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Review

Scottish Antimicrobial Prescribing Group (SAPG): development and impact of the Scottish National Antimicrobial Stewardship Programme

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ABSTRACT

In 2008, the Scottish Management of Antimicrobial Resistance Action Plan (ScotMARAP) was published by the Scottish Government. One of the key actions was initiation of the Scottish Antimicrobial Prescribing Group (SAPG), hosted within the Scottish Medicines Consortium, to take forward national implementation of the key recommendations of this action plan. The primary objective of SAPG is to co-ordinate and deliver a national framework or programme of work for antimicrobial stewardship. This programme, led by SAPG, is delivered by NHS National Services Scotland (Health Protection Scotland and Information Services Division), NHS Quality Improvement Scotland, and NHS National Education Scotland as well as NHS board Antimicrobial Management Teams. Between 2008 and 2010, SAPG has achieved a number of early successes, which are the subject of this review: (i) through measures to optimise prescribing in hospital and primary care, combined with infection prevention measures, SAPG has contributed significantly to reducing *Clostridium difficile* infection rates in Scotland; (ii) there has been engagement of all key stakeholders at local and national levels to ensure an integrated approach to antimicrobial stewardship within the wider healthcare-associated infection agenda; (iii) development and implementation of data management systems to support quality improvement; (iv) development of training materials on antimicrobial stewardship for healthcare professionals; and (v) improving clinical management of infections (e.g. community-acquired pneumonia) through quality improvement methodology. The early successes achieved by SAPG demonstrate that this delivery model is effective and provides the leadership and focus required to implement antimicrobial stewardship to improve antimicrobial prescribing and infection management across NHS Scotland.

1. Introduction

1.1. The European perspective

In 2008, sixteen countries in Europe developed a national strategy to contain antimicrobial resistance [1]. Many countries in Europe had reported a successful reduction in antibiotic resistance in specific areas, but this strategy described a comprehensive approach to tackling the problem [1].

In 2008 [2], the Swedish Strategic Programme for the Rational Use of Antimicrobial Agents and Surveillance of Resistance (STRAMA) project reported a sustained reduction in antibiotic use and low bacterial resistance rates after a 10-year follow-up period, but without any measurable negative consequences. This multidisciplinary, co-ordinated programme supported by the Swedish Government since 2000 has demonstrated that antibiotic use can be reduced without any measurable unintended harm. Key to the Swedish model appeared to be a multidisciplinary national steering group, with primarily a co-ordinating role, and regional groups

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functioning at county level that implemented a range of stewardship activities supported by comprehensive data on antibiotic use and surveillance of antimicrobial resistance. We believed that the organisation, structure and delivery of health care in Scotland had many similarities to Sweden and thereby would allow us to adopt and adapt core components of STRAMA. Sweden has a population of ca. 11 million and health care is provided via 21 county-based services, whilst Scotland has a population of 5.1 million (8% of the UK population) with healthcare delivered via 14 regional National Health Service (NHS) boards. The budget and management of health is devolved to the Scottish Parliament and the national healthcare system provides hospital and community-based care to all inhabitants via services mainly supplied by public providers. There are an estimated 11 456 acute hospital beds in Scotland.

The Welsh Antimicrobial Resistance Programme [3], established in 2005, provides similar information to STRAMA on national and regional data regarding antimicrobial use and resistance. A delegation from Scotland visited the Welsh Surveillance Unit in Cardiff to learn how prescribing and surveillance data are collected and evaluated.

1.2. The Scottish context

In 2008, The Scottish Management of Antimicrobial Resistance Action Plan (ScotMARAP) was published by the Scottish Government (http://www.scotland.gov.uk/Publications/2008/03/12153030/0). One of the key actions was initiation of the Scottish Antimicrobial Prescribing Group (SAPG), hosted by the Scottish Medicines Consortium (SMC), to take forward national implementation of the key recommendations of this action plan. The primary objective of SAPG is to co-ordinate and deliver a national antimicrobial stewardship programme. SAPG was initiated in March 2008, initially for a period of 3 years, and was supported by central funding from the Scottish Government Health Department.

In convening SAPG, we tailored the structure and operational model to reflect local existing and emergent problems as well as local geographical and staffing structures. Whilst complementing many of the strengths of STRAMA and the Welsh programme, we have also introduced some unique or novel approaches and measures.

For NHS Scotland, reducing harm from healthcare-associated infections (HAIs) has been a high priority since 2005 and national programmes to address HAIs have been co-ordinated by the Scottish Government HAI Task Force. The importance of integrating HAI within a quality strategy or framework has been recognised by guidance from the European Union [4] and elsewhere [5] and is reflected within the Healthcare Quality Strategy published in 2010 (http://www.scotland.gov.uk/Resource/Doc/311667/0098354.pdf; accessed 22 November 2010).

As part of the HAI Delivery Plan 2005–2008, a national survey of HAI prevalence (http://www.documents.hps.scot.nhs.uk/hai/sshaip/publications/national-prevalence-study/report/full-report.pdf; accessed 22 November 2010) undertaken between October 2005 and October 2006 indicated an overall prevalence of 9.5% for acute hospitals and 7.3% for non-acute hospitals. In this survey, prescription of antimicrobials was also examined as a potential proxy indicator for HAI. However, whilst local hospitals were able to collect some information in relation to the quantity and quality of antibiotic prescribing, there was no robust national validated system for measuring this. A single point-prevalence survey of antimicrobial prescribing was also performed in 10 Scottish hospitals using the Glasgow Antimicrobial Audit Tool (GAAT) [6] to give more qualitative information about the quality of prescribing within a representative sample of acute Scottish hospitals. Results from this study showed that of 3826 patients surveyed, 1079 (28.2%) received an antibiotic, 381 (35.3%) intravenously; 197 patients (28.2%) treated orally had prior intravenous therapy. Third-generation cephalosporins (28.3%) were the most frequently used antibiotics, followed by amoxicillin/clavulanic acid (co-amoxiclav) (20.2%), metronidazole (19.2%) and glycopeptides (18.6%). Although regional differences were seen, this snapshot survey provided an early indication of high levels of use of broad-spectrum parenteral antibiotics, and a significant proportion of these prescriptions were deemed inappropriate. The emergence of the *Clostridium difficile* infection (CDI) epidemic in Scottish healthcare facilities suggested a link between such prescribing practice and CDI. The outbreak of CDI in the Vale of Level Hospital, NHS Greater Glasgow and Clyde, with a high number of deaths, brought this problem to the forefront of the public, politicians' and the national media's attention. (http://www.documents.hps.scot.nhs.uk/hai/sshaip/publications/cdad/cdad-review-2008-07.pdf). The need to implement a national antimicrobial stewardship programme in all healthcare settings to support existing infection control and environmental decontamination measures was accepted as a priority in a bid to contain and reduce CDI.

The aim of SAPG, working with NHS boards and other stakeholders, is to implement a range of antimicrobial stewardship interventions intended to enhance the quality of antimicrobial prescribing to reduce unnecessary antibiotic use:

- promote use of narrow-spectrum agents and reduce use of broad-spectrum antibiotics;
- drive improvement in the quality of antibiotic use to improve clinical outcomes; and
- minimise harm from antibiotics (mortality, CDI, resistance, adverse reactions).

Within NHS boards these interventions are delivered by local Antimicrobial Management Teams (AMTs). The aim of this review is to describe the SAPG programme and to summarise some results of the first 2 years of SAPG.

2. Organisation of SAPG

2.1. National level

The SAPG programme is delivered through a hub and spoke model (as shown in Fig. 1) by NHS National Services Scotland (NSS) [which comprises Health Protection Scotland (HPS) and Information Services Division (ISD)], NHS Quality Improvement Scotland (NHS QIS), NHS Education for Scotland (NES) and NHS board AMTs.

SAPG and its host organisation, the SMC, which provides advice to NHS Scotland on new medicines, are part of NHS QIS, one of several special NHS boards in Scotland that provide a national service (http://www.nhshealthquality.org/nhsqis/37.140.141.html). NHS QIS promotes patient safety and clinical governance within NHS Scotland by developing clinical standards, assessing the performance of the NHS against these standards, and driving and supporting implementation and improvements in quality.

Some components of SAPG's work, particularly in relation to surgical prophylaxis, are aligned and embedded with the Scottish Patient Safety Programme (SPSP), another national programme hosted by NHS QIS (http://www.patientsafetyalliance.scot.nhs.uk/programme).

SAPG also has close links with another part of NHS QIS, the Healthcare Environment Inspectorate (HEI) (http://www.nhshealthquality.org/nhsqis/6710.140.1366.html) process. This independent and external inspectorate was established in April 2009 by the Scottish Government to give NHS

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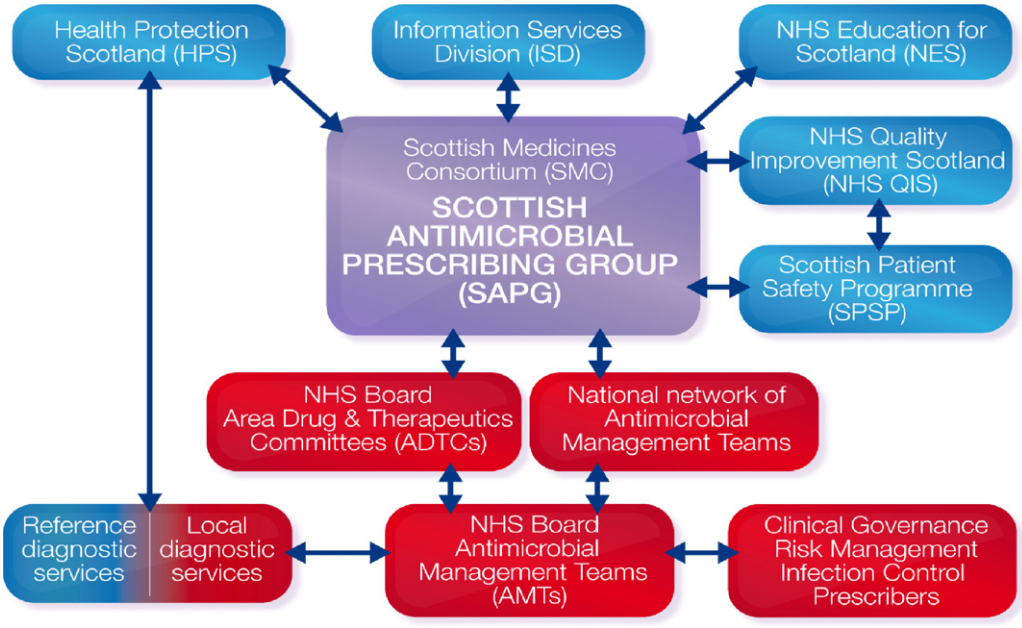

Fig. 1. Key national and local stakeholders.

boards a proactive, assertive way to self-assess and report evidence, create a methodology for analysing NHS board evidence, risk assess and identify targets for inspection, carry out and report on hospital inspection findings in the public domain, continuously monitor NHS board improvement plans, and make recommendations to Scottish ministers. SAPG influenced the design and content of the stewardship component of the Inspectorate's online self-assessment, which was based on the Infection Control Standards.

SAPG membership consists of key disciplines, including antimicrobial pharmacists, microbiologists, information and antimicrobial surveillance scientists, infectious diseases specialists, hospital medical and non-medical leadership, infection prevention specialists, a public partner representative, dentistry, veterinary medicine, quality improvement, primary care clinicians and the pharmaceutical industry. Other expert advisers are invited to contribute to specific projects on an ad hoc basis. SAPG meets every 2 months and a Project Board has been set up to provide clinical and financial governance. During its first 3-year work plan, SAPG has developed five workstreams to take forward various aspects of ScotMARAP and each has a work plan with defined timescales. A website has been in place since 2008 (http://www.scottishmedicines.org.uk/SAPG/Scottish_Antimicrobial_Prescribing_Group__SAPG_; accessed 25 February 2011) and provides access to a range of material from membership and meeting minutes to updates of national policy and guidance, details of national events, reports on progress with the different workstreams described in this review, and links to other work on patient safety and HAI.

SAPG has also established a network of AMTs that meet three times a year to discuss current national and local issues and to share good practice in antimicrobial stewardship. The agenda and direction of the network events is owned by AMTs with administrative support from SAPG. The impact of this network is powerful in terms of developing local leadership, ownership of the projects, cohesion, learning and supporting implementation at a team and personal level. Evaluation of each of the events has been very good and provides not only areas for improvement but also ensures that the content of future network events addresses the needs of the AMTs.

2.2. Regional level

AMTs are subgroups of NHS board Area Drug and Therapeutics Committees (ADTCs) and they should report to the NHS board Executive Team via the Medical Director.

The minimum constituents of an AMT are a lead clinician, lead infection specialist and lead antimicrobial pharmacist plus additional members depending on local resources [7,8]. The evidence to support the effectiveness of a variety of stewardship tools has also been subjected to systematic review [7,9,10], the last two [9,10] of which are currently being updated. Some additional national non-recurring resource was made available by the Scottish Government Health Department to support the availability of antimicrobial pharmacists within each NHS board, recognising the pivotal role of the antimicrobial pharmacist within the AMT [11]. The remit of the AMT and antimicrobial pharmacist is to support stewardship in primary and secondary care.

AMTs work closely with local Infection Prevention and Control Teams (IPCTs), attending clinical teams and also local clinical governance and patient safety teams to ensure local delivery of antimicrobial stewardship and HAI prevention. To foster more efficient working across all teams, there is a clear move to improve the strategic and operational alignment of goals and responsibilities under the overarching umbrella of patient safety with delivery through the improvement framework.

3. SAPG workstreams

The work plan and fiscal requirements for SAPG were developed and articulated through a project initiation model with actions organised into five workstreams.

These workstreams were developed to reflect national and local unmet needs and priorities. The intention was that they would be dynamic and would change with the evolution of SAPG and priorities in HAI to meet new challenges. At the heart of this work was a strongly held philosophy that we must be able to measure the impact of our interventions and that this would be supported by a mechanism of sharing data in a timely and appropriate manner. The workstreams have vertical and horizontal integration to

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achieve the goals outlined previously and each is led by an expert in the specific area. Much of the work is ongoing, and following a recent strategic review of the 3-year work plan there will be a redesign of this structure as we embark on the next phase of our work plan in April 2011. This future work is described later.

Here we report the development of this work and some early outcomes.

3.1. Organisation and accountability

This work, led by the HAI team, NHS QIS, involves working with NHS boards to ensure that essential organisational and accountability infrastructures relevant to antimicrobial stewardship are in place. A self-assessment questionnaire was developed and completed by all NHS boards in December 2008 to establish a baseline position for antimicrobial stewardship within each NHS board. A similar tool developed in England has recently been published [12] that provides a web-based tool to assess longitudinal progress on stewardship in acute hospitals or potentially to act as a benchmark with similar organisations.

Our baseline survey showed that all NHS boards now have an established AMT (of varying composition and activity) and all have an antimicrobial pharmacist or specialist pharmacist input, all AMTs report to the NHS board Medical Director and the ADTC, but links vary with other key groups such as the IPCT and clinical governance and risk management.

SAPG has also been able to integrate antimicrobial stewardship into the wider HAI agenda at board level primarily via the HEI process described earlier. In relation to stewardship, the results of inspections in acute hospitals have been generally favourable, which has confirmed good progress with the implementation of key structures and leadership within organisations as well as a good level of implementation of SAPG guidance, policies and educational initiatives. The HEI noted that antimicrobial management has been raised as a high priority for NHS boards, and local AMTs have been established in all NHS boards to lead antimicrobial management programmes. Future alignment of all local HAI stakeholders around a unified patient safety and quality improvement agenda will be assessed through this and other routes.

3.2. Infection management

This work focuses on development of a national approach to antimicrobial prescribing policies, quality indicators for prescribing in all healthcare settings, and clinical audit of infection management. This workstream is supported by a variety of healthcare professionals from around Scotland, and several subgroups have been established to lead on topics including Primary Care, Surgical Prophylaxis, Care Homes, and Public Campaigns.

One of the immediate public health challenges for SAPG was the high incidence of CDI in Scottish hospitals and the emerging problem of community-onset CDI. The contribution of antibiotics, particularly certain classes (cephalosporins, co-amoxiclav, clindamycin and quinolones), which we have termed 'C. diffogenic' agents (CDAs), to the current epidemic of CDI has been recognised from a variety of studies [13–18]. This information and evidence linking the high-level impact of antibiotic restriction combined with strict infection control measures in controlling hospital CDI outbreaks [19–23] supported the development and implementation of national guidance on restriction of CDA antibiotics. Our first national guidance document was issued in July 2008 and this was followed up with '*Hospital antibiotic management: minimum requirements for antimicrobial prescribing policies*' in December 2008 and '*Antibiotic prophylaxis in surgery*' in July 2009 (http://www.scottishmedicines.org.uk/SAPG/Scottish_Antimicrobial_Prescribing_Group__SAPG_). These guidance documents recommended a variety of minimum good practice measures previously published [8] and encouraged the use of narrow-spectrum agents for the empirical management of infection and surgical prophylaxis [18], but were suitable for local adaptation where appropriate. One of the key new recommendations was around antibiotic use and risk of CDI. All NHS boards have now reviewed their hospital antibiotic policies to ensure that the use of CDAs is restricted both for treatment of infections and in surgical prophylaxis. Implementation of these antimicrobial stewardship measures has been staggered over a period of ca. 18 months, with some NHS boards acting as early adopters of our guidance, but there is now uniformity of approach across all the boards.

Furthermore, national consensus guidance was also developed and implemented to reduce variation around the use and monitoring of key antibiotics, vancomycin and gentamicin, because these agents featured significantly in the new hospital antibiotic policies for managing empirical sepsis and, in the case of gentamicin, surgical prophylaxis.

This guidance was developed in collaboration with local pharmacokinetics experts and taking into account local and national antibiotic susceptibility data for the relevant pathogens. Successful and widespread local adoption and implementation, albeit over different time frames, has been reported via our regular surveys to AMTs and confirmed via the HEI process.

Similarly guidance on the management of infections in primary care based on the Health Protection Agency template and recommending restriction of CDAs has been adopted within all NHS boards, with implementation supported by prescribing advisers and primary care pharmacists working closely with AMTs and general practitioners. A range of indicators have been developed to measure the impact of implementation of primary care guidance and these will be discussed in Section 3.4.

3.3. Community-acquired pneumonia (CAP)

CAP remains the third commonest medical indication for hospitalisation in Scotland. The Scottish National Audit Project–Community Acquired Pneumonia (SNAP-CAP), initiated by the Health Foundation Engaging with Quality programme, was taken over by SAPG in 2009 as an exemplary quality improvement model for infection management with a view to embedding this methodology within NHS boards. A care bundle comprising oxygen administration, severity assessment and prompt antibiotic treatment has been promoted as best practice in managing pneumonia in all NHS boards, focusing on Acute Medical Admissions Units. The data management system used for SNAP-CAP is the Extranet system provided by the Institute for Healthcare Improvement (IHI) (http://www.ihi.org/ihi/about), which provides a secure environment for data entry and viewing results. In addition, the Extranet is a single point for all project resources and an efficient method for communication between SAPG and the clinical teams and has also been developed and expanded to report national prescribing indicator data, which will be discussed later. The CAP project is beginning to show a good level of compliance with the care bundle and a consistent level of engagement in some areas of Scotland. Further data related to this project will be presented separately in the future.

3.4. Information

This work, led by NHS NSS, which comprises HPS and ISD, involves the development of systems for the collection, analysis and reporting of information relating to antimicrobial prescribing and resistance in all healthcare settings. A key objective is to align the surveillance of antimicrobial prescribing and resistance activity at local and national levels to support AMTs

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and frontline staff by allowing local access to standardised information that is relevant to their own practice, ward or clinical area across NHS boards in Scotland. The aim is to support NHS boards, AMTs and IPCTs in their strategic planning and in implementation and evaluation of antimicrobial stewardship and infection control measures aimed at minimising the evolution and spread of resistant pathogens, which will limit the harmful effect of these on the public. In addition, two national reports presenting combined antimicrobial use and antimicrobial resistance data for 2008 and 2009 have been produced (http://www.documents.hps.scot.nhs.uk/hai/amr/annual-report/2009-sapg-amr-report.pdf).

3.4.1. Antimicrobial use

In Scotland, all antimicrobials for systemic use are classed as prescription-only medicines, which means that they can only be supplied in accordance with a prescription written by a doctor, dentist or other authorised prescriber. Information on the use of antibacterials in primary care is available within a database maintained by ISD and uses data from the Practitioner Services Division of NSS, which is responsible for the processing and pricing of all prescriptions dispensed in Scotland. The normal convention is to present information on the use of antibacterials expressed as number of items per 1000 population in Scotland per day (items/1000/day) and as total defined daily doses (DDD) per 1000 population per day (DDD/1000/day). This allows comparison of usage over time as well as international comparison of the use of antibacterials presented using DDD.

The DDD is the internationally recognised technical unit of measurement of medicine consumption recommended by the World Health Organization (WHO) as the standard to allow comparative use of medicines over time and between different locations. The DDD is the assumed average maintenance dose per day for a medicine used in its main indication in adults. In general, the DDDs for antibacterials are based on their use in moderately severe infections, but for antibacterials only used in severe infections their DDDs are assigned accordingly. For further details on DDD methodology please see the WHO Collaborating Centre for Drug Statistics Methodology website (http://www.whocc.no/atcddd/).

A major achievement in 2008–2009 was the development of a set of 41 nationally agreed prescribing indicators on primary care use of antibacterials as standard reports within the web-based Prescribing Information System for Scotland (PRISMS). Prescribing indicators are objective measurements that are used to monitor use of antibacterials over time, between geographical areas and against national averages. These indicators are intended to support AMTs and primary care teams by providing a complete picture of the use of antibacterials and to identify areas for improvement in prescribing practice. A report showing the key indicators focusing on the initial SAPG priority areas is available at http://www.isdscotland.org/isd/6125.html (accessed 20 January 2011). One such indicator is the overall number of antibacterial prescriptions. In 2009 the overall use of systemic antibacterials, expressed as number of items per 1000 population per day (items/1000/day), was 1.6% lower than in 2008 and is equivalent to 44 500 fewer prescriptions in 2009 than in 2008. This is the first annual reduction since 2004 but it remains to be seen whether this small reduction is the start of a trend. In 2009 our data also show that progress has been made towards restricting use of CDAs; specifically, the use of penicillin combinations (co-amoxiclav) in 2009 was 14.7% lower than in 2008 (expressed as items/1000/day), which is the largest annual reduction since 1999. Use of fluoroquinolones in 2009 was 7.1% lower than in 2008, the first annual reduction since 2002 and there was also a 21.2% reduction in the use of cephalosporins in 2009 compared with 2008. The use of first-line antibacterials promoted in SAPG's *Management of Infection Guidance for Primary Care* increased by 4.9% in 2009 compared with 2008. This is presented in Table 1.

Table 1
National Health Service (NHS) Scotland percent change in key primary care prescribing indicators, 2008 and 2009.

Prescribing indicator	% change between 2008 and 2009	
	Items/1000/day[a]	DDDs/1000/day[a]
Antibacterials associated with a higher risk of CDI (co-amoxiclav, fluoroquinolones, cephalosporins and clindamycin)	−19.5	−14.7
SAPG-recommended antibacterials (amoxicillin, doxycycline, clarithromycin, erythromycin, flucloxacillin, phenoxymethylpenicillin, nitrofurantoin and trimethoprim)	4.9	2.8

CDI, *Clostridium difficile* infection; SAPG, Scottish Antimicrobial Prescribing Group; DDD, defined daily doses.
[a] Number of items or DDD per 1000 population per day.

One particular indicator, seasonal variation in quinolones use, has been adopted as a national prescribing target for quality of prescribing and will be discussed later.

Empirical prescribing of antibiotics for acutely unwell hospitalised patients and surgical prophylaxis were identified as likely key areas of variation and poor practice. This was based on a small previous Scottish study [6] and data from participating Scottish hospitals in previous European Surveillance of Antimicrobial Consumption (ESAC) surveys [24]. Data on Scottish national standardised quantitative and qualitative information on antibacterial use in hospitals were not available, so to establish a national baseline of the prescribing landscape in hospitals SAPG co-ordinated national participation in the 2009 ESAC point-prevalence survey (PPS). ESAC PPS generally has participation from one or two hospitals from each country but, through promotion to AMTs and securing the support of senior NHS managers and clinicians, 31 Scottish hospitals participated and reviewed 8732 patients during May and June 2009. SAPG also provided support for data entry where this was not possible by AMTs. A comprehensive national report comparing the results in Scotland with European data was produced and was disseminated to all NHS boards to enable participating hospitals to benchmark local results against the national findings. The report is available at http://www.scottishmedicines.org.uk/files/ESAC_report_final_060510.pdf.

This report confirmed areas of poor practice. Less than 60% of prescribers complied with local policy, in nearly one-quarter of medical records no indication was written in the notes, and nearly one-third of patients were given surgical prophylaxis for >24 h (see Table 2). Furthermore, the results of the PPS showed that almost 40% of antimicrobials used for surgical prophylaxis in Scotland were cephalosporins and, whilst use of antibiotics associated with a higher risk of CDI for treatment of infections was lower in Scotland compared with Europe, they still represented a significant burden of overall antibiotic consumption. These results provided SAPG and

Table 2
Scotland and Europe comparison of key measures of prescribing, European Surveillance of Antimicrobial Consumption (ESAC) point-prevalence survey, 2009.

Measure	Scotland (%)	Europe (%)
Reason for use recorded in notes	76.1	71.5
Compliance with local guidelines	57.9	54.5
Use for surgical prophylaxis >1 day	30.3	65.0

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AMTs with useful information on the quality of prescribing within participating hospitals in Scotland and informed the priorities for quality improvement.

In 2011, the national database of use of medicines in hospital will become available for the first time in Scotland. The Hospital Medicines Utilisation Database (HMUD) maintained by ISD will collect information from individual hospital pharmacy systems and will present standardised information on the use of medicines at NHS board and national levels via a web-based system. The first main clinical area to benefit from this new national information will be surveillance of the use of antimicrobials in the hospital setting. SAPG have developed a series of standard reports on hospital use of antimicrobials that are accessible within HMUD. This information will complement the information on primary care use of antimicrobials available in PRISMS.

3.4.2. Antibiotic resistance

In 2009, a national surveillance programme for monitoring antimicrobial resistance in clinically important pathogens was developed.

The Scottish surveillance programme is modelled on the European Antimicrobial Resistance Surveillance System (EARSS) and is initially focusing on monitoring antimicrobial resistance in invasive isolates from hospital patients with bloodstream infections (caused by *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Streptococcus pneumoniae*, *Enterococcus faecium* and *Enterococcus faecalis*).

A major achievement in 2009 was the standardisation of antimicrobial susceptibility testing of blood cultures. This was achieved, in collaboration with diagnostic microbiology laboratories in Scotland, by the implementation of VITEK 2 systems (an automated identification and antimicrobial susceptibility testing system) in laboratories across Scotland. The VITEK 2 system provides high-quality and comprehensive comparable antimicrobial resistance information for all NHS boards in Scotland that will allow detailed analysis of resistance trends and emerging new resistances at national level. A key priority for 2011 is to develop further and to consolidate the standardisation of susceptibility testing in all NHS boards through testing and reporting via the VITEK 2 system. At the time of writing this report, ten Scottish diagnostic laboratories transfer VITEK 2 data directly to ECOSS (Electronic Communication of Surveillance in Scotland), which gives HPS access to the full data sets including phenotypic data on antimicrobial–pathogen combinations without omitting the suppressed susceptibility data (that normally are withheld for clinical reasons).

Overall there has been a large increase in reporting of Gram-negative bacteraemias from 2008 to 2009 as electronic reporting from diagnostic laboratories to HPS was fully implemented during this period. Given that reporting of bacteraemias to HPS was incomplete prior to 2009, we are not able to comment on whether there has been a true increase in the number of Gram-negative cases in this period. Resistance to nearly all clinically important classes of antibiotics, including aminopenicillins, second- and third-generation cephalosporins, fluoroquinolones and aminoglycosides, was observed amongst the Gram-negative bacteraemia isolates. No major increases in resistance (to the antibiotics tested) were observed amongst the key Gram-negative organisms (*E. coli*, *K. pneumoniae* and *P. aeruginosa*) when comparing 2009 with 2008. In contrast, resistance to third-generation cephalosporins in *E. coli* decreased significantly in this period. Stabilisation of resistance development seen in Scotland in 2009 is unusual. In the 10-year period in which resistance in Gram-negatives has been monitored throughout hospitals in Europe, resistance trends have mostly been going up. It is interesting to speculate whether the effective restriction of cephalosporins in Scotland could be associated with the containment/decrease in resistance. One exception to the general downward/stable trend was a minor increase in resistance to aminoglycosides in *E. coli*, which rose from 7.3% in 2008 to 8.2% in 2009 (a non-significant change, $P > 0.05$). Resistance to gentamicin is of particular concern and will be followed closely as this antibiotic is used increasingly in hospitals following the restriction in cephalosporin use. A further positive result was that combined resistance to third-generation cephalosporins and either fluoroquinolones or aminoglycosides decreased significantly in *E. coli* and *P. aeruginosa* ($P < 0.05$). Although resistance trends amongst the Gram-negatives are stable or decreasing for some antibiotics (and combinations of those), a different picture emerged when the data were analysed in line with the recent European expert guidance on standardisation of terminology of multidrug resistance [25]. In total, 16.6% of *E. coli* and 10.3% of *K. pneumoniae* isolates from 2009 could be categorised as multidrug-resistant (MDR), defined as resistant to at least three categories of antimicrobials with different mechanisms of actions. In a small number of isolates of *E. coli* and *K. pneumoniae* resistance was detected in up to eight antimicrobial categories. As not all isolates were tested against antibiotics of all categories, these figures could be underestimates of the true occurrence of multidrug resistance. These findings are worrying as a recent publication reported frequent identification of carbapenemase-producing Enterobacteriaceae (from the UK, India and Pakistan) that are extensively resistant to most available antibiotics [26]. The European Centre for Disease Prevention and Control (ECDC) has in 2010 recognised carbapenemase-producing Enterobacteriaceae as a significant risk for public health in Europe and worldwide as treatment options for these infections are very limited. Resistance amongst Gram-positive isolates remain less of a concern overall in Scotland and there were few changes in resistance proportions from 2008 to 2009. With the exception of meticillin-resistant *S. aureus* (MRSA), resistance remains low in the Gram-positives. One exception to this is the increase in resistance of *E. faecium* to vancomycin. Resistance has increased from 17% in 2008 to 28% in 2009. This surveillance programme is in its infancy and so it is difficult to be certain that this is a true increase. None the less, vancomycin resistance in this organism continues to be a concern due to the fact that the resistance mechanism can be transferred to other pathogens (including MRSA). Despite promising trends in some areas, antimicrobial resistance remains a serious cause for concern, and new mechanisms of resistance are being reported, particularly the emergence of carbapenemases.

3.5. Education

This work, led by NHS NES, involves scoping and development of training materials on antimicrobial stewardship both for undergraduate and postgraduate healthcare professionals. A range of online resources are available on the website http://www.nes.scot.nhs.uk/initiatives/healthcare-associated-infection/online-short-courses (accessed 7 December 2010).

A framework of learning outcomes for antimicrobial stewardship that aligns with '*The Scottish Doctor*' has been developed after broad consultation, and SAPG has recommended its adoption into the curricula of the five Scottish Medical Schools and we plan to assess progress with its implementation in 2011. The framework is also being evaluated by the two Schools of Pharmacy in Scotland to ensure that those learning outcomes applicable to pharmacists are covered by their undergraduate curricula.

The Doctors Online Training System (DOTS), a mandatory web-based education resource for all foundation training doctors in Scotland, has been revised to highlight current issues and the August 2009 cohort of doctors was the first to undertake the revised programme. Access to the DOTS programme has

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Table 3
National antimicrobial prescribing indicators introduced by the Scottish Government in 2009.

- *Hospital-based empirical prescribing*: antibiotic prescriptions are compliant with the local antimicrobial policy *and* the rationale for treatment is recorded in the clinical case note in ≥95% of sampled cases.
- *Surgical antibiotic prophylaxis*: duration of surgical antibiotic prophylaxis is <24 h *and* compliant with local antimicrobial prescribing policy in ≥95% of sampled cases.
- *Primary care empirical prescribing*: seasonal variation in quinolone use (winter months versus summer months) is ≤5%, calculated from PRISMS data held by NHS boards.

PRISMS, Prescribing Information System for Scotland.

recently been extended to allow other medical staff, pharmacists and non-medical prescribers to undertake the training, and a primary care module has also been added. An evaluation of DOTS carried out by NES in 2007 revealed a high level of participation and satisfaction amongst Scottish foundation doctors (http://www.nes.scot.nhs.uk/media/813342/nes%20fy%20antimicrobial%20training%202008.pdf; accessed 7 December 2010).

E-learning resources have also been produced on bacterial resistance and CDI to provide continuing professional development opportunities for healthcare staff, and NES are monitoring their uptake and feedback evaluation. A recent 2010 review (Helen Maitland, pers. comm.) advised that 1148 learners had completed the CDI tutorial and in one NHS board all consultants were mandated to complete this, with 94% of them considering the tutorial to be useful in terms of impacting on their clinical practice. In total, 322 learners have completed the more recently available bacterial resistance tutorial and 98% stated its relevance to their clinical practice.

Training for pharmacists on the pharmaceutical care of patients with infections has been developed and delivered throughout Scotland to over 900 community and hospital pharmacists.

To address variation between NHS boards in training provision on antimicrobial stewardship for junior doctors and other new clinical staff, an induction pack has been produced and made available for AMTs and other staff involved in training. This piece of work has been commended by the HEI (http://www.nes.scot.nhs.uk/initiatives/healthcare-associated-infection/training-resources/training-on-the-use-of-antimicrobials-in-clinical-practice; accessed 7 December 2010).

The availability and increasing uptake of these educational resources is encouraging and for senior clinical staff, with the support of the Scottish Royal Colleges Academies, we are planning a range of focused educational activities to support their learning needs.

4. Prescribing indicators to support reduction of *Clostridium difficile* infection

A priority area for the Scottish Government and SAPG is reducing CDI. A letter issued to NHS board chief executives [CEL 11 (2009) 9] in April 2009 announced a CDI HEAT (Health Efficiency and Access to Treatment) target defined as a reduction in the rate of CDI amongst people aged ≥65 years by at least 30% by 31 March 2011 (this was increased to 50% in May 2010) [27]. The Scottish Government and SAPG agreed three supporting antimicrobial prescribing indicators to underpin this HEAT target and these are summarised in Table 3.

The prescribing indicators were developed by SAPG following broad consultation with specialists throughout Scotland, with two aimed at evaluating the quality of hospital prescribing (empirical treatment and surgical prophylaxis) and one aimed at primary care prescribing. The evidence to support these indicators, in the context described, has been recently reviewed [28]. The indicators are either measurable from routinely available data or can be measured in a sustained way by clinical teams.

4.1. Hospital indicators

The two hospital prescribing target indicators for empirical prescribing and surgical prophylaxis were chosen to measure compliance with local antimicrobial policies. SAPG had previously recommended review of all hospital antimicrobials to restrict CDAs. Compliance with policy would therefore give assurance that restrictive policies had been effectively implemented. The antibiotic stewardship aim of ensuring effective treatment for patients with bacterial infection was achieved by aligning the hospital empirical prescribing indicator with measures for improving the quality of care for patients with pneumonia in Acute Medical Admissions Units [29] and by aligning the surgical prophylaxis indicator with measures for ensuring effective antibiotic prophylaxis in the SPSP [30].

We used the IHI Extranet, which has been developed to support international quality improvement projects over more than 10 years [31] and was already being used by all NHS boards for both the SPSP [30] and the SAPG pneumonia work.

Table 3 identifies the measures used to assess compliance with the hospital-based empirical prescribing. Data are collected in Acute Admission Units (medical and surgical) by sampling a recommended 20 patients per month per ward. Whilst the data collected are not formally quality assured in line with current practice within the SPSP and other IHI quality improvement initiatives, local AMTs are working with clinical staff to ensure the validity of the data. Compliance with the empirical prescribing policy is measured against the first antibiotic prescribed for a condition listed in the policy. The data for 2010 in Fig. 2 show a general improvement in compliance and recording in the notes compared with 2008 and 2009. These data cover the period September 2009 to September 2010. Approximately 7500 patients had been audited during this time and the overall compliance rate was 76%. However, the improvement is not consistent and reliable across all areas. To achieve a higher level of compliance, SAPG will support organisational and systems change through the existing quality improvement structures within boards.

These national results are reported every 3 months to the Scottish Government and a copy of the national report is sent to AMTs and NHS board Medical Directors along with their own board-level data for comparison. An example of this information is available in Table 4.

Boards can agree to share data with each other and are also encouraged to share these data with clinical teams to drive quality improvement. The mechanisms for sharing these data and the degree of sharing are variable amongst boards. Ideally, all data in relation to HAIs should be owned, collected and shared by the clinical teams supported by infection prevention, AMTs and patient safety teams. Frequently, these data are combined with infection prevention data and communicated jointly at educational and audit events for clinical teams. This cohesive working between teams with shared goals is the proposed steer for national collaboration and integration of quality improvement programmes.

A similar approach has been undertaken to collect data for surgical prophylaxis. Two components of the prophylaxis prescription, compliance with local policy and restricting duration to <24 h, are collected. It was suggested that this could be done initially for two common surgical procedures such as orthopaedics, vascular surgery or colorectal surgery. Local data from a variety of hospitals, collecting different procedures, show a variable level of compli-

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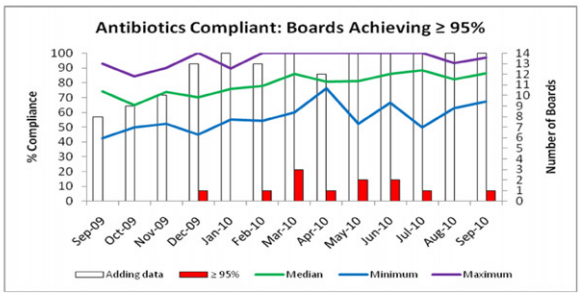
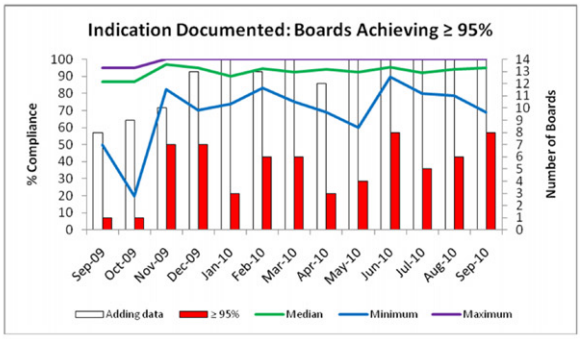
Antibiotics compliant with empirical prescribing policy



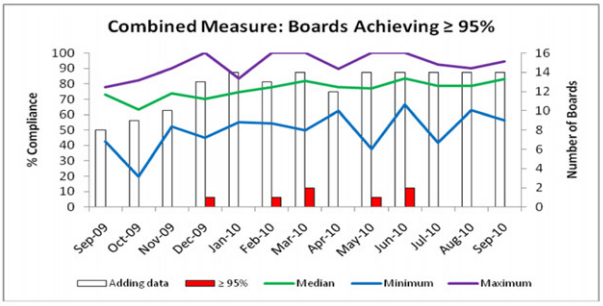
By September 2010, one NHS board achieved the target of ≥95% compliance with the measure *antibiotics compliant with empirical prescribing policy*. Median compliance ranges from 65% to 89%.

Indication for antibiotic treatment recorded in notes



By September 2010, eight NHS boards were achieving the target of ≥95% compliance with the measure *indication for antibiotic treatment documented in the notes*. Median compliance ranges from 87% to 97%.

Combined measure: policy compliant and indication documented



By September 2010, no NHS board achieved the target of ≥95% compliance with the combined measure *antibiotics compliant with policy and indication documented*. Median compliance ranges from 63% to 84%.

Fig. 2. Empirical prescribing indicators, national data.

ance with local policy. We also are aware that some hospitals have not fully implemented the new restricted policy and are still using cephalosporin-based regimens in some specialties. Both measures (compliance and duration) are now being incorporated into the SPSP surgical checklist PAUSE [30] and a robust mechanism of collecting and reporting these data is presently being developed. These data will be used to support improvement in this area. Therefore, we presently do not have standardised reliable data on compliance with this target. Boards and SAPG presently rely on local AMT intelligence, through audit, to evaluate clinical practice. Further, streamlining of the key recommended procedures where collection of these data is mandatory will further facilitate engagement with collection of these data.

Table 4
Example of 3-monthly reporting of national and local data.

National data
Compliance with empirical prescribing policy: national compliance is 78%.
National results show a 1% increase in median from August 2010 report, 9/14 boards had an increase in median compliance since August 2010 report.
Indication documented in notes: national compliance is 91%.
National results show a 1% increase in median compliance since August 2010 report, 8/14 boards had an increase in median compliance since August 2010 report.
Combined measure: national compliance is 76%.
National results show a 1% increase in median compliance since August 2010 report, 11/14 boards had an increase in median compliance since August 2010 report.
Local data for NHS Tayside (as an example board)
This includes data from September 2009 to September 2010. The median compliance for NHS Tayside for each of the three measures is:
- antibiotics compliant with empiric policy: 83%
- indication documented in patient's notes: 86%
- combined measure, antibiotics compliant and indication documented: 82%.

Action: To facilitate improvement, areas of non-compliance should be identified and discussed with front-line staff.

Note: By September 2010, one board achieved ≥95% compliance with the measure *antibiotics compliant with empirical prescribing policy*, eight boards achieved ≥95% compliance with the measure *indication for antibiotic treatment documented in notes*, and no board achieved ≥95% compliance with the combined measure.

4.2. Primary care indicators

The primary care target (seasonal variation in quinolone use) has been suggested as a quality indicator by ESAC [24,32] and data are available to show substantial variation between NHS boards. The range of variation for this indicator across NHS boards in Scotland was greater than the range observed across European countries in ESAC primary care studies [32].

Seasonal variation is defined as the increase in use of antibacterials during the two winter quarters (October–March) relative to use in the preceding two summer quarters (April–September). Fluoroquinolones are antibiotics that are not recommended for use within primary care, except for a few specific infections, and their inappropriate use has been associated with an increased risk of CDI, particularly the 027 and 106 strains, both of which are prevalent in Scotland [13,15,33]. Excess usage of fluoroquinolones during the winter months suggests inappropriate use for respiratory infections.

The suggested indicator and target are that seasonal variation in the use of fluoroquinolones should be no more than 5% greater in the winter months compared with the preceding summer months. In Scotland this indicator has been made accessible as a standard report within PRISMS. Fig. 3 shows annual seasonal variation in the use of fluoroquinolones expressed as DDD/1000/day. This suggests that at a national level good progress has been made towards the

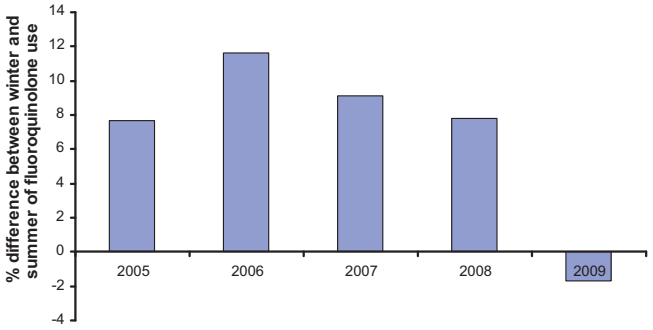


Fig. 3. National Health Service (NHS) Scotland percent seasonal variation in fluoroquinolone use, 2005–2009.

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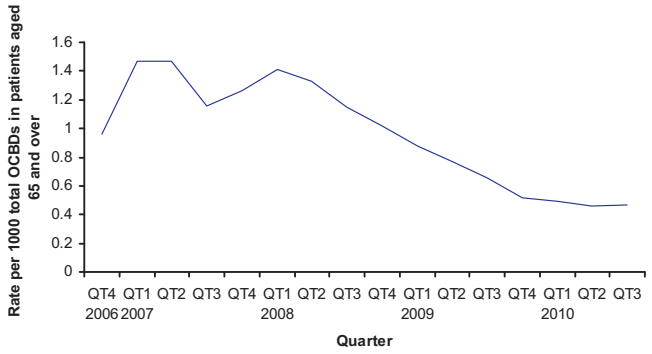

Fig. 4. Overall quarterly *Clostridium difficile* infection rates for Scotland [per 1000 total occupied bed days (OCBDs)] in patients aged ≥65 years.

Scottish Government's target of ≤5% seasonal variation in fluoroquinolone use and that for the first time in 2009 the target has been met at a national level. This may reflect the impact of initiatives led by AMTs and primary care teams to reduce inappropriate use of fluoroquinolones since the introduction of this target. The negative seasonal variation seen in some boards means there was a lower use of fluoroquinolones in the winter of 2009 than in the previous summer, but this effect is expected to disappear in subsequent years as overall fluoroquinolone use reduces.

4.3. Impact on Clostridium difficile infection

Mandatory surveillance of CDI in patients aged ≥65 years showed a continuing decline in rates (per 1000 occupied bed-days) during 2009. Over the four quarters of 2009, the overall CDI rate dropped consecutively from 0.88 in Q1 to 0.77 in Q2, 0.66 in Q3 and 0.52 in Q4, for an overall decrease of 41% during 2009. This trend has continued into 2010 although the rate of decline appears to be slowing (see Fig. 4). Compared with 2008, the number of cases dropped 43% (6322 to 3625) and the overall rate for Scotland decreased by 42% (1.23 to 0.71). There is a temporal association between the introduction of restrictive antimicrobial policies in line with SAPG guidance and the declining rates of CDI in Scotland. However, it is difficult to quantify the true impact of this type of intervention separately from others that have been implemented concurrently to control and prevent CDI.

With the use of time series analysis [22,23] we plan to quantify the true impact of these national interventions separately from other infection control measures. Local data from one region (NHS Tayside) suggest a strong link between the implementation of restrictive measures and local reduction in CDI (N. Vernaz et al., pers. comm.).

5. Unintended consequences

The changes in antimicrobial prescribing patterns caused by the introduction of the national antimicrobial stewardship programme are creating new selective pressures on the microbial flora found in humans and the environment both of hospitals and the community, and potentially cause new clinical problems, referred to as 'unintended consequences'. These include the emergence of new MDR strains, adverse effects of the 'newly' recommended antibiotics, and re-emergence of infections that previously were uncommon. Whilst many of these consequences such as resistance will take years to manifest, other potentially harmful effects may be more overt over a shorter term. These include antibiotic-related toxicity, such as aminoglycoside-induced nephrotoxicity or ototoxicity, or the concern that 'older' narrower-spectrum agents used in combination may be less clinically effective leading to increased mortality, greater re-admission or higher rate of complications. There is evidence of increasing use of agents such as co-trimoxazole, tetracyclines, fosfomycin and temocillin, amongst others, as part of treatment regimens to replace the broader-spectrum CDAs.

Therefore, for any range of improvement measures we need to collect data on these balancing measures. Systems are presently being developed nationally and locally in collaboration with all NHS boards and professional communities [e.g. ear, nose and throat (ENT) and renal specialty groups] and will become an integrated part of the national surveillance programme. Reassuringly, early data from one Scottish board suggest that following introduction of a restricted empirical policy for managing sepsis there was no related increase in mortality in an Acute Medical Admissions Unit (B. White et al., NHS Lanarkshire, pers. comm.). Similar data are being collected and analysed from other hospitals throughout Scotland.

6. Discussion

The SAPG work plan has not been designed to reflect a robust scientific evaluation of the impact of a national antimicrobial stewardship programme. We have adopted a pragmatic 'real-world' approach to antimicrobial stewardship that has combined components of project management, quality improvement, information management and performance assessment through accountability or judgement measures. These are co-ordinated nationally but implemented locally by AMTs that work closely with IPCTs and others, all of which are embedded within the patient safety collaboration. The teams are supported by a powerful clinical network and are underpinned by a robust educational support that is dynamic to meet the needs of local healthcare professionals. Research opportunities have been limited and have focused around using rigorous scientific methodology, for example time series analysis with transfer function modelling [22,23], to evaluate the local and national benefit and any adverse impact of our interventions.

SAPG at its inception had a range of objectives, but the initial focus was to support infection control measures to achieve the Scottish Government's CDI HEAT target for 30% reduction of CDI by March 2011. The use of prescribing indicators as national targets to support this overarching goal appears to have been successful. However, there are clearly inherent difficulties where measures for accountability or judgement are used to promote quality improvement. For example, Chassin et al. [34] argue that recent accountability measures in US hospitals promote quality improvement. However, measurement for the purpose of accountability or judgement and measurement for the purpose of improvement of healthcare processes are two very different things [35]. The two approaches can play complementary roles in advancing organisational goals if properly understood, but confusing measurement for accountability with measurement for improvement can give rise to organisational confusion [36]. The reasons for this are two-fold: (i) measurement does not equate with improvement, which requires making changes to healthcare processes and structures; and (ii) measurement for improvement is not focused on judging whether data meet a compliance threshold or target but rather is a means of determining whether the changes we make to improve are effective and to what degree. Furthermore, quality improvement incorporates sets of related measures (process, outcome and balancing) to help us understand the broader effect of the changes tested [37]. The most effective strategy to implement these interventions is a key to their success. Feedback reporting of data combined with an implementation strategy, which includes educational support, has proved to be most consistently effective [38]. We believe that SAPG, which has adopted such an approach, as well as our

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collaborative working with local AMTs has achieved a high degree of success at national and local levels. The HEAT target and associated prescribing indicators have clearly resulted in engagement from hospital leadership, clinicians have accepted their need, at least for the medium term, and have provided SAPG with a focus to measure its interventions. However, the development of the pneumonia care bundle measures and close collaboration with the SPSP in the area of surgical prophylaxis demonstrates SAPG's long-term desire to embrace the improvement approach to improving antibiotic use. National collaboration to develop and implement a national antibiotic change package that would encompass an antibiotic review bundle, for continuing care, is another example of our direction of travel.

From 2011 to 2014 SAPG plans to undertake the following actions, which are aligned with the HAI Taskforce Delivery Plan 2011–14 and will support NHS boards and frontline clinical staff to enhance the quality of antimicrobial prescribing to deliver safe, effective, patient-centred care. These include: (i) integration of core SAPG work with key local, national and international stakeholders working in HAI, and quality improvement both at strategic and operational levels; (ii) maintaining delivery of existing stewardship activities and evaluation of their impact at local and national levels; (iii) development of antimicrobial stewardship activities in primary care integrated with other national programmes; (iv) application of quality improvement methodology to clinical priority areas to optimise patient care in the management of infections; and (v) development and promotion of an evidence base for antimicrobial stewardship interventions and antimicrobial resistance.

Effective antimicrobial stewardship will significantly contribute to the HAI agenda and will preserve or increase the longevity of the effectiveness of antibiotics [39]. However, when considering future metrics and targets for HAI and antibiotic use, decision-makers must make a careful and balanced choice based on the available scientific evidence to support their use as well as local priorities. It is unlikely that even complete compliance with all the proposed measures will reduce the risk of HAI to zero [40] and this realism should be reflected in any future metrics or targets [41].

In conclusion, we hope that in the future we will not only be able to provide an update regarding our progress in achieving these goals but share our experience and learning with the stewardship community. We also hope that the publication of this report will not only fulfil one of our objectives of sharing our experiences and work with the international community but encourage collaborations by fostering links with other national programmes. Our journey has just begun, we are encouraged by our early efforts and success but we have much to do and learn from each other.

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