International Journal of Antimicrobial Agents 57 (2021) 106346

Contents lists available at ScienceDirect

International Journal of Antimicrobial Agents

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

Implementation of a novel antimicrobial stewardship strategy for rural facilities utilising telehealth

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ARTICLE INFO

Article history:
Received 14 December 2020
Accepted 10 April 2021

Editor: Stefania Stefani

Keywords:
Antimicrobial stewardship
Rural
Telehealth

ABSTRACT

A significant portion of healthcare takes place in small hospitals, and many are located in rural and regional areas. Facilities in these regions frequently do not have adequate resources to implement an onsite antimicrobial stewardship programme and there are limited data relating to their implementation and effectiveness. We present an innovative model of providing a specialist telehealth antimicrobial stewardship service utilising a centralised service (Queensland Statewide Antimicrobial Stewardship Program) to a rural Hospital and Health Service. Results of a 2-year post-implementation follow-up showed an improvement in adherence to guidelines [33.7% (95% CI 27.0–40.4%) vs. 54.1% (95% CI 48.7–59.5%)] and appropriateness of antimicrobial prescribing [49.0% (95% CI 42.2–55.9%) vs. 67.5% (95% CI 62.7–72.4%) ($P < 0.001$). This finding was sustained after adjustment for hospitals, with improvement occurring sequentially across the years for adherence to guidelines [adjusted odds ratio (aOR) = 2.44, 95% CI 1.70–3.51] and appropriateness of prescribing (aOR = 2.48, 95% CI 1.70–3.61). There was a decrease in mean total antibiotic use (DDDs/1000 patient-days) between the years 2016 (52.82, 95% CI 44.09–61.54) and 2018 (39.74, 95% CI 32.76–46.73), however this did not reach statistical significance. Additionally, there was a decrease in mean hospital length of stay (days) from 2016 (3.74, 95% CI 3.08–4.41) to 2018 (2.55, 95% CI 1.98–3.12), although this was not statistically significant. New telehealth-based models of antimicrobial stewardship can be effective in improving prescribing in rural areas. Programmes similar to ours should be considered for rural facilities.

1. Introduction

A significant portion of health care and antimicrobial use takes place in small, often rural and regional, hospitals [1,2]. In Australia, inappropriate prescribing of antimicrobials is higher in rural and regional areas than in major city hospitals, particularly for high-risk infections, namely Gram-positive bacteraemia with sepsis (13% vs. 7%; $P = 0.004$), empirical therapy for sepsis (26% vs. 12%; $P < 0.001$) and endocarditis (8% vs. 3%; $P = 0.02$) [3]. It has been shown that inappropriate use of antimicrobials contributes to the development of antibiotic-resistant pathogens and that patients with antibiotic-resistant infections have an increased mortality compared with patients infected with non-resistant organisms [4].

Rural and regional facilities often have limited resources and/or skill set to implement onsite antimicrobial stewardship programmes (ASPs) [5]. There are additional structural problems such as persistent staff shortages (with high reported rates of locum medical and nursing staff), insufficient training and education, geographical isolation and competing priorities to antimicrobial stewardship [6–10]. These factors all contribute to inappropriate prescribing of antibiotics, resulting in escalation of prescribers' fears

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https://doi.org/10.1016/j.ijantimicag.2021.106346

of clinical failure in the management of infections, therefore promoting overprescribing of antimicrobials [10].

Given the ongoing burden of inappropriate prescribing and barriers to programme delivery as well as sustainability, novel antimicrobial stewardship strategies are required for rural areas. One such strategy is utilising remote specialist services to deliver multimodal programmes, utilising telehealth platforms as an aid to optimise antibiotic use. Telehealth has been shown to increase clinicians' access to specialty care providers as well as integrating patient care with provider education [11,12].

In a rural Hospital and Health Service (HHS), we developed, in consultation with local stakeholders, an ASP model utilising telehealth to assess the effectiveness and sustainability of the programme.

2. Methods

2.1. Research design

We conducted a retrospective cohort study with two phases (baseline and intervention) as defined by the RECORD guidelines [13]. The baseline phase was from January 2016 to December 2016 and the intervention phase was from January 2017 to December 2018 (Supplementary Fig. S1).

2.2. Setting

The study was performed in a rural HHS that spans a region of 396 650 km^2, comprising 21% of Queensland [14]. According to the Australian Statistical Geography Standard Remoteness Area (ASGS-RA) classifications, all four participating hospitals are situated in very remote classifications (RA5) [15]. The hospital sizes range from 8 to 23 licensed inpatient beds. Based on Australian Institute of Health and Welfare (AIHW) peer group classification, one hospital is classified under 'Public acute group C hospitals', while the other three are under 'Public acute group D hospitals' [2].

2.3. Antimicrobial stewardship programme (ASP)

The intervention phase consisted of developing a tailored ASP for a rural HHS with no onsite infectious diseases (ID) physicians or clinical microbiologists or antimicrobial stewardship pharmacists. The programme was designed in 2016 and implemented in January 2017 by a centralised service, namely the Queensland Statewide Antimicrobial Stewardship Program, as part of a collaborative decision-making process with local antimicrobial stewardship champions from the HHS. The centralised service was staffed by ID physicians, antimicrobial stewardship pharmacists, a clinical nurse consultant and a program co-ordinator. The local antimicrobial stewardship champions supported programme implementation and health service governance oversight, whilst the centralised service was responsible for strategic programme design, audit and feedback, clinical service provision, onsite visits and focused education.

The ASP was delivered in a staged approach and began with onsite visits by the centralised service with a focus on clinical engagement with local clinicians prior to the intervention phase. Programme implementation consisted of a telephone hotline staffed by an ID consultant and an antimicrobial stewardship pharmacist from the centralised service during working hours from Monday to Friday to answer clinical questions as well as to obtain approval for the tailored antibiotic restrictions (intravenous antibiotic/s as well as oral ciprofloxacin and clindamycin that were expected to continue for longer than 3 days). The consultation at day three was viewed as an appropriate time point in that most initial laboratory results would have been completed and also that the consult service was not available on the weekends. Antimicrobial stewardship weekly ward rounds utilising telehealth were conducted by the centralised service and clinicians from the local hospitals. In addition, education of staff (prescribers and allied healthcare professionals) regarding appropriate use of antibiotics was provided on a monthly basis utilising telehealth.

2.4. Outcome measures

Baseline and post-implementation data on overall hospital-based appropriateness and quantity of antimicrobial prescribing were compared utilising data from an adapted Hospital National Antimicrobial Prescribing Survey (H-NAPS) model and pharmacy dispensing software, respectively. The adapted H-NAPS was a model aimed at assessing the appropriateness of empirical antimicrobials, intravenous-to-oral switch, and duration of antimicrobial prescribing for the most common infective principal diagnoses for small Australian hospitals, namely respiratory infections [community-acquired pneumonia (CAP) and infective exacerbation of chronic obstructive pulmonary disease (COPD)], skin and soft-tissue infections (SSTIs), urinary tract infections (UTIs), intra-abdominal infections and sepsis. Each patient's prescription was assessed at three time points through the patient's therapeutic course, defined as: 'empirical' (assessed at 08:00h on day two); 'review of treatment' (assessed at 08:00h on day four); and 'duration' (assessed at 08:00h on the final day of therapy or on discharge script duration) [16]. The auditors determined the appropriateness of each antimicrobial prescription for each time point. An inappropriate antimicrobial prescription was characterised by lack of concordance with national or local prescribing guidelines (including antimicrobial choice, dose, route and duration of therapy) or where the auditor deemed that the prescription is not a reasonable alternative to those listed within the guidelines (based on additional documented clinical factors and the likely causative or cultured pathogens). An antimicrobial prescription may also be classified as inappropriate if an antimicrobial is not indicated, the patient has an allergy to the antimicrobial chosen or there is a serious drug interaction present [17]. Antimicrobial quantitative usage included all inpatient hospital use in defined daily doses (DDD) per 1000 occupied bed-days according to the definitions from the National Antimicrobial Utilisation Surveillance Program (NAUSP) [18].

2.5. Statistical analysis

Overall adherence and appropriateness of antimicrobial prescribing for the baseline and intervention phases were calculated for each facility and were combined for the HHS. Total antimicrobial use and appropriateness were summarised using the mean and 95% confidence interval (CI). We evaluated the change in total antibiotic use between the baseline for the six most commonly prescribed antibiotic classes compared with the intervention phase. Appropriateness of prescribing utilising a modified H-NAPS was assessed for each prescription at each of the time points between 2016 and 2018. We used univariate and multivariable logistic regression models to evaluate the effect of the year on antibiotic prescriptions for adherence to guidelines and appropriateness of prescribing and the results were presented as the odds ratio and 95% CI. In multivariable logistic models, we also adjusted for the four participating hospitals. Hospital length of stay was calculated using the mean and 95% CI for each calendar year from January 2016 to December 2018 for the following conditions: respiratory infections (CAP and infective exacerbation of COPD); SSTIs; and UTIs.

Table 1
Antibiotic usage for the most commonly prescribed classes, stratified by calendar year

Subclass	DDDs/1000 patient-days [mean (95% CI)] 2016	2017	2018
Dicloxacillin/flucloxacillin	105.52 (60.19–150.75)	125.76 (70.40–181.11)	118.43 (60.33–176.53)
CefalexinCefalotinCefazolin	76.43 (52.70–100.17)	45.91 (30.30–61.52)	37.85 (25.16–50.53)
AmoxicillinAmpicillin	102.55 (49.36–155.75)	101.89 (71.29–132.49)	117.28 (83.99–150.56)
CeftriaxoneCefotaximeCeftazidime	25.26 (12.41–38.12)	20.05 (10.51–29.60)	22.70 (10.66–34.74)
Amoxicillin and enzyme inhibitor	311.12 (182.59–439.66)	282.71 (214.24–351.17)	213.96 (151.98–275.94)
Ciprofloxacin	26.58 (10.93–42.24)	14.76 (4.66–24.86)	15.72 (4.98–26.47)

DDD, defined daily doses; CI, confidence interval.

Table 2
Adherence to guidelines and appropriateness of antimicrobial prescriptions by calendar year

Year	*n* (%) [95% CI] Adherence to guidelines	Appropriateness of prescribing
2016	65 (33.7) [27.0–40.4]	100 (49.0) [42.2–55.9]
2017	145 (46.5) [40.9–52.0]	224 (62.9) [57.9–67.9]
2018	177 (54.1) [48.7–59.5]	241 (67.5) [62.7–72.4]

CI, confidence interval.

Table 3
Hospital length of stay (LOS) for the five most common infectious conditions by calendar year

Year	Mean LOS (days) (95% CI)
2016	3.74 (3.08–4.41)
2017	3.42 (2.91–3.92)
2018	2.55 (1.98–3.12)

CI, confidence interval.

3. Results

3.1. Comparison of antibiotic usage

We found no significant difference in the mean total antibiotic use (DDD/1000 patient-days) between the time period of 2016 (52.82, 95% CI 44.09–61.54) and 2018 (39.74, 95% CI 32.76–46.73) (Supplementary Table S1). In addition, there was no significant difference in the means between the baseline phase and the intervention phase for the most commonly prescribed antibiotic classes; however, there was a decreasing trend for all classes, except for amoxicillin/ampicillin and dicloxacillin/flucloxacillin that increased (Table 1).

3.2. Adherence and appropriateness of antimicrobial prescriptions

The most common indications that were assessed for adherence and appropriateness of antimicrobial prescriptions were respiratory infections (49%) and SSTIs (31%).

Adherence and appropriateness of antimicrobial prescribing improved from baseline to the intervention phase ($P < 0.001$) (Table 2). This finding was sustained after adjustment for hospitals, with improvement occurring sequentially across the years for adherence to guidelines [adjusted odds ratio (aOR) = 2.44, 95% CI 1.70–3.51] and appropriateness of prescribing (aOR = 2.48, 95% CI 1.70–3.61) compared with 2016 (Supplementary Table S2). However, there was variability in adherence to guidelines (Supplementary Fig. S2) as well as appropriateness of prescribing (Supplementary Fig. S3) across facilities.

3.3. Clinical outcomes

We observed no significant difference in the mean hospital length of stay between the baseline and intervention phases for the most common infection conditions, as indicated by their overlapping CIs (Table 3). There was, however, a downward trend of 32%.

4. Discussion

We were able to demonstrate the implementation of a successful and sustainable antimicrobial stewardship model in rural facilities. This multifaceted ASP, which was supported by a centralised antimicrobial stewardship service utilising telehealth, showed an improvement both in adherence to guidelines and appropriateness of antimicrobial prescribing ($P < 0.001$) over a 2-year period. We observed a decreasing trend for the most frequently prescribed antibiotics, except for except amoxicillin/ampicillin and dicloxacillin/flucloxacillin that increased. There was also a consistent decrease in hospital length of stay during our study period, although this decrease did not reach statistical significance.

Our study evaluated antibiotic usage, adherence to guidelines and appropriateness of antimicrobial prescribing. To date, studies that have evaluated the impact of antimicrobial stewardship in regional and rural facilities have focused on antibiotic usage [1,12,19]. A strength of utilising appropriateness of antimicrobial prescribing as a marker of judicious use, rather than usage data, is that it facilitates a more informed approach to tailoring antimicrobial stewardship strategies for a facility [3]. It also takes into consideration differences in the case mix of patients presenting to different hospitals, as the methodology uses the indication attributed by the treating clinician and therefore adjusts for conditions where different antibiotics are recommended [e.g. variation in methicillin-resistant *Staphylococcus aureus* (MRSA) epidemiology] [3].

Implementation of our ASP was endorsed by the local hospital executive who provided strong governance and accountability. In addition, champions were identified at each facility and the ASP utilised an established formalised network arrangement for provision of the service to facilities. These factors have been identified as being key strategies to promote the sustainability of ASPs in rural hospitals [20].

A number of studies have evaluated the use of telehealth service to support ASPs in rural facilities and have demonstrated that telehealth is a viable method to expand access to specialty care and to promote antimicrobial stewardship [1,9,11,12]. We utilised a telehealth model where clinicians in rural facilities with no onsite ID or antimicrobial stewardship expertise were supported by a centralised antimicrobial stewardship service that allows team members from rural facilities an opportunity to interact and address antimicrobial stewardship interventions at the point of care [11]. This real-time interaction offers several advantages, including a collaborative patient management plan as well as upskilling clinicians, over the more traditional tele-stewardship programmes in which specialists review antibiotic prescriptions and communicate recommendations via secure websites, messaging systems and/or the electronic medical record [21]. Our programme adopted a similar approach to that previously been described by Stenehjem et al.

where only the most intensive ASP strategy, utilising a combination of ID hotline plus an onsite pharmacist conducting prospective audit and feedback supported by a central ID support service, was associated with a significant reduction in total (11%) and broad-spectrum (24%) antibiotic use compared with baseline [1]. This highlights the importance of regular engagement by experts with the local staff. In addition, it also provides a better understanding of local context, which facilitates rapport and trust in the stewardship process amongst local clinicians [1].

Our study has several limitations. The antimicrobial stewardship interventions were rolled out over a period of time, which may have diluted the effect during the intervention phase (2017–2018). In addition, there were changes in staffing of healthcare workers both at the centralised and local facilities, which may have resulted in changes in antibiotic use and appropriateness of antibiotic prescribing. This may have contributed to the reduced ability to demonstrate the effect of the intervention, however it is reflective of real-world programme implementation. Despite this, we were able to demonstrate an improvement in appropriateness of antibiotic prescribing and a trend towards a decrease in antibiotic usage for the most commonly prescribed antibiotics during the intervention phase. In our study, there was very low usage of broad-spectrum antibiotics such as meropenem and vancomycin and thus we chose to focus on the most commonly prescribed antibiotics instead of categories of broad- and narrow-spectrum antibiotics. This study was conducted in one HHS; however, there were differences in uptake of the interventions at the individual facilities, which probably reflects unmeasured differences in culture and implementation strategies. The hospitals in our study were relatively small with a low patient volume and thus it was not feasible to collect meaningful data by utilising the standardised methodologies undertaken in point prevalence studies, H-NAPS. We utilised a modified H-NAPS that is a patient-centred approach by assessing antimicrobial therapy throughout a patient's inpatient journey and intended continuation upon discharge, which reflects clinical practice. As in standard methodologies utilised in point prevalence studies, we only utilised data collected for patients prescribed antibiotics and did not capture data on instances where antibiotics should have been prescribed but were not. We were also not able to account for diagnostic errors. Assessment of antimicrobial appropriateness was undertaken by trained assessors from the centralised ASP representing a multidisciplinary team who were independent from the prescribing of the antibiotic at the local sites. Variability in assessing appropriateness has previously been reported [22]. Although this study did not evaluate the duration of intravenous antimicrobial therapy, we were able to demonstrate a sustained trend towards a decrease in hospital length of stay, which could have been attributed to shorter durations of intravenous antibiotics resulting in earlier discharge of patients from the hospital. A centrally co-ordinated ASP involving 47 private hospitals in South Africa also concluded that focusing on interventions such as excessive antibiotic duration can provide substantial returns in low-resource settings [23].

In conclusion, we have demonstrated that implementing ASPs in rural facilities is sustainable and can improve the appropriateness of antimicrobial prescribing when local clinicians are actively involved and supported by a centralised antimicrobial stewardship multidisciplinary service utilising telehealth. Rural hospitals are least likely to have formal ASPs, therefore ongoing antimicrobial stewardship strategies must address these settings in order to promote optimal antimicrobial use in these under-resourced areas.

Declaration of Competing Interest

None declared.

Acknowledgments

The authors would like to thank Catherine Martin, Krispin Haijowicz, Emily Waddell, Stacey McNamara and Michelle Doidge for their valuable contributions to the Queensland Statewide Antimicrobial Stewardship Program.

Funding

None.

Ethical approval

This was a quality assurance activity under the Australian National Health and Medical Research Council guidelines and an exemption from ethics was obtained from the Royal Brisbane & Women's Hospital Human Research Ethics Committee [HREC/18/QRBW/115 09.03.2018].

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ijantimicag.2021.106346.

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