across a wide range of methods and sources [29]. This approach also enables the inclusion of extensive grey literature [30] and helps to highlight areas requiring further research [31]. Consequently, scoping reviews generally do not include formal critical appraisal of study quality, as their purpose is not to evaluate the strength of evidence or draw conclusions regarding effectiveness [32].

The Arskey and O'Malley five-stage framework approach [32] and the PRISMA-ScR Guidelines [33], were used to support the review (Supplemental File 1). The review protocol was registered and is available for review, https://hrbopenresearch.org/articles/7-52/v2.

### Stage 1: Identifying the research question

What progress has been achieved in Ireland since the first guidelines on AMS were launched in 2009 [26]?

Review objectives:

1 To present evidence of the progress of AMS implementation since the publication of the guidelines [26].
2 To explore factors that have supported or challenge the progress of AMS implementation since the publication of the guidelines [26].

All publications included in the review are mapped to the four categories of the recommendations (Table 1) of the 2009 guidelines and are used as a framework to map the findings [26].

### Stage 2: Identifying the relevant studies

Following input from a university librarian, the reviewers conducted a comprehensive search in four bibliographic databases in January 2023: Web of Science (Clarivate) Embase (Elsevier), CINHAL (EBSCOhost), and PubMed. The search strategy incorporated specific terms such as: "antibiotic management" OR "antibiotic stewardship" OR

"antimicrobial management" OR "antimicrobial stewardship" AND Ireland, (Supplemental File 2). The inclusion and exclusion criteria for the review are shown in Table 2. Additionally, relevant studies meeting these criteria were sought through the reference lists of selected studies.

Specialised government and non-government organisations that were deemed pertinent to the study aim by the research team were included in the search of the grey literature, (Table 3).

### Stage 3: Study selection

Titles and abstracts of eligible records were de-duplicated and stored in Mendeley [34]. Screening of titles and abstracts was undertaken independently by two authors (FB, EOR) and assessed against the inclusion criteria using Covidence [35]. We requested publications that were not available online from the study authors. Any queries that arose were resolved by discussions and the input from an additional author (OM). All five authors (FB, EOR, OM, TF, MS) evaluated, discussed the remaining full-text publications and agreed on the final publications for this review. Reasons for exclusion are detailed in Fig. 2.

### Stage 4: Charting the data

Data extraction was undertaken using a template aligned to the aims and objectives of our scoping review. Items extracted included author, year of publication, study details, objectives study populations and results aligned to SARI 2009 recommendations [26].

**Table 2** Eligibility criteria for study selection for peer-reviewed and grey literature

**Studies were included if they were:**

- Focused on AMS (antibiotics only).
- Undertaken in or applicable to ROI.
- Peer-reviewed articles and in English.
- Published from January 2010-December 2021.

**Studies were excluded if they were:**

- Studies of AMS which focused on non-antibiotic therapeutics including, antifungal, antiparasitic or antiviral agents.
- Editorials, dissertations, conference proceedings, reviews, or letters.

**Table 3** Target organisations

- Health Protection Surveillance Centre, ROI
- Health Information and Quality Authority. ROI
- Health Service Executive, ROI
- European Centre for Disease Prevention and Control
- World Health Organization

### Stage 5: Collating, summarising and presenting the results

Final citations were grouped, reviewed and mapped according to the four recommendations of the 2009 guidelines. The review was written in accordance with PRISMA-ScR guidelines [33] (Supplementary File 2) and because the aim of the review was to document

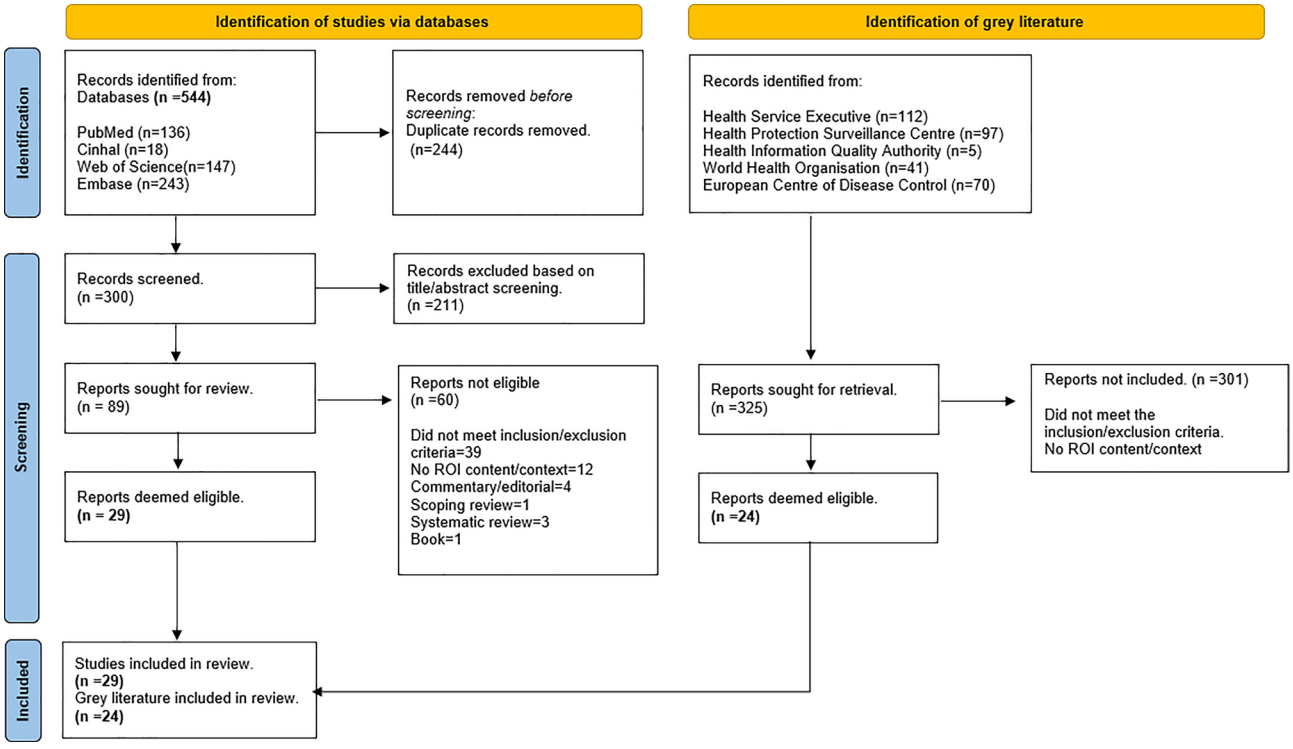



**Fig. 2** Prisma flow diagram of the review and selection process [36]

**Table 4** Study characteristics for the included peer-reviewed papers ($n=29$)

| Study information | References |
|---|---|
| **Study Design** | |
| Cross sectional survey of practice ($n=7$) | [37–43] |
| Cross sectional microbiology study for optimal treatment ($n=3$) | [44–46] |
| Point prevalence survey in hospitals; descriptive and/or predictive ($n=2$) | [47, 48] |
| Point prevalence survey in LTCF; descriptive and/or predictive ($n=4$) | [49–51] |
| Quality improvement report ($n=1$) | [52] |
| Critique ($n=1$) | [53] |
| Controlled study of feasibility of intervention ($n=1$) | [54] |
| Controlled pre- post- intervention study ($n=1$) | [55] |
| Uncontrolled pre- post- intervention study ($n=5$) | [56–60] |
| Uncontrolled evaluation of educational material for trainee doctors ($n=1$) | [61] |
| Qualitative interviews of HCP ($n=3$) | [62–64] |
| **Settings** | |
| Hospital ($n=15$) | [39, 40, 42, 46, 48, 52–57, 59, 60, 64] |
| Long-term care facility ($n=7$) | [37, 38, 49–51, 62, 65] |
| GP and LTCF ($n=2$) | [43, 45] |
| GP practice ($n=4$) | [41, 44, 58, 63] |
| Educational setting ($n=1$) | [61] |
| **Grant funding for studies** = 6 | [45, 54, 57, 60, 62, 63] |

the extent or range of progress of AMS in Ireland over 11 years, a quality assessment of included studies was not required.

## Results

### Search results: online databases and grey literature

The search retrieved 869 records, 544 from peer reviewed papers and 325 from targeted sites. Of the 544 records 244 duplicates were removed with 300 assessed based on title and abstract screening and resulting in 89 articles selected for full-text review and 29 of these met the inclusion criteria. Of the 325 records from targeted sites 301 were excluded and 24 reports met the inclusion criteria, (Fig. 2).

### Description of studies

There were 29 peer reviewed papers, critique ($n=1$), qualitative ($n=3$), and quantitative ($n=25$), and 24 reports from national ($n=22$), European ($n=1$), and international agencies ($n=1$) included in the final review. Study characteristics are presented in Table 4.

Fifty-three publications (Supplementary File 3) were mapped to one or more of the four categories of the recommendations (FB, EOR, OM), (Table I). The relevant SARI recommendations to which peer reviewed papers and reports could be mapped alone and in combinations are presented in Fig. 3. Briefly, twenty-one of the 29 peer review papers mapped to a single recommendation: four in category A, five in category B, eight in category C and four in category D. Eight peer reviewed papers mapped to two recommendation, AC ($n=2$), AD ($n=1$), BC ($n=2$), and CD ($n=3$). No paper mapped to more than two categories.

Eleven of the twenty-four grey reports mapped to a single recommendation category: two in category B, eight in category C and one in category D. Twelve papers mapped

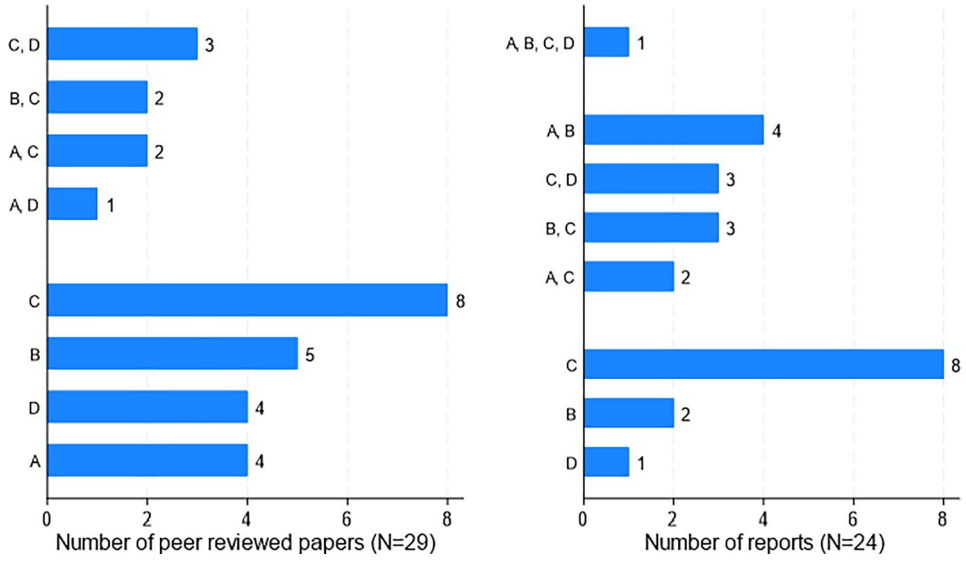



**Fig. 3** Illustration of the number of SARI *"antimicrobial stewardship in hospitals in Ireland in 2009"* recommendation categories addressed in peer reviewed papers and reports, published 2010–2021 (**A**) structure and Organisation of antimicrobial stewardship, (**B**) Roles and Responsibilities for prescribers, (**C**) antimicrobial stewardship interventions and (**D**) recommendations for non-acute residential healthcare institutions [26], table I

into two recommendation categories: AB ($n=4$), AC ($n=2$), BC ($n=3$) and CD ($n=3$). A single report mapped to all four categories [26].

Following additional discussions and agreement with all authors (FB, EOR, OM, TF, MS), we further mapped all publications (including grey literature) to the subcategories within the four recommendations Table 5, (Supplementary File 4) [26, p 5–6]. Details for studies and reports were mapped to more than one recommendation are in Fig. 3 and Supplemental File 5. Some grey reports could not be mapped to the subcategories as they did not meet the criteria, (Supplementary File 6). Table 6 provides an overview of achievements, challenges and areas for future attention mapped to the Guidelines for Antimicrobial Stewardship in Hospitals in Ireland. SARI Hospital Antimicrobial Stewardship Working Group December 2009 [26].

In the peer reviewed literature, the included studies presented more targeted single issue research questions compared to the grey literature. The grey literature largely represents a high-level outline, often undertaken as a national or European overview, demonstrating AMS progress from a broader perspective. This additional information underscores the need for systematic agency-driven and funded data collation which provides a synopsis of achievements in AMS.

## Discussion

This scoping review maps the progress of AMS in Ireland to the SARI 2009 guideline recommendations, over an 11-year period [26]. Several studies and recent grey reports indicate that recommendations such as the recruitment of specialist staff [17, 70], introduction of KPIs for national prescribing guidelines [67], online education on AMS [17, 25], national point prevalence surveys incorporating antibiotic prescribing data [16, 17, 80, 81, 84] and participation in global and European surveillance [47, 48, 69] are met. However, the evidence is limited for other recommendations, such as implementation of governance structures, resources, leadership and management support for education programs at the undergraduate level, IT systems to support AMS, and protocols for informing patients and their families in all healthcare facilities of the rationale for antibiotics.

### A: Structure and Organisation of antimicrobial stewardship

Our study highlights the structural and organisational achievements in AMS including an increase in specialised staff such as consultant microbiologists and antimicrobial pharmacists, the implementation of key performance indicators, the conduct of national point prevalence surveys (including antibiotic consumption), and the development of standardised nationwide online education. These initiatives are recognised by the Organisation for Economic Co-operation and Development (OECD) as important strategies for promoting the prudent use of antibiotics and reducing resistance [85, 86].

However, in 2017 Ireland participated in Europe's second point prevalent survey (PPS) of hospital acquired infection and antimicrobial usage (AMU) [80]. The survey included 46 public sector hospitals. Key findings relevant to our review included 17 hospitals reporting having no infection prevention and control doctor (IPCD) and 17 reporting having no antimicrobial pharmacist (AMP). At this time Ireland's AMU prevalence was 39.7% significantly higher than the overall EU average of 30.5% and an increase from 34% reported in May 2012 [87]. These findings highlight substantial gaps in infection prevention and control resources and AMS across Irish hospitals at the time of the report.

The review findings are consistent with existing literature and highlight key challenges to establishing effective AMS strategies including a limited governance framework [88], insufficient leadership at hospital executive level, shortages of key personnel, including AMS pharmacists [88], the absence of a defined budget [65] and inadequate ITC to support AMS systems [89].

Addressing these challenges requires the implementation of robust and effective governance structures [90]. Executive hospital leadership should actively promote antimicrobial stewardship by ensuring the allocation of adequate resources and dedicated budgetary support [91]. In addition, improved access to detailed PPS data would improve the quality of information available to evaluate the implementation of AMS in Ireland.

### B: Roles and Responsibilities for prescribers

In line with existing evidence, the findings underscore the need to strengthen national governance structure [92] and to further examine the factors that promote prudent prescribing [93]. The World Health Organization (WHO) identifies governance as a critical pillar of AMS programs, highlighting leadership commitment, policy frameworks, resource allocation, and accountability as essential to ensuring program success [94]. Factors that promote prudent prescribing include the availability of clear clinical guidelines, access to rapid diagnostic testing, continuous education for healthcare staff and regular feedback on prescribing patterns to prescribers [88].

Greater emphasis needs to be placed on educating patients and their families on the use and misuse of antibiotics [88]. Patient and family education plays a critical role in supporting the goals of AMS. Empowering individuals with knowledge helps reduce inappropriate antibiotic use, slows the spread of resistance, and improves overall healthcare outcomes [95, 96].

**Table 5** Peer reviewed studies and grey reports mapped to subcategories of SARI 2009 recommendations [26]

| Category and Recommendations | Review Findings – Peer Reviewed Studies | Review Findings – Grey Literature |
|---|---|---|
| **A: Structure and Organisation of Antimicrobial Stewardship** | | |
| Development of hospital antimicrobial stewardship programmes, along with provision of appropriate resources, should be a priority for the Health Services Executive (HSE). | The remit of Antimicrobial Stewardship Teams (AMT) is compromised due to insufficient resources limiting the scope of activities [40]. **2015** Covid-19 highlighted the lack of resources for AMS [42]. **2021** | • A "*lack of AMS programmes in a small number of hospitals*" with recommendation to identify and address gaps [25, p.16]. **HIQA 2016**<br>• Healthcare organisations need AMS programmes that are "*in line with best practice, evidence-based guidelines and reflects the size, complexities and specialities of the service with the required resources to implement.*" [66, p.53]. **HIQA 2017**<br>• New Key Performance Indicators (KPIs) for AMS programmes [67]. **AMRIC 2018**<br>• Updated IPC and AMS guidelines for community health and social care services [68]. **HIQA 2018**<br>• Provision of resources is a priority. A lack of training and time available were noted as challenges [69]. **ECDC 2020**<br>• Since 2019, staffing numbers and skill mix have increased [70] **AMRIC 2021** and posts were approved by the HSE AMRIC National Team [17]. **iNAP2 2021** |
| All acute hospitals should have an annually assessed antimicrobial stewardship programme | Audits of AMS interventions shows that practices vary between hospitals [39]. **2014** Ireland participates in the European Point Prevalence Studies of Healthcare Associated Infection and antimicrobial consumption [47]. **2018** | Not all hospitals have a prescribing audit. [25, 68] **HIQA 2016, 2018.** Recommendation that audits of prescribing practices should be undertaken regularly [17] **iNAP2 2021.** |
| National treatment guidelines for common infections in hospital should be developed, for adaptation at local level | Covid-19 removed the focus from AMS. Guideline development is a priority [42]. **2021** | Antimicrobial prescribing guidelines exist [69] **ECDC 2020** however need exists for further education and guideline dissemination [17]. **iNAP2 2021** |
| Undergraduate and postgraduate education of health professionals should include principles of prudent antimicrobial prescribing | Education on AMS is a priority for all healthcare professionals, both at undergraduate and postgraduate level, (including consultants) [53] **2020** and is essential to promote awareness of AMS and AMR [61]. **2019** | • E-learning modules on AMS are available on the Irelands' national online educational platform for healthcare professionals known as HSELanD [25]. **HIQA 2016**<br>• Education programmes for AMS are not standardised [69]. **ECDC 2020**<br>• Ideally all undergraduate students should have a foundation course in AMR, AMS and IPC before the first clinical placement [70]. **AMRIC 2021** |
| All acute hospitals must have on-site presence of a medical microbiologist or infectious diseases physician, with responsibility for leading the antimicrobial stewardship programme, and 24-hour access to expert advice for management of infections | • 7% of all hospitals did not have a Consultant Microbiologist and 76% did not have a Consultant in Infectious Diseases post [39]. **2014**<br>• "*There is a need to collate and disseminate local antimicrobial resistance patterns to GPs and LTCFs in order to inform updates to antimicrobial prescribing guidelines and antimicrobial prescribing at a local level*" (45, p 311) [51]. **2017**<br>• European PPS includes information on antimicrobial structure (including Consultant Microbiologist or Consultant in Infectious Diseases in posts) and process indicators [47]. **2018** | The number of consultant microbiologist posts has steadily increased since 2001 and additional investments were made in specialised staff, including consultant microbiologists, AMS pharmacists, and surveillance scientists. Some Model 2 hospitals (in-patient and out-patient care for differentiated, low-risk medical patients, unlikely to require full resuscitation) still lack these posts. Recruiting and retaining specialised staff remains a significant challenge [25]. **HIQA 2016** |
| All acute hospitals must have one or more clinical pharmacists with responsibility for antimicrobial stewardship | No publications identified (NPI) | NPI |

**Table 5** (continued)

| Category and Recommendations | Review Findings – Peer Reviewed Studies | Review Findings – Grey Literature |
|---|---|---|
| All pharmacists with responsibility for antimicrobial stewardship should have access to a structured training programme delivered at a national level | NPI | NPI |
| All hospitals should have appropriate administrative and information technology support for antimicrobial stewardship, including an appropriate pharmacy information technology system | With the focus on Covid-19 removed, IT in AMS was identified as a resource requiring more funding [42]. **2021** | ICT systems should support AMS such as electronic health records and e-prescribing [25]. **HIQA 2016** |
| The hospital chief executive/manager must ensure promotion of rational antimicrobial use is a strategic goal for the hospital | NPI | Hospital management have overall responsibility in the implementation of prescribing and stewardship guidelines [25, 68]. **HIQA 2016, 2018** |
| All acute hospitals should have a multi-disciplinary Drugs and Therapeutics Committee | NPI | Multi-disciplinary drugs and therapeutics committee are not in place in all hospitals [25]. **HIQA 2016** |
| **B: Roles and Responsibilities for Prescribers** | | |
| All prescribing of antimicrobials, either for treatment or prophylaxis, should follow the principles of prudent antimicrobial | NPI | • Introduction and availability of online "Start Smart" antibiotic care bundle. [71] **RCPI 2012**<br>• *"82% (37/45) of hospitals surveyed had restricted prescribing rights for key antimicrobial agents"* [25, p.81]. **HIQA 2016**<br>• Several AMS process indicators can serve as KPIs for AMS programs [72]. **HSE 2017**<br>• Various strategies should be considered to support the introduction of a new antimicrobial, such as:<br>◦ Providing clear prescribing guidance on its appropriate use in clinical settings.<br>◦ Updating or issuing new formulary and antimicrobial prescribing guidelines [16]. **iNAP1 2017**<br>• Paper-based approach to prescribing makes audit and monitoring of prescribing challenging [69]. **ECDC 2020**<br>• Improved primary care prescribing data is needed to inform progress and practice [73]. **AMRIC 2020**<br>• Guidance on antibiotic prescribing during Covid-19 including the recognition and management of acute bacterial infection and adherence of the principles of *"start smart then focus"* for patients prescribed antibiotics [74]. **HSE 2020**<br>• Surgical Antibiotic Prophylaxis guidelines made available at http://www.antibiotic prescribing.ie [75]. **HSE 2021**<br>• Optimisation of antibiotic use in human and animal health needs to be developed and implemented using AMS programmes and education supporting prescribing practices and access to rapid diagnostics [17]. **iNAP2 2021**<br>• KPIs now include percentage of acute hospitals implementing the national policy on restricted anti-microbial agents services [70]. **AMRIC 2021** |
| **B: Roles and Responsibilities for Prescribers (continued)** | | |

**Table 5** (continued)

| Category and Recommendations | Review Findings – Peer Reviewed Studies | Review Findings – Grey Literature |
|---|---|---|
| Rational antimicrobial prescribing should be included in clinical governance requirements for all clinicians | The prudent use of antibiotics and a clear rationale for their use in all settings, including hospitals [56] **2017** [52], **2019** [64], **2020**; LTCFs [44] **2011**, and GP practices [41], **2018** [63], **2019** and [58] **2020** are essential. | • "*In the most successful hospitals, there was clear evidence that this has been enabled by the presence of: appropriate governance arrangements with effective senior management support*" [25, p.13]. **HIQA 2016**<br>• *Start Smart and then Focus* antibiotic care bundle was included as a KPI by the HSE in 2018. The green/red list antibiotic prescribing tool was introduced and used in practice and an example of clinical governance. [72] **HSE 2017,** [67] **AMRIC 2018**<br>• *"Establishing a national reference service for AMR including the current reference laboratories, but with a clear governance structure and dedicated long-term funding."* [69, p.63]. **ECDC 2020**<br>• Clear governance, accountability, and collaboration are crucial for effective IPC, HCAI, and AMR management, ensuring the successful implementation of the iNAP2 plan through integrated surveillance and stewardship [16, 17] **iNAP1 2017, iNAP2 2021**<br>• Proposed governance structure for AMS in hospital and community settings Antimicrobial Resistance Infection Control [70]. **AMRIC 2021** |
| Patients, or their legal guardians, should be informed of the rationale for prescribing antimicrobials, and informed of any associated risks or adverse effects | NPI | NPI |
| **C: Antimicrobial Stewardship Interventions** | | |
| The recommended core, high impact interventions to promote prudent antimicrobial use. | | |
| • Clinical review of patients receiving antimicrobials by an antimicrobial stewardship team (microbiologist/infectious diseases physician/pharmacist), with direct advice and feedback to prescribers | One of the core interventions for AMS is clinical review of patients receiving antimicrobials [55] **2011** [56], **2017**, and optimising antimicrobial usage by prescribers with direct advice/feedback [42] **2021**, including critical care settings [57]. **2018** | PPS ICU clinical review conducted [76] **HPSC 2017** HALT clinical teams did not review antibiotic prescribing [77]. **HALT 2017** |

**Table 5** (continued)

| Category and Recommendations | Review Findings – Peer Reviewed Studies | Review Findings – Grey Literature |
|---|---|---|
| • Regular surveillance/audit of antimicrobial use, with interactive feedback of results to prescribers | Surveillance and audit of antimicrobial use in a variety of settings including hospitals, LTCF and General Practitioners practice provide insight into prescribing practices and identify areas for improvement.<br>• Identifying areas for quality improvement [38]. **2015**<br>• Improved communication channels [60]. **2018**<br>• Education, training, establishment of an AMS strategy linked to prescribers' feedback [51] **2018** [49]. **2019**<br>• Interventions (quality improvement bundles, weekly audits and feedback to prescribers) [59]. **2020**<br>• Antimicrobial consumption feedback to prescribers [53]. **2020**<br>• Improved diagnostics (including the use biomarkers and procalcitonin) [42]. **2021**<br>Ireland participates in global surveillance, including the Efficacy in Neonates and Children (GARPEC) network and the Global Point Prevalence Survey on Antimicrobial Consumption and Resistance (Global-PPS) network [48]. **2019** | • An AMS policy was available and there was evidence of measuring against it [78]. **HPSC 2013**<br>• Annual surveillance reports from HPSC show surveillance trends in AMR [79]. **HPSC 2014**<br>• Healthcare service commended for significantly improved surveillance of antimicrobial consumption with *"benchmarked feedback being provided to individual hospitals"* [25, p.67]. **HIQA 2016**<br>• Overall, antimicrobial usage prevalence was 39.7% in 2017 which was an increase from 34% reported in May 2012. For 91% of antimicrobial prescriptions, the indication was documented [80]. **HPSC 2017**<br>• Recommended enhanced surveillance, standardisation of data collection with sharing of real time findings. [16, p.13] **iNAP1 2017** [17, p.28] **iNAP2 2021**<br>• Each hospital's AMS team should regularly monitor and review antimicrobial use [81]. **HPSC 2019**<br>• National PPSs are undertaken in a wide variety of healthcare settings with results published on HPSC website [82] **HALT 2013** [77], **HALT 2016** [76], **HPSC 2017** [81], **HPSC 2019**<br>• Ireland contributes to global surveillance and participates in European surveillance since 1999. [83] **WHO 2020,** [69] **ECDC 2020**<br>• Since September 2019, each General Practitioner with more than 100 General Medical Scheme (GMS) patients has received a quarterly individualized report on antibiotic use for their GMS cohort over the past 12 months [73]. **AMRIC 2020** |
| • Limiting the use of specific antimicrobial agents through restricting availability, restricting use to specified clinical settings, or requiring pre-authorisation by a member of the antimicrobial stewardship team prior to prescribing<br>The recommended therapeutic interventions to improve the quality of antimicrobial use. | AMS interventions promote responsible and targeted use of restricted antibiotics e.g. weekly audits with feedback to prescribers, promoting adherence of guidelines and utilising prescribing applications [52] **2019** [42]. **2021** | Evidence presented of restrictive usage practices of specific antibiotics [81]. **HPSC 2019** |
| • Ensuring antimicrobial therapy is optimised to the individual patient including, where necessary, therapeutic drug monitoring | The use of laboratory diagnostics to facilitate antimicrobial stewardship and the early discontinuation of antibiotics [46]. **2019** | PPSs conducted in critical care demonstrated evidence of reviewing antibiotic prescription [76]. **HPSC 2017** |
| • Ensuring empiric antimicrobial therapy is streamlined as soon as possible, to ensure therapy is directed against the causative pathogen(s) | NPI | Guidance on surgical prophylaxis supporting appropriate prescribing [75]. **HSE 2021** |
| • Having an effective programme for timely conversion of parenteral antimicrobial therapy to oral therapy | Demonstration of a successful pharmacist led intervention supporting intravenous to oral antibiotic therapy switch strategy [55]. **2011** | Evidence of timely action in relation converting from parental to oral therapy [81]. **HPSC 2019** |

**Table 5** (continued)

| Category and Recommendations | Review Findings – Peer Reviewed Studies | Review Findings – Grey Literature |
|---|---|---|
| • Antimicrobial stewardship teams should promote the management of patients in Outpatient Parenteral Antimicrobial Therapy (OPAT) programmes, for selected clinical situations<br>The recommended educational interventions and prescribing aids to improve the quality of antimicrobial use | NPI | Outpatient parental antibiotic therapy (OPAT) services were available in 2/3 of public hospitals in 2015 [25]. **HIQA 2016** |
| • All hospitals should have a programme of ongoing education for prescribers | NPI | • The need for interdisciplinary education resources was identified and the development of a competency framework recommended [25]. **HIQA 2016**<br>• The need for higher education institutions to provide foundation courses in AMR, AMS and IPC for all multidisciplinary healthcare students was recommended. [67] **AMRIC 2018**<br>• Significant emphasis should be placed on the ongoing education and training of healthcare professionals regarding healthcare-associated infections, AMR, and the importance of AMS. [78] **HPSC 2013** [16], **iNAP1 2017** [81], **HSPC 2019.**<br>• A suite of e-learning modules on IPC and AMS for HSELanD have been developed and also an IPC Link Practitioner Programme [17]. **iNAP2 2021** |
| • All hospitals should have local/regional antimicrobial prescribing guidelines, which are regularly updated and are based, whenever possible, on local antimicrobial resistance data | NPI | • Healthcare professionals have access to several online resources that provide comprehensive prescribing guidelines [71]. **RCPI 2012**<br>• Implementation of high impact interventions to promote prudent prescribing in critical care recommended. [78] **HPSC 2013**<br>• KPIs are available to support implementation of an AMS programme [72]. **HSE 2017**<br>• Up to 85% of hospitals had compliance with local guidelines [81]. **HPSC 2019**<br>• The community prescribing guidelines on http://www.antibioticprescribing.ie are continuously updated to promote appropriate antimicrobial use [17]. **iNAP2 2021**<br>• Provision of antibiotic prescribing data at prescriber and service levels across all settings is needed to inform prescriber behavioural change services [70]. **AMRIC 2021** |
| • All hospitals should consider using specific order forms or designate a section of the prescription chart for prescribing of antimicrobials. | NPI | NPI |
| • Consideration should be given to using prescribing aids, such as standardised documentation of treatment decisions and information technology-based prescribing supports | Evidence that prescribing aids such as feedback mechanisms, education and feedback, support guideline adherence in hospitals [60] **2018** [54] **2019** [64] **2020** and GP practice [58] **2020** [59]. **2020** | • Hospital IT redevelopment plans need to incorporate electronic prescribing with prescriber decision support, electronic patient records and laboratory information systems in Critical Care units [78]. **HPSC 2013**<br>• Identification of KPIs for implementation in acute hospitals [72]. **HSE 2017**<br>• The essential need for accurate and appropriate antibiotic prescribing in Intensive Care units [76]. **HPSC 2017**<br>• Evidence of prescribing aids including applications and care bundles. [71] **RCPI 2012** [17], **iNAP2 2021** Further dissemination of aids by AMS teams is advised [69]. **ECDC 2020**<br>• The need to progress implementation of electronic prescribing throughout the healthcare systems was identified, to support AMS and audit services [70]. **AMRIC 2021** |
| Commercial promotion of antimicrobials should follow the Code of Marketing Practice, produced by the Irish Pharmaceutical Healthcare Association, and local guidelines approved by the hospital's Drugs and Therapeutics Committee. | NPI | NPI |

**Table 5** (continued)

| Category and Recommendations | Review Findings – Peer Reviewed Studies | Review Findings – Grey Literature |
|---|---|---|
| The recommended laboratory interventions to improve the quality of antimicrobial use | | |
| • All acute hospitals should have 24-hour access to an accredited microbiology laboratory | NPI | *"93% (42/45) of hospitals have 24/7 microbiology laboratory services and 89% (40/45) has Irish National Accreditation Board (INAB) accreditation* [25, p 81]. **HIQA 2016** |
| • Laboratories should carry out local surveillance of antimicrobial resistance, including annual review of antibiograms where appropriate. | NPI | Laboratories carry out surveillance of AMR, provide antibiograms and report antimicrobial susceptibilities and include comments on reports [69]. **ECDC 2020**<br>New diagnostic tools for AMR need further research focus [17]. **iNAP2 2021** |
| • Laboratories should report antimicrobial susceptibilities in a restrictive manner, and reports should include interpretative comments to guide prescribers | In 2016 Ireland had fully implemented selective reporting of antibiotic susceptibility test (AST) results however two thirds of countries in Europe had not achieved this yet. Barriers to implementation "*include a lack of guidelines, poor system support, insufficient resources, and limited professional capability*" [43, p163]. **2017** | |
| • Laboratories should develop, or provide access to, rapid diagnostic methods and key inflammatory markers | NPI | Progress has been made in the upgrading of equipment in HSE Microbiology Reference Laboratories and enhanced rapid laboratory diagnostic capacity to support AMR and IPC stewardship services [70]. **AMRIC 2021** |
| **D: Recommendations for Non-Acute Residential Healthcare Institutions** | | |
| **Structure and organisation:** | | |
| • All non-acute residential healthcare institutions should have an antimicrobial stewardship programme, appropriate to local requirements | Antibiotic prescribing in LTCF is influenced by many social and contextual elements [62]. **2014** | • Several areas of concern regarding AMS and prescriber feedback in LTCFs were highlighted:<br>∘ *"94% of LTCFs reported that no training was provided on antimicrobial (AM) prescribing.98% of LTCFs reported having no active AMS committee.56% of LTCFs reported the absence of local AM prescribing guidelines."* [77, p.73]. **HALT 2016**<br>∘ "*9.8% of LTCF residents were taking an antibiotic,"* [77, p.19] **HALT 2016**<br>• The lack of formal networking between HSE hospitals and community organisations was noted [69]. **ECDC 2020**<br>• Timely surveillance, reporting, and analysis of antibiotic consumption need improvement to better inform all stakeholders services [70]. **AMRIC 2021** |
| • Each institution should have access to antimicrobial stewardship advice from a consultant microbiologist or infectious diseases physician, and antimicrobial pharmacist | NPI | Community AMS pharmacists are in post since 2020 [69] **ECDC 2020** |
| • Each institution should have a designated person, or team, responsible for antimicrobial audit and implementation of stewardship interventions | NPI | • A more integrated approach for AMS at hospital and community is needed [69]. **ECDC 2020**<br>•*"Ten percent of facilities reported having a named person responsible for AMS in the facility"* (84, p33). **HSE 2021**<br>• The need for the development of a community IPC/AMS network at CHO/Area Level was advised [70]. **AMRIC 2021** |
| **Stewardship interventions:** | | |

**Table 5** (continued)

| Category and Recommendations | Review Findings – Peer Reviewed Studies | Review Findings – Grey Literature |
|---|---|---|
| • Where possible, institutions may implement any of the recommended interventions listed in Section C | A key objective of AMS initiatives in LTCF should address inappropriate prophylaxis prescribing [45] **2017** [50]. **2019** | • Enhanced IPC and AMS capacity through multidisciplinary, integrated teams working across health and social care services was recommended [17]. **iNAP2 2021**<br>• A strategy for the implementation of HSE community IPC is available [17]. **iNAP2 2021**<br>• *"95% of nursing staff reported no access to education on use of antimicrobials and AMS in 2021, replicating the findings of HALT 2016"* [84, p35]. **HSE 2021**<br>• The need to improve the surveillance, collection, analysis, and timely reporting of antimicrobial consumption data, with feedback, is recommended. This needs to include general practice, LTCFs and dental services [70]. **AMRIC 2021** |
| • All institutions should have local or regional guidelines for empiric antimicrobial therapy of commonly encountered infections | There is an urgent requirement for AMS strategies to tackle AMR and ensure appropriate prescribing of antimicrobials in LTCF settings [45]. **2017** | • GPs also provide clinical care and prescribing for LTCF residents and an online prescribing aid is available on the http://www.antibioticprescribing.ie website [73]. **AMRIC 2020**<br>• Assessment of the quality and type of antibiotic prescribing against relevant antibiotic guidelines is needed [84]. **HSE 2021** |
| • All institutions should carry out point prevalence surveys of antimicrobial use | Participation in the three HALT PPSs conducted in Ireland has increased identification of targets for future AMS interventions [38] **2015** [65], **2018**, including guidelines appropriate to LTCF and annual educational programmes for staff [49]. **2019** However, significant gaps persist in IPC as well as AMS programs and governance structures within Irish LTCFs [37] **2013** e.g. limited surveillance, access to IPC practitioners, policies and procedures [50]. **2019** Inadequate support systems and limited IPC and AMS committees were in place [51]. **2018** | PPS are conducted in LTCFs [69]. **ECDC 2020** Community Healthcare Organisation (CHO) -based AMS pharmacists conducted the first PPS in 2020/2021 in HSE Residential Care Facilities for Older Persons [17]. **iNAP2 2021** However, a different methodology to HALT studies was employed, including additional information on antimicrobial use which makes comparison difficult [84]. **HSE 2021** |

### C: antimicrobial stewardship interventions

Our findings highlight several notable achievements, including national participation in global surveillance, the timely adoption of restrictive usage practices, the availability of national e-learning modules on AMS and the development of hospital laboratory standards. However, the successful implementation of a national AMS programme requires the implementation of several key elements, as reflected in this review. These include sustained government support, long-term political commitment and leadership accountability [88].

A clear governance structure, ideally led by a physician or pharmacist [97] is essential for the successful implementation of a national action plan. Additionally, adequate funding is also necessary to support staffing and structural resources [4, 98]. Although e-learning modules in AMR, AMS and IPC have been introduced [17], there is currently no standardisation of these subjects across multidisciplinary undergraduate and postgraduate education [69]. The findings of this review highlight additional factors that are important to AMS implementation including the provision of education and training for health care staff, ensuring access to appropriate technology, strengthening diagnostic capabilities, and establishing robust laboratory surveillance with feedback mechanisms [99, 100].

The WHO has education of healthcare professionals as one of it five strategies to combat resistance [101] and has developed a competency framework to guide this initiative [102]. Furthermore, studies have proposed curricula and educational strategies across healthcare disciplines at both pre and post registration levels [103, 104].

Laboratory diagnostics play a fundamental role in AMS by ensuring accurate prescribing, improving patient outcomes, and addressing antimicrobial resistance [105]. Technological advances, such as rapid diagnostics and clinical decision support systems, are integral to antimicrobial stewardship by promoting targeted therapy, reducing resistance, and improving patient outcomes [106].

**Table 6** Overview of achievements, challenges and areas for future attention mapped to the guidelines for antimicrobial stewardship in hospitals in Ireland. SARI hospital antimicrobial stewardship Working Group December 2009 [26]

| SARI 2009 Recommendation Category | Achievements | Challenges | No documented or incomplete evidence identified regarding implementation of practice/progress |
|---|---|---|---|
| **A: Structure and Organisation of Antimicrobial Stewardship** | • Increased specialist staff to support AMS activities.<br>• Key Performance Indicators for AMS introduced (2018).<br>• Antibiotic prescribing data has been collected as part of national point prevalence surveys.<br>• National prescribing guidelines exist.<br>• Standardised education on AMS in Practice is in place via online HSELand training.<br>• Increased number of Consultant Microbiologists in post. | • While there are increased specialised staff in post additional personnel are required to successfully implement AMS in healthcare.<br>• Audits of antibiotic prescribing have demonstrated inconsistency in AMS application and audit implementation amongst some sites.<br>• National guidelines require continuous updating and wider dissemination.<br>• Lack of standardised multidisciplinary undergraduate education.<br>• Recruitment and retention of specialised staff is a challenge.<br>• Ownership of AMS needs to be developed. While management are indicated as responsible, in this scoping review there is a lack of consistency related the standardised existence of Drugs and Therapeutics Committees.<br>• ICT support needs to be developed and implemented to support AMS in healthcare settings. | • All acute hospitals must have one or more clinical pharmacists with responsibility for AMS.<br>◦ The way this is presented it is not clear where they are but there has been a significant recruitment in the number of AMS pharmacists but how they are aligning in terms of the strategy is unclear which leaves a gap.<br>• All pharmacists with responsibility for antimicrobial stewardship should have access to a structured training programme delivered at a national level. |
| **SARI 2009 Recommendation Category** | **Achievements** | **Challenges** | **No documented or incomplete evidence identified regarding implementation of practice/progress** |
| **A: Structure and Organisation of Antimicrobial Stewardship** | | • Issues related to the recommendation that all acute hospitals have at least one antimicrobial pharmacist and the availability of a structured national training programmes for pharmacists remain unanswered by the literature. | |
| **B: Roles and Responsibilities for Prescribers** | • Some evidence of prudent prescribing and effective governance in high performing hospitals.<br>• Resources available for prescribing e.g. Start Smart, then Focus and http://www.antibiotic.ie,<br>• Good progress identified at hospital level when appropriate and effective governance arrangements are implemented, including effective senior management supports. | • Lack of evidence of prudent prescribing in the LTCF setting<br>• Further research is required on how to implement prudent prescribing.<br>• National governance structure recommended but requires further focus and implementation. | • Patients, or their legal guardians, should be informed of the rationale for prescribing antimicrobials, and informed of any associated risks or adverse effects |
| **C: Antimicrobial Stewardship Interventions** | • Ireland participates in global surveillance.<br>• Evidence of restrictive usage practices of specific antibiotics.<br>• Evidence of timely conversion from parental to oral therapy.<br>• National e-learning modules available on AMS.<br>• Most hospitals laboratories have achieved accreditation and 24/7 services. | • Clinical teams did not review antibiotic prescribing in all settings.<br>• Participation in European PPS shows antibiotic usage increasing.<br>• Further education required on prescribing aids.<br>• Surveillance in LTCFs identified factors and structures that contribute to inappropriate prescribing e.g. complexity of patient needs, inadequate staffing and resources, and infrequent audits and feedback to prescribers. | • All hospitals should consider using specific order forms or designate a section of the prescription chart for prescribing of antimicrobials. |
| **SARI 2009 Recommendation Category** | **Achievements** | **Challenges** | **No documented or incomplete evidence identified regarding implementation of practice/progress** |

**Table 6** (continued)

| SARI 2009 Recommendation Category | Achievements | Challenges | No documented or incomplete evidence identified regarding implementation of practice/progress |
|---|---|---|---|
| **C: Antimicrobial Stewardship Interventions** | • Laboratories carry out surveillance of AMR and antibiograms. | • Access to OPAT services is not available in all hospitals.<br>• There was no evidence of agreed course content on AMR, AMS and IPC for undergraduate or postgraduate students.<br>• New diagnostic tools require further research.<br>• The introduction of electronic prescribing needs to be prioritised. | • Commercial promotion of antimicrobials should follow the Code of Marketing Practice, produced by the Irish Pharmaceutical Healthcare Association, and local guidelines approved by the hospital's Drugs and Therapeutics Committee. |
| **D: Recommendations for Non-Acute Residential Healthcare Institutions** | • Evidence of increased participation in HALT point prevalence surveys in LTCFs.<br>• Community AMS pharmacists have been in their roles since 2020 and undertook their first PPS in 2020/21. | • Limited integration between acute and non-acute residential settings.<br>• High prevalence rate of antibiotic usage evident with lack of AMS committees.<br>• Limited training on non-acute specific AMS prescribing.<br>• Over 50% of LTCF reported a lack of AMS guidelines.<br>• A lack of resources and governance highlighted.<br>• Limited surveillance reported from LTCFs.<br>• Establishment of a HSE IPC community strategy required. | Non applicable |

### D: recommendations for non-acute residential healthcare institutions

The findings demonstrate that research on implementing AMS strategies in LTCFs is limited compared to other healthcare settings [107]. Consistent with the existing evidence, the challenges to implementation include inadequate diagnostic resources, limited surveillance, insufficient government commitment, and a lack of tailored strategies as well as inadequate human and financial resources [108, 109], [110].

Furthermore, sustainability remains a concern [111] particularly in integrating staff education into AMS programs [112]. While educating patients, residents, and their families about responsible antibiotic use and resistance is a key part of AMS strategies in LTCFs [113], we found no evidence of such initiatives in this review. However, both the ECDC and WHO consider this practice a key component for effective AMS in these setting [114, 115].

The successful implementation of this strategy requires the development of clear educational materials, staff training to facilitate effective communication, and the integration of education into routine care. Visual reminders such as posters and brief educational sessions can reinforce key messages. Ongoing feedback and adjustment of strategies ensure the education remains effective and relevant [116].

#### Implementation

Whilst there are several policy documents and recommendations available to support the implementation of AMS strategies, there is an absence of a measurable structured implementation plan. Programmes mandated by Europe have been successful [10, 14] and has been demonstrated to be feasible to apply in Ireland. Although KPIs have been introduced, incorporating these into a clear shared mandated implementation plan with defined specific measurable elements would enhance the monitoring and evaluation of challenges and achievements related to AMS.

Overall, Ireland demonstrates strong strategic commitment to AMS, but continued focus is needed to ensure uniform and sustained implementation in practice. Consequently, Ireland's AMS progress highlights a common challenge: moving from well-developed policy and reporting structures to uniformly embedded, measurable practice across all levels of the healthcare system.

#### Progress

Since the publication of Ireland's first antimicrobial stewardship guidelines in 2009, significant progress has been made. This includes the publication of three national action plans to combat resistance [16, 17, 117] increased investment in specialised staff including Community Healthcare Organisation based antimicrobial stewardship pharmacists and the development of online AMS resources including education and prescribing aids. Our review period ended in 2021 however in 2022, the HSE published "*Antimicrobial Stewardship: Guidance for All Healthcare Settings*" [118] updating the original 2009 publication on AMS [26]. These new guidelines provide updated recommendations on key areas including an expanded scope covering all healthcare settings, updated definitions and terminology, a clearer focus on AMS team and leadership roles, more detailed guidance on education, enhanced surveillance, increased use of

technology and more targeted interventions. Overall, the updated 2022 guideline [118] reflect a more comprehensive, multidisciplinary, and technology-driven approach to combating AMR, with greater emphasis on collaboration, education, and data-driven interventions.

## Strengths and limitations

The strengths of this review include its novel approach to the topic, the use of a peer-reviewed published protocol and the utilisation of the SARI (2009) recommendations to map both the peer reviewed and grey literature.

As a scoping review, no formal quality appraisal of included studies and reports was undertaken. While several reports were included, recommendations were often repeated rather than providing information on current actions making gaps in practice difficult to identify. In addition, the inclusion of a cut-off date of 2021 was partly due to the research question and to the launch of new guidelines in 2022. Furthermore, studies conducted during initial years of the Covid-19 pandemic could produce data that are potentially less reliable or complete, or report practices that may not reflect long-term changes to AMS. The impact of Covid-19 on AMS is a worthwhile research question which we did not have the scope to address concurrently.

## Conclusion

This study is the first to assess AMS progress in Ireland since the launch of the initial guidelines in 2009. Although progress has been made, it remains limited, and the existing published data do not provide a clear measure of its extent. The findings of this review can be used to support future research, policy development and implementation efforts. Adopting a structured approach with clearly defined, measurable targets, rather than aspirational action lists, may facilitate a more accurate evaluation of progress and drive more effective AMS outcomes.

## Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12913-026-14498-y.

Supplementary material 1

### Authors' contributions

F B Roles: Conceptualisation, Investigation, Methodology, Project Administration, Validation, Writing – Original Draft Preparation, Writing – Review & Editing. OM. Roles: Conceptualisation, Methodology, Supervision, Writing – Review & Editing. APF. Roles: Methodology, Supervision, Writing – Review & Editing. EJOR. Roles: Methodology, Supervision, Writing – Review & Editing. MPS. Roles: Conceptualisation, Methodology, Supervision, Writing – Review & Editing.

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### Data availability

No datasets were generated or analysed during the current study.

## Declarations

### Ethics approval and consent to participate

Not applicable.

### Consent for publication

Not applicable.

### Competing interests

The authors declare no competing interests.

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### References

1. The antibiotic alarm. Nature. 2013, Mar;14495, (7740):141. https://doi.org/10.1038/495141a PMID: 23495392.
2. Darby EM, Trampari E, Siasat P, Gaya MS, Alav I, Webber MA, et al. Molecular mechanisms of antibiotic resistance revisited. Nat Rev Microbiol. 2023, May, 1;21(5):280–95. https://doi.org/10.1038/s41579-022-00820-y PMID: 36411397.
3. Jonas OB, Irwin A, Berthe FCJ, Le Gall FG, MPN, et al. Drug resistant infections: a threat to Our Economic future. Internet. 2017. Available from: http://documents.worldbank.org/curated/en/323311493396993758/fin alreport. 2017.
4. Pokharel S, Raut S, Adhikari B. Tackling antimicrobial resistance in low-income and middle-income countries. BMJ Glob Health. 2019, Nov, 1;4(6):e002104. https://doi.org/10.1136/bmjgh-2019-002104 PMID: 31799007.
5. Albrich WC, Monnet DL, Harbarth S. Antibiotic selection pressure and resistance in Streptococcus pneumoniae and Streptococcus pyogenes. Emerg Infect Dis. 2004;10(3):514–17. https://doi.org/10.3201/eid1003.030252 PMID: 15109426.
6. Davies J, Davies D. Origins and Evolution of antibiotic resistance. Microbiol Mol Biol Rev. 2010, Sep;74(3):417–33. https://doi.org/10.1128/MMBR.00016-10 PMID: 20805405.
7. Sanchez GV, Fleming-Dutra KE, Roberts RM, Hicks LA. Core elements of outpatient antibiotic stewardship. Core elements of Outpatient antibiotic stewardship morbidity and mortality weekly Report recommendations and reports 2016. MMWR. Recommendations Rep. 2016;65(6):1–12. https://doi.org/10.15585/mmwr.rr6506a1 PMID: 27832047.
8. US Department of Health and Human Services: Centers for Disease Control. Antibiotic resistance threats in the United States. 2019. Atlanta, Georgia; 2019 Nov.Available from: https://doi.org/10.15620/cdc:82532.
9. Gerding DN. The search for good antimicrobial stewardship. Jt Comm J Qual Improv. 2001;27(8):403–04. https://doi.org/10.1016/s1070-3241(01)27034-5 PMID: 11480201.
10. European Community. Council resolution of 8 June, 1999 on antibiotic resistance; a strategy against the microbial threat. Off J The Eur Community. 1999;195:1–3. Available from: EUR-Lex - 31999Y0713(01) - EN - EUR-Lex.
11. National Disease Surveillance Centre: SARI. A strategy for the control of Antimicrobial Resistance in Ireland. Report of the subgroup of the Scientific advisory committee of the national disease surveillance centre. NDSC, 2001. 2001. Available from: http://hdl.handle.net/10147/43720. NDSC.
12. Burd M, Humphreys H, Glynn G, Mitchell E, McDonald P, Johnson H, et al. Control and the prevention of methicillin-resistant Staphylococcus aureus in hospitals in Ireland: North/South study of MRSA in Ireland 1999. J Hosp Infect. 2003, Apr;53(4):297–303. https://doi.org/10.1053/jhin.2002.1393.
13. Bronzwaer SLAM, Goettsch W, Olsson-Liljequist B, Wale MCJ, Vatopoulos A, Sprenger MJ. European antimicrobial resistance surveillance system (EARSS): objectives and organisation. Eurosurveillance. 1999, Apr, 1;4(4):41–44. https://doi.org/10.2807/esm.04.04.00066-en PMID: 12631906.
14. Murphy OM, Murchan S, Whyte D, Humphreys H, Rossney A, Clarke P, et al. Impact of the European antimicrobial resistance surveillance system on the development of a national programme to monitor resistance in Staphylococcus aureus and Streptococcus pneumoniae in Ireland, 1999–2003. Eur J Clin Microbiol Infect Dis. 2005, Jul;24(7):480–83. https://doi.org/10.1007/s10096-005-1357-z. PMID: 15977004.

15. Cunney R. The strategy for the Control of antimicrobial resistance in Ireland (SARI). Wkly Releases (1997–2007). 2004;8(1):ii=2358. Available from: https://doi.org/10.2807/esw.08.01.02358-en.
16. Department of Health (2017). Ireland's national action plan on antimicrobial resistance 2017-2020.(iNAP) Available from 2017. http://health.gov.ie/national-patient-safety-office/patient-safety-surveillance/antimicrobialresistance-amr/.
17. Government of Ireland. Ireland's one Health national action plan on antimicrobial resistance 2021 –2025 (known as iNAP2). Available from: National action plan on antimicrobial resistance. 2021.
18. Brick A, Kakoulidou T, Humes H. Projections of national demand and bed capacity requirements for public acute hospitals in Ireland, 2023-2040. In: Based on the hippocrates model, ESRI research series 213. Dublin. Dublin, Ireland: ESRI; 2025. https://doi.org/10.26504/RS213. Available from: https://www.esri.ie/publications/projections-of-national-demand-and-bed-.
19. Kennelly B, O'Callaghan M, Coughlan D, Cullinan J, Doherty E, Glynn L, et al. The COVID-19 pandemic in Ireland: an overview of the health service and economic policy response Health policy Technol. Health Policy Technol. 2020;9(4):419–29. https://doi.org/10.1016/j.hlpt.2020.08.021 PMID: 32923355.
20. Mercille J, Turner B, Lucey DS. Ireland's takeover of private hospitals during the COVID-19 pandemic. HEPL. 2022;17(2):232–37. https://doi.org/10.1017/S1744133121000189 PMID: 34001297.
21. Sicari P, Sutherland D, Health sector performance and efficiency in Ireland. OECD Economic Department Working papers. Vol. 1750. OECD Economics Department Working Papers; 2023: 0_1, 3, 6-62. Mar. https://doi.org/10.1787/6a000bf1-en.
22. O'Neill N, Mercille J. Private equity investment in long-term care: the case of Ireland. Health Policy (New Y) (New Y). 2025, Sep, 1;159:105378. https://doi.org/10.1016/j.healthpol.2025.105378 PMID: 40554198,. Sep; 159.
23. Health Information and Quality Authority (HIQA) Annual Report. Annual Report 2020 | HIQA. 2020. https://doi.org/10.61145/ccpo5684.
24. Walsh B, S. Connolly long-term care system profile: Ireland global observatory of long-term care. 2024). Available from: https://goltc.org/system-profile/ireland, London.
25. Health Information and Quality Authority (HIQA). Report of the review of antimicrobial stewardship in public acute hospitals. 2016. Available from: https://www.hiqa.ie/sites/default/files/2017-01/Antimicrobial-Stewardship-Review.pdf.
26. Health Protection Surveillance Centre: SARI Hospital Antimicrobial Stewardship Working Group. Guidelines for antimicrobial stewardship in hospitals in Ireland. Dublin: 2009. Available from: http://hdl.handle.net/1014: Health Protection Surveillance Centre.
27. Daudt HML, Van Mossel C, Scott SJ. Enhancing the scoping study methodology: a large, inter-professional team's experience with Arksey and O'Malley's framework. BMC Med Res Methodol. 2013;13(1):1–9. https://doi.org/10.1186/1471-2288-13-48 PMID: 23522333.
28. Munn Z, Peters MDJ, Stern C, Tufanaru C, McArthur A, Aromataris E. Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. BMC Med Res Methodol. 2018;18(1):143. 10.1186/s12874-018-0611-x. PMID: 30453902.
29. Peters MDJ. Managing and coding references for systematic reviews and scoping reviews in EndNote. Med Reference Serv Q. 2017;36(1):19–31. 10.1080/02763869.2017.1259891. PMID: 28112629.
30. Godin K, Stapleton J, Kirkpatrick SI, Hanning RM, Leatherdale ST. Applying systematic review search methods to the grey literature: a case study examining guidelines for school-based breakfast programs in Canada. Syst Rev [Internet]. 2015;4(1):1–10. https://doi.org/10.1186/s13643-015-0125-0. PMID: 26494010.
31. Jordan Z, Lockwood C, Munn Z, Aromataris E. Redeveloping the JBI model of evidence based healthcare. Int J Multiling Evidence-Based Healthcare. 2018;16(4):227–41. https://doi.org/10.1097/XEB.0000000000000139. PMID: 29664758.
32. Arksey H, O'Malley L. Scoping studies: towards a methodological framework. Int J Soc Res Methodol Soc Res Methodol. 2005;8(1):19–32. https://doi.org/10.1080/1364557032000119616.
33. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. Ann Intern Med. 2018;169(7):467–73. https://doi.org/10.7326/M18-0850.
34. Mendeley-reference management software & researcher network. 2026 Jan 27.
35. Covidence systematic review software. Melbourne, Australia: Veritas Health Innovation.
36. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. 2021. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372:n71. https://doi.org/10.1136/bmj.n71 PMID: 33782057.
37. Donlon S, Roche F, Byrne H, Dowling S, Cotter M, Fitzpatrick F. A national survey of infection control and antimicrobial stewardship structures in Irish long-term care facilities. Am. J. Infect. Control. 2013, Jun;41(6):554–57. https://doi.org/10.1016/j.ajic.2012.06.010. PMID: 23149086.
38. Burns K, Roche F, Donlon S. Healthcare-associated infections and antimicrobial use in long-term care facilities: the Irish experience with the HALT surveys. J Hosp Infect. 2015;89(4):276–80. https://doi.org/10.1016/j.jhin.2014.12.006 PMID: 25638357.
39. Fleming A, Tonna A, O'Connor S, Byrne S, Stewart D. A cross-sectional survey of the profile and activities of antimicrobial management teams in Irish hospitals. Int J Clin Pharm. 2014;36(2):377–83. https://doi.org/10.1007/s11096-013-9907-4 PMID: 24382694.
40. Fleming A, Tonna A, O'Connor S, Byrne S, Stewart D. Antimicrobial stewardship activities in hospitals in Ireland and the United Kingdom: a comparison of two national surveys. Int J Clin Pharm. 2015, Oct, 1;37(5):776–81. https://doi.org/10.1007/s11096-015-0114-3 PMID: 25851503.
41. Maguire F, Murphy ME, Rourke M, et al. A cross-sectional study of antibiotic prescribing for childhood upper respiratory tract infections in Irish general practice Irish. Med J. 2018, Dec;111(10):835. Available from: https://imj.ie/a-cross-%20sectional-study-of-antibiotic-prescribing-for-childhood-upper-respiratory-%20tract-infections-in-irish-general-practice/PMID: 30558408.
42. Martin E, Philbin M, Hughes G, Bergin C, Fe Talento A. Antimicrobial stewardship challenges and innovative initiatives in the acute hospital setting during the COVID-19 pandemic. The J Antimicrob Chemother. 2021;76(1):272–75. https://doi.org/10.1093/jac/dkaa400 PMID: 3301763.
43. Pulcini C, Tebano G, Mutters NT, Tacconelli E, Cambau E, Kahlmeter G, et al. Selective reporting of antibiotic susceptibility test results in European countries: an ESCMID cross-sectional survey. Int. J. Antimicrob. Agents. 2017, Feb, 1;49(2):162–66. https://doi.org/10.1016/j.ijantimicag.2016.11.014 PMID: 28093208.
44. Vellinga A, Cormican M, Hanahoe B, Bennett K, Murphy AW. Antimicrobial management and appropriateness of treatment of urinary tract infection in general practice in Ireland. BMC Fam Pract. 2011;12(1):12. https://doi.org/10.1186/1471-2296-12-108 PMID: 21967276.
45. Fleming A, Barry L, Byrne S, Prentice M. Antimicrobial susceptibility of long term care facility and general practice urine samples in patients 65 years and older: an observational study. Eur J Public Health. 2016, Apr, 1;27(2):307–12. https://doi.org/10.1093/eurpub/ckw138 PMID: 27777243.
46. Fitzgerald DJ, Knowles SJ, Downey P, Robson MS. Examining the infectious aetiology and diagnostic criteria of maternal pyrexia in labour to improve antibiotic stewardship. Eur J Criminol Obstet Gynecology Reprod Biol: X. 2019, Jan, 1;1:1. https://doi.org/10.1016/j.eurox.2018.100001.
47. Plachouras D, Kärki T, Hansen S, Hopkins S, Lyytikäinen O, Moro ML, et al. Antimicrobial use in European acute care hospitals: results from the second point prevalence survey (PPS) of healthcare-associated infections and antimicrobial use, 2016 to 2017. Eurosurveillance. 2018, Nov;23(46):1800393. https://doi.org/10.2807/1560-7917.ES.23.46.1800393. PMID: 30458917.
48. Hsia YF, Lee BR, Versporten A, Yang YH, Bielicki J, Jackson C, et al. Use of the WHO access, watch, and reserve classification to define patterns of hospital antibiotic use (AWaRe): an analysis of paediatric survey data from 56 countries. The Lancet Global Health. 2019, Jul, 1;7(7):e861–71. https://doi.org/10.1016/S2214-109X(19)30071-3 PMID: 31200888.
49. Tandan M, Burns K, Murphy H, Hennessy S, Cormican M, Vellinga A. Improving antimicrobial prescribing: a multinomial model Identifying factors associated with first- and second-line prescribing. J Am Med Dir Assoc. 2019, May, 1;20(5):624–28. https://doi.org/10.1016/j.jamda.2018.10.028. Epub 2018 Dec 13. PMID: 30554988.
50. Tandan M, O'connor R, Burns K, Murphy H, Hennessy S, Roche F, et al. A comparative analysis of prophylactic antimicrobial use in long-term care facilities in Ireland, 2013 and 2016. Eurosurveillance. 2019;24(11):1–10. https://doi.org/10.2807/1560-7917.ES.2019.24.11.1800102. PMID: 30892182.
51. Tandan M, Burns K, Murphy H, Hennessy S, Cormican M, Vellinga A. Antimicrobial prescribing and infections in long-term care facilities (LTCF): a multilevel analysis of the HALT 2016 study, Ireland, 2017. Eurosurveillance. 2018, Nov;23(46):1800278. https://doi.org/10.2807/1560-7917.ES.2018.23.46.1800278. PMID: 30458910.
52. Cunney R, Kirrane-Scott M, Rafferty A, Stapleton P, Okafor I, Mcnamara R. 'Start smart': using front-line ownership to improve the quality of empiric

antibiotic prescribing in a paediatric hospital. BMJ Open Qual. 2019, Aug, 1;8(3):e000445. https://doi.org/10.1136/bmjoq-2018-000445 PMID: 31523725.
53. O'Sullivan CE. Antimicrobial stewardship failure: time for a new model. The J Antimicrob Chemother. 2020, May, 1;75(5):1087–90. https://doi.org/10.1093/jac/dkaa006 PMID: 32068845.
54. O'Riordan F, Shiely F, Byrne S, O'Brien D, Palmer B, Dahly D, et al. An investigation of the effects of procalcitonin testing on antimicrobial prescribing in respiratory tract infections in an Irish university hospital setting: a feasibility study. The J Antimicrob Chemother. 2019;74(11):3352–61. https://doi.org/10.1093/jac/dkz313 PMID: 31325313.
55. Dunn K, O'Reilly A, Silke B, Rogers T, Bergin C. Implementing a pharmacist-led sequential antimicrobial therapy strategy: a controlled before-and-after study. Int J Clin Pharm. 2011, Apr;33(2):208–14. https://doi.org/10.1007/s11096-010-9475-9 PMID: 2174419.
56. Ni Riain U, Tierney M, Doyle C, Vellinga A, Fleming C, Cormican M. Targeted de-escalation rounds may effectively and safely reduce meropenem use. Ir J Med Sci. 2017, Aug, 1;186(3):729–32. https://doi.org/10.1007/s11845-016-1504-9 PMID: 27686471.
57. Tiszai-Szucs T, Mac Sweeney C, Keaveny J, Bozza FA, Hagan O, Martin-Loeches Z, et al. Feasibility of antimicrobial stewardship (AMS) in critical care settings: a multidisciplinary approach strategy. In: Med Sci. Vol. 6(2). Basel, Switzerland; 2018 May 25. https://doi.org/10.3390/medsci6020040 PMID: 29799500.
58. O'Connor N, Breen R, Carton M, Mc Grath I, Deasy N, Collins C, et al. Improving the quality of antibiotic prescribing through an educational intervention delivered through the out-of-hours general practice service in Ireland. The Eur J Gener Pract. 2020, Dec, 16;26(1):119–25. https://doi.org/10.1080/13814788.2020.1784137 PMID: 32757866.
59. O'Kelly B, Rueda-Benito A, O'Regan M, Finan K. An audit of community-acquired pneumonia antimicrobial compliance using an intervention bundle in an Irish hospital. J Glob Antimicrob Resist. 2020, Dec, 1;23:38–45. https://doi.org/10.1016/j.jgar.2020.07.021 PMID: 23801028.
60. McCarthy KN, Hawke A, Dempsey EM. Antimicrobial stewardship in the neonatal unit reduces antibiotic exposure. Acta paediatrica. 2018;107(10):1716–21. https://doi.org/10.1111/apa.14337 PMID: 29603353.
61. Stevens NT, Bruen C, Boland F, Pawlikowska T, Fitzpatrick F, Humphreys H. Is online case-based learning effective in helping undergraduate medical students choose the appropriate antibiotics to treat important infections? JAC Antimicrob Resist. 2019, Dec, 1;1(3). https://doi.org/10.1093/jacamr/dlz081. PMID: 34222954.
62. Fleming A, Bradley C, Cullinan S, Byrne S. Antibiotic prescribing in long-term care facilities: A qualitative, multidisciplinary investigation. BMJ Open. 2014;4(11):1–13. https://doi.org/10.1136/bmjopen-2014-006442 PMID: 25377014.
63. O'Doherty J, Leader LFW, O'Regan A, Dunne C, Puthoopparambil SJ, O'Connor R. Over prescribing of antibiotics for acute respiratory tract infections; a qualitative study to explore Irish general practitioners' perspectives. BMC Fam Pract. 2019, Feb, 14;20(1). https://doi.org/10.1186/s12875-019-0917-8 PMID: 30764777.
64. O'Riordan F, Shiely F, Byrne S, Fleming A, et al. A qualitative process evaluation of the introduction of procalcitonin testing as an antimicrobial stewardship intervention. Int J Clin Pharm. 2021, Jun;43(3):532–40. https://doi.org/10.1007/s11096-020-01159-1 PMID: 33001314.
65. Ricchizzi E, Latour K, Kärki T, Buttazzi R, Jans B, Moro ML, et al. Antimicrobial use in European long-term care facilities: results from the third point prevalence survey of healthcare-associated infections and antimicrobial use, 2016 to 2017. Eurosurveillance. 2018;23(46). https://doi.org/10.2807/1560-7917.ES.2018.23.46.1800394 PMID: 30458913.
66. Health Information and Quality Authority(HIQA). National standards for the prevention and control of healthcare-associated infections in acute healthcare services. 2017. Available from: https://www.hiqa.ie/sites/default/files/2017-05/2017-HIQA-National-S.
67. Health Service Executative(HSE) Antimicrobial Resistance and Infection Control Team (AMRIC). Performance assurance process for key performance indicators for HCAI AMR in acute hospitals. 2018. Available from: https://hse.ie/hcai.
68. Health Information and Quality Authority (HIQA). National standards for infection prevention and control in community services. 2018. Available from: https://www.hiqa.ie/sites/default/files/2018-09/National-Standards-for-IPC-in-Community-services.pdf.
69. EUROPEAN COMMISSION DIRECTORATE-GENERAL FOR HEALTH AND FOOD SAFETY. European Centre for Disease Prevention and Control. Final joint report in respect of a one health country visit to Ireland from 07 October 2019 to 11 October 2019 to discuss policies relating to antimicrobial resistance. (2020). 2020. Available fromhttps://www.ecdc.europa.eu/sites/default/files/documents/antimicrobial-resistance-one-health-ireland-country-visit.pdf.
70. Health Service Executive (2021). Health Service Executive 2022–2025 AMRIC action plan Available from: 2022. https://bit.ly/3nWROS7.
71. Royal College of Physicians of Ireland Hospital Antimicrobial Stewardship Working Group. Start smart, then focus an antibiotic Care bundle for hospitals. 2012. Available from: https://www.hse.ie/eng/services/publications/clinical-strategy-and-programmes/start-smart-stay-focused.pdf.
72. Health Service Executive (HSE) Quality Improvement Division. Recommendations for implementation of key performance indicators for antimicrobial stewardship in acute hospitals in Ireland. 2017. Available from: http://hdl.handle.net/10147/631096.
73. AMRIC Oversight Group & Antimicrobial Stewardship Advisory Group. Summary PCRS AMRIC GP Green Red Rep 2019/2020 AMRIC Oversight Group Antimicrob Stewardship Advisory Group Key. 2020;3.
74. Health Service Executive. Antimicobial Resistance and Infection Control Team. Antimicrobial stewardship in COVID-19 (version 1 23/04/20). Vol. 19. 2020. Available from http://hdl.handle.net/10147/627550.
75. Health Service Executive (HSE)/Royal College of Surgeons in Ireland (RCSI) Surgical antibiotic prophylaxis duration position paper October 2021. 2021. Available from: https://www.hse.ie/eng/services/list/2/gp/antibiotic-prescribing/hospital-related-guidelines/surgical-antibiotic-prophylaxis-duration-position-statement-october-2021-v1.pdf. Dublin: HSE/RCSI.
76. Health Protection Surveillance Centre (HPSC). Health Protection surveillance Centre, Point prevalence survey of hospital Acquired infections & antimicrobial use in European acute care hospitals, May, 2017: intensive care unit Report Ireland. J Med Microbio. Available from: https://www.hpsc.ie/az/microbiologyantimicrobialresistance/infectioncontrolandhai/surveillance/hospitalpointprevalencesurveys/2017/nationalppsreports/PPS%202017%20Adult%20I.
77. Health Protection Surveillance Centre. Point prevalence survey of healthcare-associated infections & Antimicobial use in long-term Care facilities: may 2016. 2017 HALT. Available from: https://www.hpsc.ie/a-z/microbiologyantimicrobialresistance/infectioncontrolandhai/surveillance/hcaiinlongtermcarefacilities/haltreports/2016report/File, 16218,en.pdf - Ireland National Report: March.
78. Burns K, Foley M, Donlon S, Health Protection Surveillance Centre, Point Prevalence Survey of Hospital Acquired Infections & Antimicrobial Use in European Acute Care Hospitals: May 2012 - Republic of Ireland Critical Care Report: February 2013. 2012. Available from: https://www.hpsc.ie/a-z/microbiologyantimicrobialresistance/infectioncontrolandhai/surveillance/hospitalpointprevalencesurveys/2012/pps2012reportsforireland/.
79. Health Protection Surveillance Centre (HPSC). Annual Epidemiological Report 2014. Vol. 5. 2014. Available from: Annual Epidemiological Reports 1999–2016 - Health Protection Surveillance Centre.
80. Health Protection Surveillance Centre. Point prevalence survey of hospital Acquired infections & antimicrobial use in European acute care hospitals, May, 2017: summary of the national Report: Ireland. J Med Microbiol. 2017;32. Available from: PPS, 2017 National Report_FINAL_191218.pdf.
81. Breslin R, Fenton S, Oza A, Burns K, Philbin M. Annual hospital antimicrobial Point prevalence survey in Ireland: 2019. 2020. Available from: https://www.idsociety.ie/meetings/idsi webinars2021/submissions/2021021/eposter.
82. HEALTH PROTECTION SURVEILLANCE CENTRE. Point prevalence survey of healthcare-associated infections & antimicrobial use in long-term care facilities (HALT): may 2013 a Summary of data from intellectually disabled facilities REPUBLIC OF. IRELAND: NATIONAL REPORT-MARCH; 2014.
83. World Health Organization. Global antimicrobial resistance surveillance system (GLASS) report: early implementation 2020. 2020. Available from https://iris.who.int/handle/10665/332081.Licence:CC BY-NC-SA. Geneva: World Health Organization 3.0 IGO. 2021.
84. Health Service Executive. Report of the findings of the Point prevalence survey of antimicrobial use in HSE older Persons residential care facilities. HSE Ireland. 2021 Available from: http://hdl.handle.net/10147/630897
85. Organisation for Economic Co-operation and Development (OECD). Fighting antimicrobial resistance in EU and EEA countries. 2023. Available from: https://www.oecd.org/content/dam/oecd/en/publications/reports/2023/11/fighting-antimicrobial-resist. Paris: OECD.
86. Organisation for Economic Co-operation and Development (OECD). (2023), Embracing a one Health framework to fight antimicrobial resistance, OECD

Health policy studies. Paris: OECDPublishing; 2023 Sep. https://doi.org/10.1787/ce44c755-en.
87. European Centre for Disease Prevention and Control. Point prevalence survey of healthcare-associated infections and antimicrobial use in European acute care hospitals 2011-2012. Stockholm. European Centre for Disease Prevention and Control; 2013.
88. US Department of Health and Human Services: Centers for Disease Control. Core elements of hospital antibiotic stewardship programs. 2019. Available from: https://www.cdc.gov/antibiotic-use/core-elements/hospital.html. Atlanta, GA: US Department of Health and Human Services, CDC.
89. Nassar H, Abu-Farha R, Barakat M, Alefishat E. Antimicrobial stewardship from Health professionals' perspective: awareness, barriers, and level of implementation of the program. Antibiotics. 2022;11(1):99. https://doi.org/10.3390/antibiotics11010099 PMID: 35052979.
90. Birgand G, Castro-Sánchez E, Hansen S, Gastmeier P, Lucet JC, Ferlie E, et al. Comparison of governance approaches for the control of antimicrobial resistance: analysis of three European countries. Antimicrob Resist Infect Control. 2018, Feb, 20;7(1). https://doi.org/10.1186/s13756-018-0321-5. PMID: 29468055.
91. Pulcini C Binda FLamkang C, Binda F, Lamkang AS, Trett A, Charani E, Goff DA, et al. Developing core elements and checklist items for global hospital antimicrobial stewardship programmes: a consensus approach. Clin Microbiol Infect. 2019, Jan;25(1):20–25. https://doi.org/10.1016/j.cmi.2018.03.033. Epub 2018 Apr 3 PMID: 29625170.
92. Anderson M, Schulze K, Cassini A, Plachouras D, Mossialos E. A governance framework for development and assessment of national action plans on antimicrobial resistance. The Lancet Infect Dis. 2019;19(11):e371–84. https://doi.org/10.1016/S1473-3099(19)30415-3.
93. Ashiru-Oredope D, Hopkins S, Vasandani S, Umoh E, Oloyede O, Nilsson A, et al. Healthcare workers' knowledge, attitudes and behaviours with respect to antibiotics, antibiotic use and antibiotic resistance across 30 EU/EEA countries in 2019. Eurosurveillance. 2021;26(12):1–10. https://doi.org/10.2807/1560-7917.ES.2021.26.12.1900633 PMID: 33769250.
94. World Health Organization. Toolkit for antimicrobial stewardship programmes in low- and middle-income countries. 2019. https://www.who.int/publications/i/item/9789241515481.
95. Price L, Gozdzielewska L, Young M, Smith F, MacDonald J, McParland J, et al. Effectiveness of interventions to improve the public's antimicrobial resistance awareness and behaviours associated with prudent use of antimicrobials: a systematic review. The J Antimicrob Chemother. 2018, Jun, 1;73(6):1464–78. https://doi.org/10.1093/jac/dky076 PMID: 29554263,. Jun.
96. McParland JL, Williams L, Gozdzielewska L, Young M, Smith F, MacDonald J, et al. What are the 'active ingredients' of interventions targeting the public's engagement with antimicrobial resistance and how might they work? Br J Health Psychol. 2018, Nov;23(4):804–19. https://doi.org/10.1111/bjhp.12317. Epub 2018 May 27 PMID: 29804314.
97. Mendelson M, Morris AM, Thursky K, Pulcini C. How to start an antimicrobial stewardship programme in a hospital. Clin Microbiol Infect. 2020;26(4):447–53. https://doi.org/10.1016/j.cmi.2019.08.007 PMID: 31445209.
98. Monmaturapoj T, Scott J, Smith P, Watson MC. What influences the implementation and sustainability of antibiotic stewardship programmes in hospitals? A qualitative study of antibiotic pharmacists' perspectives across South West England. Eur J Hosp Pharm. 2022, Mar;29;29(E1): E46-51. e1):e46–51. https://doi.org/10.1136/ejhpharm-2020-002540 PMID: 33789988.
99. Mehta JM, Haynes K, Wileyto EP, Gerber JS, Timko DR, Morgan SC, et al. Comparison of prior authorization and prospective audit with feedback for antimicrobial stewardship. Infect Control Hosp Epidemiol. 2014;35(9):1092–99. https://doi.org/10.1086/677624 PMID: 25111916.
100. Rolfe R, Kwobah C, Muro F, Ruwanpathirana A, Lyamuya F, Bodinayake C, et al. Barriers to implementing antimicrobial stewardship programs in three low- and middle-income country tertiary care settings: findings from a multi-site qualitative study. Antimicrob Resist Infect Control. 2021, Dec, 1;10(1). https://doi.org/10.1186/s13756-021-00929-4 PMID: 33766135.
101. World Health Organization. Global action plan on antimicrobial resistance. Geneva. 2015). Available from: https://www.who.int/antimicrobial-resistance/global-action-plan/en/.
102. World Health Organization. Health workers' education and training on antimicrobial resistance: curricula guide. Available from: (2019). https://iris.who.int/handle/10665/329380. License:CC BY-NC-SA 3.0 IGO.
103. Castro-Sánchez E, Drumright LN, Gharbi M, Farrell S, Holmes AH. Mapping antimicrobial stewardship in undergraduate medical, dental, pharmacy, nursing and veterinary education in the United Kingdom. PLoS One. 2016, Feb, 29;11(2):e0150056. https://doi.org/10.1371/journal.pone.0150056. PMID: 26928009; Feb.
104. Al-Taani GM, Karasneh RA, Al-Azzam S, Bin Shaman M, Jirjees F, Al-Obaidi H, et al. Knowledge, attitude, and behavior about antimicrobial use and resistance among medical, nursing and pharmacy students in Jordan: a cross sectional study. Antibiotics. 2022;11(11):1559. https://doi.org/10.3390/antibiotics11111559 PMID: 36358214.
105. Morency-Potvin P, Schwartz DN, Weinstein RA. Antimicrobial stewardship: how the microbiology laboratory can right the ship. Clin Microbiol Rev. 2017, Dec, 14;30(1):381–407. https://doi.org/10.1128/CMR.00066-16 PMID: 27974411.
106. Cowman K, Chen V, Guo Y, Nori P. Using technology to enhance antimicrobial stewardship impact in the acute care setting. Curr Treat Options Infect Dis. 2020;12(2):145–57. https://doi.org/10.1007/s40506-020-00218-5.
107. Van Buul LW, van der Steen Jt, Veenhuizen RB, Achterberg WP, Schellevis FG, Essink RTGM, et al. Antibiotic use and resistance in long term care facilities. J Am Med Dir Assoc. 2012;13(6):.e568.1–568.13. https://doi.org/10.1016/j.jamda.2012.04.004 PMID: 22575772.
108. US Department of Health and Human Services: Centers for Disease Control. The core elements of antibiotic stewardship for nursing homes. 2015. Available from: http://www.cdc.gov/longtermcare/index.html. Atlanta, GA: US Department of Health and Human Services, CDC.
109. Lim CJ, Kwong MW-L, Stuart RL, Buising KL, Friedman ND, Bennett NJ, et al. Antibiotic prescribing practice in residential aged care facilities - health care providers' perspectives. The Med J Aust. 2014;201(2):101–05. https://doi.org/10.5694/j.1326-5377.2014.tb04232.x PMID: 25045989.
110. Bal AM, Gould IM. Antibiotic stewardship: overcoming implementation barriers. Curr Opin Infect Dis. 2011, Aug;24(4):357–62. https://doi.org/10.1097/QCO.0b013e3283483262 PMID: 21587070.
111. Crnich CJ, Jump R, Trautner B, Sloane PD, Mody L. Optimizing antibiotic stewardship in nursing homes: a narrative review and recommendations for improvement. Drugs Aging. 2015, Sep, 29;32(9):699–716. https://doi.org/10.1007/s40266-015-0292-7 PMID: 26316294.
112. Zimmerman S, Sloane PD, Bertrand R, Olsho LEW, Beeber A, Kistler C, et al. Successfully reducing antibiotic prescribing in nursing homes. J Am Geriatrics Soc. 2014;62(5):907–12. https://doi.org/10.1111/jgs.12784 PMID: 24697789.
113. Van Schooneveld T, Miller H, Sayles H, Watkins K K, Smith PW. Survey of antimicrobial stewardship practices in Nebraska long-term care facilities. Infect Control Hosp Epidemiol. 2011, Jul;32(7):732–34. https://doi.org/10.1086/660855. PMID: 21666410.
114. European Centre for Disease Prevention and Control (ECDC). Key messages for primary care prescribers. 2023. Available from: https://antibiotic.ecdc.europa.eu/en/get-informed/key-messages/primary-care-prescribers. Stockholm: ECDC.
115. Beović B, Čižman M, Papst L, Pečavar B, Šubelj M, et al. Antibiotic prescribing in long-term care facilities for the elderly: EVIPNet evidence brief for policy, number 3. World Health Organization. Regional Office for Europe; 2018. https://iris.who.int/handle/10665/346473. License:CC BY-NC-SA 3.0 IGO.
116. Lee CR, Lee JH, Kang LW, Jeong BC, Lee SH. Educational effectiveness, target, and content for prudent antibiotic use. Biomed Res Int. 2015, 2015;2015:1–13. https://doi.org/10.1155/2015/214021. Epub 2015 Apr 5 PMID: 25945327.
117. Government of Ireland. Ireland's third one Health national action plan on AntimicrobialResistance 2026 – 2030 (known as iNAP3).Available at 2025. https://www.gov.ie/en/publication/d72f1-joint-action-on-antimicrobial-resistance/.
118. Health Service Executive Ireland. Antimicrobial stewardship guidance for all healthcare settings. Available from: https://www.hse.ie/eng/services/list/2/gp/antibiotic-prescribing/antibicrobial-stewardship-audit-tools/hse-amric1antimicrobial-stewardship-guidance-for-all-healthcare-settings-v1-published-august-2022.pdf

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