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Impact of integrating objectives and key results into an antimicrobial stewardship program: A retrospective analysis

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Abstract: **Background**: Objectives and key results (OKRs), a popular management tool in enterprises, have rarely been explored in healthcare. **Objectives**: This study assessed the impact of OKRs on an antimicrobial stewardship program (ASP) in a large tertiary hospital. **Methods**: A retrospective analysis was conducted before and after the implementation of OKRs in ASP (the pre-study period was from March to December 2018 and the post-study period was from March to December 2019) on the number of deaths directly caused by infections, the intensity of antimicrobial use and the incidence of bacterial resistance. **Results**: A total of 259,143 hospitalized patients were included in the study (130,956 before and 128,187 after). The results showed that after the implementation of OKRs in ASP, the antibiotic use density (AUD) decreased by 4.24 DDDs/100 person-days, with a statistically significant difference ($p<0.017$), while there was no statistical difference in the number of deaths directly caused by infections and the incidence of bacterial resistance. Further analysis revealed that the rate of antimicrobial use among hospitalized patients decreased by 1.87%, the average length of hospital stay was shortened by 0.61 days and the per capita cost of antimicrobial drugs decreased by 48 yuan, all with statistical significance ($P<0.01$). **Conclusion**: OKRs, as a simple and practical management tool, have proven highly effective for ASP management and should be widely promoted in the medical field.

Keywords: Antimicrobial stewardship; Antimicrobial use density; Cost savings; Length of stay; Retrospective studies

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INTRODUCTION

Antimicrobial misuse has driven a surge in bacterial resistance, posing a grave threat to global public health (Salam *et al.*, 2023). Studies have shown that approximately 10-20% of antibiotic prescriptions may be unnecessary or inappropriate (Davidson *et al.*, 2023; Hussain *et al.*, 2022). In 2019, the Antimicrobial Resistance Collaborators estimated that antibiotic-resistant bacteria caused at least 141,000 deaths annually across the 35 countries in the WHO Region of the Americas, creating significant financial strain (Antimicrobial Resistance Collaborators , 2023). A recent study found that the cost of antibiotic resistance was as high as 55 billion per year in the United States, though the actual cost could be much higher than current estimates suggest (O'Leary, 2022).

Implementing antimicrobial stewardship (AMS) is one of the most effective ways to combat antibiotic abuse and resistance in hospitals worldwide. The ASP was brought to the forefront by the Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America in 2007 to address this significant health issue. These programs promote the appropriate use of antibiotics by helping clinicians select the correct dose, duration and route of administration. According to a report published by the CDC of the United States, ASP is a "win-win" program for all those involved. AMS is a crucial process that has been shown to reduce antibiotic use, prevent antimicrobial resistance, improve patient outcomes and reduce costs without increasing hospital admissions or deaths (Crespo-Rivas *et al.*, 2021). ASP usually requires a multidisciplinary approach, including an infectious disease physician and a clinical pharmacist trained in infectious diseases. Pharmacists, as core members of antimicrobial management teams (AMTs), perform multiple roles to achieve the program's goals. They maximize favorable outcomes, minimize adverse reactions and prevent the spread of antibiotic-resistant bacteria.

An OKR is a practical and single management strategy that helps achieve objectives and track results. It has become widely used across all industries, as team members tend to be more engaged and productive when they have a clear goal (Zhang and Xiao, 2024). Many businesses, from startups to multi-billion-dollar companies, have successfully used OKRs to promote growth. However, the use of OKR tools by pharmacists in the ASM program has not been reported. This investigation is designed to quantify the effects of embedding the OKR management system within existing ASPs and formulate an original operational approach for antimicrobial stewardship administration.

Study design and application

In response to the National Health Administrative Authority's notice on further improving the stewardship of

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clinical antibiotic use (National Health and Family Planning Commission of the People's Republic of China, 2018), a 100-day ASP was conducted at the Second XiangyaHospital of Central South University—a 3,500-bed teaching hospital in Changsha, Hunan Province, China.

The ASP team comprised medical administrators, infection preventionists, respiratory therapists and clinical pharmacists. Medical administrators organized and coordinated program implementation. Through multiple rounds of discussion, the project team defined the program's OKRs, detailed in fig. 1. The program's primary objective was to optimize antimicrobial use. Three key results were selected across distinct dimensions: Infection-related mortality rate, AUD and the incidence rates of multidrug-resistant organisms.

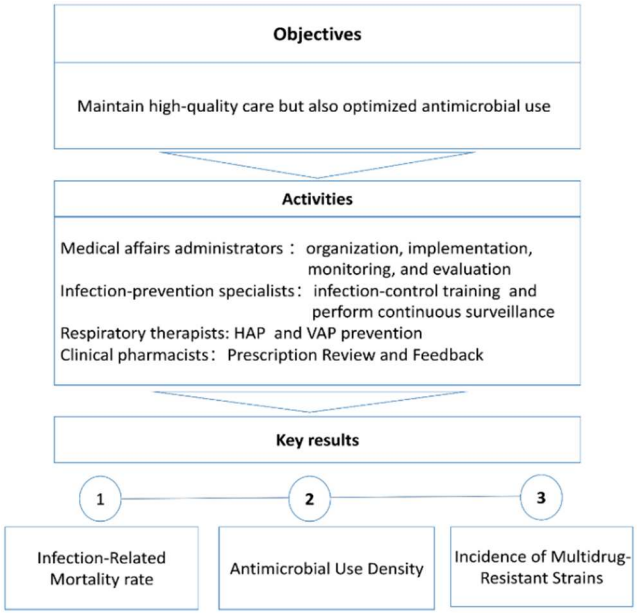

Fig. 1: Objectives and key results of ASP.

To achieve these goals, medical affairs department administrators oversaw program execution, monthly monitoring of key results and analysis of related data to evaluate intervention efficacy. Infection preventionists delivered regular infection control training to healthcare workers and conducted surveillance. Respiratory therapists focused on preventing hospital-acquired pneumonia (HAP) and ventilator-associated pneumonia (VAP). Clinical pharmacists reviewed antimicrobial prescriptions for appropriateness and provided timely feedback to prescribers. Daily, a team of 10 pharmacists electronically reviewed all antibiotic orders via the hospital information system. Prescriptions flagged as inappropriate—whether regarding drug selection, dosage, treatment duration, or combination therapy—prompted pharmacists to issue evidence-based suggestions to clinicians. Recommendations adhered to China's Guiding Principles for Clinical Antibiotic Use (2015) and National Guidelines for Antibiotic Therapy (Second Edition). Clinicians who disagreed with suggestions engaged in discussions with pharmacists. Notably, all recommendations were non-imposed, with no restrictive measures applied to prescription practices.

The study was conducted in full compliance with the hospital's policies and procedures. It was also reviewed by the hospital's medical affairs office, which oversees the implementation of quality improvement initiatives and ensures that they align with the hospital's objectives and standards. This study was conducted in strict compliance with relevant ethical regulations and internationally accepted research standards.

MATERIALS AND METHODS

Study design

A retrospective, before-and-after observational study was conducted in compliance with the STROBE statement (Appendix). The pre-implementation period was defined as March to December 2018, and the post-implementation period as March to December 2019.

Study setting

The study was carried out at the Second Xiangya Hospital of Central South University, a 3,500-bed tertiary teaching hospital in Changsha, China.

Participants

Inclusion criteria

The inpatient data included the intervention period and the subsequent six months (March to December 2019), while the comparison group included all days in the corresponding period in 2018. There were no restrictions on age, gender, or diseases and all data used were anonymized to protect patient privacy. Data, other than tree key results, were collected through the hospital information system (HIS), such as the proportion of inpatients treated with antibiotics, the proportion of surgical antibiotic prophylaxis, the length of hospital stay and hospitalization costs of antibacterial agents, the proportion of surgical antibiotic prophylaxis, the incidence of surgical site infections, hospitalization costs of antibacterial agents.

Exclusion criteria

Outpatient and emergency department data were excluded.

Data sources and measurements

Data were extracted from the hospital information system (HIS). The primary outcomes were: Infection-related mortality rate; Antibiotic use density; Incidence of multidrug-resistant organisms. Secondary outcomes included: Proportion of inpatients receiving antimicrobials; Proportion of surgical antimicrobial prophylaxis; Length of hospital stay; Per capita antimicrobial cost Surgical site infection rate.

Statistical analysis

Continuous variables were expressed as mean ± standard deviation (SD) and categorical variables were expressed as frequencies and percentages. The Chi-square test was used to compare the proportion of antibiotic use, infection rate in Type I incision surgery and mortality due to infection in patients between pre-intervention (March to December 2018) and post-intervention (March to December 2019). The *t-tests* were used to estimate AUD and the cost of antibiotics per patient. Statistical analysis was performed using SPSS software (Version 26.0). Bonferroni correction was applied to correct the inflation of type I error arising from multiple pairwise comparisons. The significance level ($\alpha = 0.05$) was divided by the number of comparisons made to obtain a corrected significance and the statistical significance of key results was defined as $p<0.017$ (n=3) and the multiple comparisons significance level of non-key results was defined as $p<0.01$ (n=5).

RESULTS

A total of 259, 143 individuals (Fig. 2) were enrolled in the study (130,956 pre-intervention and 128,187 post-intervention). The key outcomes are presented in table 1. AUD decreased by 4.24 DDDs/100 person-days from baseline ($p<0.017$), while infection-related mortality and bacterial resistance incidence showed no statistically significant changes.

Further analysis (Table 2) indicates that the reduction in AUD —driven primarily by a significant decrease in the proportion of inpatients receiving antibiotics while surgical prophylaxis remained unchanged—translated into a 1.87% decrease in antimicrobial use rate, a 0.61-day shorter hospital stay, and a 48 yuan decrease in per capita drug costs (all $p<0.01$), without increasing surgical-site infection incidence ($p>0.17$).

DISCUSSION

Antibacterial drugs are the most extensively used medications in clinical practice, inevitably leading to instances of misuse (Sweileh, 2021). To address the significant threat this poses to human health, optimizing antibacterial usage has become a consensus among health authorities and medical institutions. Thus, the implementation of an ASP is essential (Feng *et al.*, 2024). A multitude of studies have demonstrated that ASP can diminish the duration of antibiotic therapy, enhance the appropriateness and frequency of dosing, improve clinical outcomes, mitigate toxicity, delay the emergence of drug resistance and decrease overall antimicrobial consumption (Chikeka *et al.*, 2023; Wang *et al.*, 2024; Zhou *et al.*, 2023). OKR tools were adopted within the program to optimize antimicrobial use. OKR tools give a clear goal and specific measurable results, which keep members of ASP focused, aligned and continuously working to achieve these objectives. In this project, the infection-control team continuously monitored healthcare-associated infections (HAIs), implemented evidence-based prevention and control measures and conducted real-time audits of their adherence. They also intensified institution-wide education on infection prevention for all healthcare workers. Respiratory therapists focused on preventing hospital-acquired pneumonia (HAP) and ventilator-associated pneumonia (VAP) in critically ill patients. Pharmacists intervened at critical decision points in physicians' prescribing practices, offering immediate, non-mandatory recommendations aligned with the guiding principle of clinical use of antibiotics, allowing physicians to promptly optimize therapy while retaining full autonomy over the final prescription. The recommendations made by pharmacists were highly accepted.

A review of existing literature indicates that the integration of OKRs into the ASP framework is reported for the first time in this study. Consequently, this study implemented the OKRs management tool and achieved favorable outcomes. As shown in tables 1 and 2, the results demonstrate that the ASP reduced the rate of antibiotic use among inpatients, significantly lowered AUD, decreased the cost of antibiotics for hospitalized patients and shortened the average length of stay. Therefore, applying OKRs to AMS is both effective and innovative.

Nevertheless, table 1 shows no significant changes in infection-related mortality or the incidence of multidrug-resistant organisms. This may be explained by the fact that clinicians' initial antimicrobial choices were already relatively rational; even when empiric therapy was suboptimal, adjustments based on clinical response occurred within two to three days—too brief to influence outcomes. Although reduced antimicrobial use is expected to curb resistance, such trends could not be identified due to the limited observation window.

It is worth emphasizing that nosocomial infections must be a foremost priority. The results of this project demonstrate that infection-control practitioners and respiratory therapists can significantly lower the incidence of healthcare-associated infections among inpatients, as evidenced by the corresponding reduction in antimicrobial utilization rates. Yet, given the large inpatient volume and the daily deluge of antibiotic prescriptions, ASP teams remain critically short of clinical pharmacists. Artificial intelligence (AI) tools are necessary for pharmacists to obtain key information and provide auxiliary analysis. However, AI will face many challenges due to technical limitations, as implementing large language model-based support for antibiotic prescribing is complex (Giacobbe *et al.*, 2025).

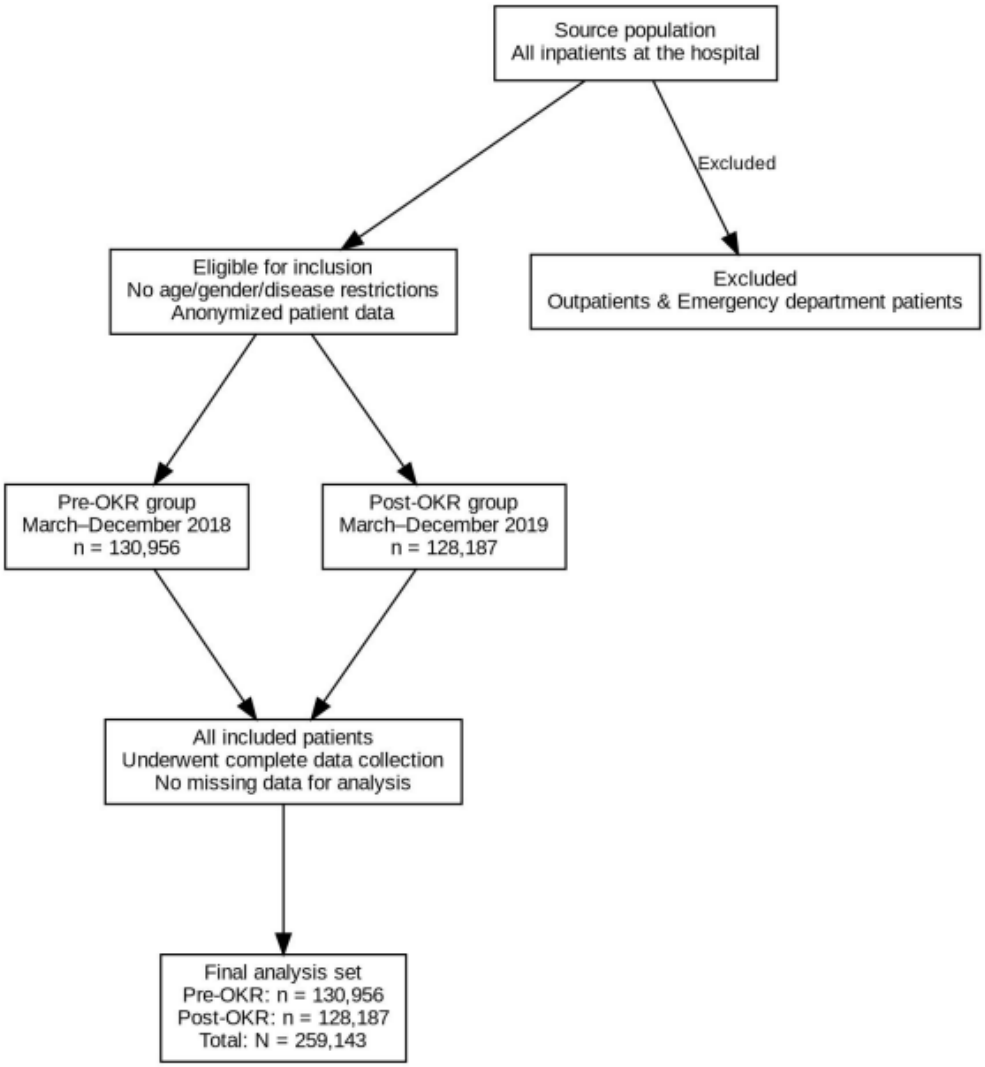

Fig. 2: Flow chart of integrating OKRs into an ASP.

Table 1: Key results of ASP between pre-intervention and post-intervention.

	Pre-intervention (N =130, 956)	Post-intervention (N = 128187)	*P* value
Infection-related mortality rate (%)	0.01(15/ 130956)	0.01(13/ 128187)	*0.450*
Antibiotic use density (DDDs per 100 bed days)	43.31	39.07	0.0013
The incidence of multidrug-resistant strains (%)	13.72(1200/8745)	14.07(1270/9026)	0.260

Abbreviations: DDDs: Defined daily doses

Table 2: non-key results of ASP between pre-intervention and post-intervention.

	Pre-intervention (N =130,956)	Post-intervention (N = 128187)	*P* value
The proportion of inpatients treated with antibiotics (%)	39.96(52334 / 130956)	38.09(48829/128187)	*0.000*
The proportion of surgical antibiotic prophylaxis in the incision (%)	34.18(11343/33185)	33.21(13414/40390)	*0.0120*
The rate of surgical site infection (%)	0.08（27 /33185）	0.06(21/40390)	0.080
Days of stay in the hospital (days)	9.18	8.57	0.000
Median costs of antimicrobial treatment per patient (Yuan)	1109.70	1061.70	0.000

Limitations of this study include the restricted observation windows: the pre-implementation baseline was limited to 100 days and the post-implementation follow-up to seven months. The primary reason for this truncation was the marked decline in inpatient volume and the profound shift in case mix caused by the COVID-19 pandemic; these abrupt changes rendered the corresponding datasets incomparable with historical norms.

CONCLUSION

An ASP grounded in OKRs can promote rational antibiotic use in hospitals, lower disease burden and shorten length of stay. OKR is a simple, practical and effective tool that deserves wide adoption in hospital management.

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Authors' contributions
Shuang Liu: Conceptualization, methodology, writing-original draft, writing-review and editing; Yiping Liu: Conceptualization, methodology, supervision, writing-review and editing and visualization.

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Data availability statement
The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Ethical approval
As a quality improvement study with fully anonymized, non-traceable data. Approval was granted by the Clinical Research Ethics Committee of the Second Xiangya Hospital, Central South University. The ethical approval number is LYEC2026-0110. This study was performed in adherence with the STROBE guidelines. See supplementary file for the STROBE checklist.

Conflict of interest
The authors declare no conflict of interest.

Supplementary data
https://www.pjps.pk/uploads/2026/07/SUP1784371894.pdf

REFERENCES

Antimicrobial Resistance Collaborators and (2023). The burden of antimicrobial resistance in the Americas in 2019: A cross-country systematic analysis. *Lancet regional health. Americas*, **25**: 100561.

Chikeka K, Gbadamosi K, Tran H, Chughtai I, Muhammad S, Senay M, Lam B, Ngouajio-Teguiafa L, Nonyel N, DeLaine L, McSwain C, Price D and Michaels K (2023). Pilot study: Impact of a pharmacist-led 48-hour antibiotic time-out on antibiotic utilization and outcome measures in a community teaching hospital. *Hosp Pharm*, **58**(3): 277-281.

Crespo-Rivas JC, Guisado-Gil AB, Peñalva G, Rodriguez-Villodres A, Martin-Gandul C, Pachon-Ibanez ME, Lepe JA and Cisneros JM (2021). Are antimicrobial stewardship interventions effective and safe in long-term care facilities? A systematic review and meta-analysis. *Clin. Microbiol. Infect.*, **27**(10): 1431-1438.

Davidson LE, Gentry EM, Priem JS, Kowalkowski M and Spencer MD (2023). A multimodal intervention to decrease inappropriate outpatient antibiotic prescribing for upper respiratory tract infections in a large integrated healthcare system. *Infect Control Hosp Epidemiol*, **44**(3): 392-399.

Dutcher L, Degnan K, Adu-Gyamfi AB, Lautenbach E, Cressman L, David MZ, Cluzet V, Szymczak JE, Pegues DA, Bilker W, Tolomeo P and Hamilton KW (2022). Improving outpatient antibiotic prescribing for respiratory tract infections in primary care: A stepped-wedge cluster randomized trial. *Clin. Infect. Dis.*, **74**(6): 947-956.

Feng W, He T, Zhang Y, Mu Y, Pu Y, Liu Y, Ouyang Z, Song H, Zhong Y, Lu H, Zhou Y, Zou P, Yang G, Tian H, Jin J, Liang G, Yang L, Zhang L, Liu Y, Dai W, Qing H, Zhang J, Shi Q, Li Q, Yang D, Zhang R and Wei X (2024). Comparing the efficacy of empirical anti-infective therapy and follow-up observation for newly diagnosed pulmonary ground-glass nodules with suspected inflammatory etiology: A multicenter prospective observational study protocol. *Health Sci Rep*, **7**(11): e70201.

Giacobbe DR, Guastavino S, Marelli C, Murgia Y, Mora S, Signori A, Rosso N, Giacomini M, Campi C, Piana M and Bassetti M (2025). Antibiotics and artificial intelligence: Clinical considerations on a rapidly evolving landscape. *Infect Dis Ther*, **14**(3): 493-500.

Hussain A, Asghar U, Asghar Gill I, Shahid M, Shahid A, Hassan MN, Ali I, Naheed F and Numan Zahid M (2022). A clinical audit to evaluate antibiotic prescribing practice in pediatric patients admitted for enteric fever. Rationalizing antibiotic stewardship program. *Pak J Pharm Sci*, **35**(4): 993-997.

Kern JM, Berger K, Lechner AM, Porsche U, Wallner M and Past EM (2024). Lack of microbiological awareness on the ward as a key factor for inappropriate use of anti-infectives: results of a point prevalence study and user satisfaction survey in a large university hospital in Austria. *Infection*, **52**(3): 995-1008.

Kooda K, Canterbury E and Bellolio F (2022). Impact of

pharmacist-led antimicrobial stewardship on appropriate antibiotic prescribing in the emergency department: A systematic review and meta-analysis. *Ann Emerg Med*, **79**(4): 374-387.

National Health and Family Planning Commission of the People's Republic of China. Notice on Continuously Improving the Management of Clinical Use of Antimicrobial Agents. Gazette of the National Health and Family Planning Commission of the People's Republic of China, **2018**(5): 79-80.

O'Leary K (2022). The global burden of antimicrobial resistance. *Nat. Med.*,

Salam MA, Al-Amin MY, Salam MT, Pawar JS, Akhter N, Rabaan AA and Alqumber M (2023). Antimicrobial resistance: A growing serious threat for global public health. *Healthcare (Basel, Switzerland)*, **11**(13): 1946.

Sweileh WM (2021). Global research publications on irrational use of antimicrobials: Call for more research to contain antimicrobial resistance. *Global Health*, **17**(1): 94.

Wang Y, Knobloch K, Lovett S, Lyons N and Rech MA (2024). A pharmacist-driven deprescribing protocol for negative urine and sexually transmitted infection cultures in the emergency department increases antibiotic-free days. *Am J Health Syst Pharm*, **81**(3): e83-e89.

Xia H, Li J, Yang X, Zeng Y, Shi L, Li X, Qiu S, Yang S, Zhao M, Chen J and Yang L (2024). Impacts of pharmacist-led multi-faceted antimicrobial stewardship on antibiotic use and clinical outcomes in urology department of a tertiary hospital in Guangzhou, China: An interrupted time-series study. *J. Hosp. Infect.*, **151**: 148-160.

Zhang Y and Xiao W (2024). A study on the effectiveness of a nursing intervention based on objectives and key results goal management in bowel preparation before colonoscopy. *Altern. Ther. Health Med.*, AT10330 [pii].

Zhou X, Gong J, Su D, Wu Z, Jia X, Wang Y, Xu N and Shang J (2023). Effect of pharmacist intervention on antibiotic prophylaxis in orthopedic internal fixation: A retrospective study. *Res Social Adm Pharm*, **19**(2): 301-307.