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Enhancing Microbiological Testing Rates Prior to Antimicrobial Therapy in Hospitalized Patients Using the FOCUS-PDCA Cycle Model

FOCUS-PDCA Döngüsü Modeli Kullanılarak Hastanede Yatan Hastalarda Antimikrobiyal Tedavi Öncesi Mikrobiyolojik Test Oranlarının Artırılması

Chen et al. Increasing Microbiological Testing Rates Prior to Antibacterial Therapy

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Abstract
Introduction: Enhancing compliance with microbiological testing prior to antimicrobial therapy is fundamental to diagnostic stewardship, precision antimicrobial prescribing, and the containment of antimicrobial resistance—a key objective of national healthcare quality and safety initiatives. This study evaluated the effectiveness of the Find, Organize, Clarify, Understand, Select, Plan, Do, Check, Act (FOCUS-PDCA) cycle model as a quality improvement framework to improve adherence to microbiological testing protocols in hospitalized patients.
Materials and Methods: Baseline data were collected from hospitalized patients receiving antimicrobial therapy between January and December 2022 to evaluate three diagnostic stewardship indicators: (1) overall microbiological testing rate before antimicrobial therapy, (2) microbiological testing rate for hospital-acquired infection (HAI) diagnoses, and (3) submission rate before the concomitant use of key antimicrobials. From January to June 2023, the FOCUS-PDCA model was implemented, incorporating systematic problem identification, root cause analysis, targeted interventions, and subsequent evaluation of performance metrics to assess improvements in testing compliance.
Results: Implementation of the FOCUS-PDCA model led to statistically significant improvements across all indicators. The overall pre-antimicrobial testing rate increased from 44.29% to 69.94% post-intervention [odds ratio (OR): 0.64; 95% confidence interval (CI), 0.63–0.65; p<0.001). The HAI-related testing rate rose from 72.63% to 90.0% (OR: 0.81; 95% CI, 0.74–0.88; p<0.001), achieving the national target. The submission rate before concomitant use of key antimicrobials increased from 89.76% to 96.47% (OR: 0.91; 95% CI, 0.88–0.95; p<0.001), although it remained slightly below the national threshold of 100%. All observed differences were statistically significant (p<0.05).
Conclusion: The FOCUS-PDCA model effectively enhanced diagnostic stewardship by significantly increasing compliance with microbiological testing protocols prior to antimicrobial therapy in hospitalized patients. These findings underscore the value of structured quality improvement frameworks in antimicrobial stewardship programs to promote rational, evidence-based antimicrobial use.
Keywords: FOCUS-PDCA, diagnostic stewardship, microbiological testing, antimicrobial therapy, hospital-acquired infection

Öz
Giriş: Antimikrobiyal tedavi öncesi mikrobiyolojik testlere uyumu artırmak, tanı yönetimi, hassas antimikrobiyal reçeteleme ve antimikrobiyal direnç kontrolü için temel öneme sahiptir. Bu, ulusal sağlık hizmetleri kalite ve güvenlik girişimlerinin temel amaçlarından biridir. Bu çalışmada, hastanede yatan hastalarda antimikrobiyal tedavi öncesi mikrobiyolojik test protokollerine uyumu artırmak için bir kalite iyileştirme çerçevesi olarak Bul, Organize Et, Açıkla, Anla, Seç, Planla, Uygula, Kontrol Et, Önlem Al (FOCUS-PDCA) döngü modelinin etkinliği değerlendirilmiştir.
Gereç ve Yöntem: Ocak ve Aralık 2022 arasında antimikrobiyal tedavi gören hastanede yatan hastalardan temel veriler toplanarak üç temel tanı yönetimi göstergesi değerlendirildi: 1) antimikrobiyal tedavi öncesi genel mikrobiyolojik test oranı, 2) hastane kaynaklı enfeksiyontanılarıyla ilişkili mikrobiyolojik test oranı ve 3) temel antimikrobiyallerin eş zamanlı kullanımından önceki başvuru oranı. Ocak-Haziran 2023 arasında, sistematik sorun tanımlama, kök neden analizi, hedefli müdahalelerin geliştirilmesi ve uygulanması ve mikrobiyolojik

test uyumluluğundaki iyileştirmeleri değerlendirmek için performans ölçütlerinin daha sonraki değerlendirmesini içeren FOCUS-PDCA modeli uygulandı.
Bulgular: FOCUS-PDCA modelinin uygulanması, ölçülen tüm göstergelerde istatistiksel olarak anlamlı iyileştirmeler sağladı. Antimikrobiyal tedavi öncesi genel mikrobiyolojik test oranı, başlangıçta %44,29 iken müdahaleden sonra %69,94'e yükseldi [olasılık oranı (OR): 0,64, %95 güven aralığı (GA): 0,63–0,65, p<0,001). Hastane kaynaklı enfeksiyonla ilişkili tanı testleri için başvuru oranı, %72,63'ten %90,0'a yükseldi (OR: 0,81, %95 GA: 0,74–0,88, p<0,001) ve ulusal hedefe ulaştı. Ek olarak, temel antimikrobiyallerin eş zamanlı kullanımından önceki başvuru oranı, %89,76'dan %96,47'ye yükseldi (OR: 0,91, %95 GA: 0,88–0,95, p<0,001), ancak %100'lük ulusal eşik değerinin altında kaldı. Başlangıç ve müdahale sonrası oranlar arasında gözlemlenen tüm farklılıklar istatistiksel olarak anlamlıydı (p<0,05).
Sonuç: FOCUS-PDCA modelinin uygulanması, hastanede yatan hastalarda antimikrobiyal tedaviden önce mikrobiyolojik test protokollerine uyumu önemli ölçüde artırarak tanı yönetimi uygulamalarını etkili bir şekilde iyileştirmiştir. Çalışma, FOCUS-PDCA modelinin akılcı ve kanıta dayalı antimikrobiyal kullanımını teşvik etmedeki klinik önemini vurgulamıştır. Bu bulgular, tanı uygulamalarını optimize etmek için yapılandırılmış kalite iyileştirme çerçevelerinin antimikrobiyal yönetim programlarına entegre edilmesini desteklemektedir.
Anahtar Kelimeler: FOCUS-PDCA, mikrobiyolojik test, antimikrobiyal tedavi, hastane kaynaklı enfeksiyon

Introduction

The National Institute of Hospital Administration launched (HAI) a special action initiative (2021–2023) aimed at increasing microbiological testing rates prior to antimicrobial therapy in hospitalized patients—a central objective of national healthcare quality and safety efforts[1]. This initiative established tiered benchmarks: a minimum submission rate of 50% for all hospitalized patients receiving therapeutic antibiotics, at least 90% for those diagnosed with hospital-acquired infections (HAIs), and 100% for cases involving the empirical use of two or more key antibiotics. Key antibiotics include carbapenems, glycopeptides, new tetracyclines, polymyxins, β-lactams, and systemic antifungals. The Find, Organize, Clarify, Understand, Select, Plan, Do, Check, Act (FOCUS-PDCA) cycle model, an extension of the traditional PDCA framework, has demonstrated efficacy in identifying workflow deficiencies and improving microbiological testing rates among inpatients receiving antimicrobial therapy. The model involves sequential steps—FOCUS—followed by PDCA—providing a systematic and iterative method for process optimization. This study applied the FOCUS-PDCA cycle model to evaluate microbiological testing rates among hospitalized patients, providing evidence-based guidance for optimizing specimen submission and promoting rational antimicrobial use in clinical practice.

Materials and Methods

Study Design and Participants

This retrospective study analyzed microbiological testing rates prior to the initiation of systemic antimicrobial therapy in hospitalized patients. Baseline (pre-intervention) data were collected from January 1 to December 31, 2022. Post-intervention data, following implementation of the FOCUS-PDCA cycle model, were collected from January 2023 to June 2023. Thus, microbiological testing data from the full year of 2022 were used for pre-intervention analysis, while data from the first half of 2023 were used for post-intervention evaluation. The study included patients who received systemic antimicrobial therapy during hospitalization. Patients receiving prophylactic antibiotics or localized antimicrobial treatments—such as eye drops, irrigation solutions, enemas, or topical formulations—were excluded.

Problem Identification

Current Status Assessment: A retrospective analysis of inpatient data from January 1 to December 31, 2022, was conducted using the hospital's infection monitoring system to evaluate microbiological testing practices. The results revealed that the pretreatment specimen submission rate was substantially below the national benchmark of 50%, as specified in the national special action plan for antimicrobial stewardship.

Establishment of Quality Improvement Team: A multidisciplinary quality improvement team was formed under the leadership of the Department of Hospital Infection Control. The team comprised 10 members representing key departments, including Hospital Infection Control, Medical Affairs, Clinical Laboratory, Information Technology, Nursing, and major clinical units. In addition, representatives from the hospital's infection surveillance software provider and personnel from affiliated group hospitals were included. The team's primary responsibilities were to develop, implement, and monitor targeted interventions aimed at improving microbiological testing rates across the institution.

Clarification of Microbiological Testing Process and Operational Standards: The standard submission workflow began with physicians ordering microbiological tests based on clinical indications. Orders were verified by nursing staff prior to specimen collection—such as blood, urine, or respiratory samples—to ensure accurate labeling and timely transport to the laboratory under prescribed conditions. Upon receipt, the Clinical Laboratory Department processed the specimens according to standardized microbiological protocols, and results were recorded in the hospital's data system for statistical analysis. The system automatically calculated the microbiological submission rate prior to antimicrobial therapy using timestamps for antibiotic administration and specimen collection/orders. These results were subsequently distributed to relevant clinical departments as part of performance assessments within the quality improvement initiative.

Root Cause Analysis: To identify factors contributing to the low baseline pretreatment specimen submission rate, the quality improvement team conducted structured brainstorming sessions and comprehensive root cause analyses. The following categories of contributing factors were identified:

(1) Personnel-related factors: Limited awareness among medical staff regarding the importance of pretreatment specimen collection for guiding empirical therapy, lack of initiative in performing essential clinical duties, insufficient emphasis and clear guidance from department heads on timely specimen submission, and inadequate or infrequent training on diagnostic stewardship principles and practical specimen collection procedures

(2) System-related factors: Limitations of the information system, including inaccuracies in capturing indications for antimicrobial use, absence of time-stamped records for specimen collection in inpatient units, and inadequate data validation processes for quality control

(3) Management-related factors: Structural weaknesses in management, such as underdeveloped accountability frameworks, absence of performance-based incentives, delayed feedback on submission compliance, and insufficient oversight from functional departments

(4) Documentation-related factors: Incomplete documentation of antimicrobial stewardship protocols, limited feasibility of existing work plans, non-standardized workflows, and poorly defined responsibilities (Figure 1).

Quality Improvement Plan

Target: Based on the standards outlined in the National Special Action Guide, a continuous quality improvement (CQI) target was set to achieve a microbiological testing rate of ≥50% among hospitalized patients receiving systemic antimicrobial therapy.

Timeline and Strategy: In early January 2023, personnel from the Department of Hospital Infection Control conducted a comprehensive baseline assessment and formally established the CQI Team. By late January, the team collaborated with relevant departments to identify operational challenges, perform a root cause analysis, and develop targeted intervention strategies. The intervention plan was fully

implemented from February to June 2023. Outcomes were evaluated in June 2023, and the results were analyzed to determine areas of success and identify remaining gaps.

Implementation

Based on the findings of the root cause analysis, a multifaceted intervention strategy was developed and implemented (Table 1). Key components of the strategy included enhancements to institutional management structures and the promotion of cross-disciplinary collaboration. A quality control team was established to monitor improvements in microbiological testing prior to antimicrobial initiation. The team was led by the hospital Vice President and included representatives from the Departments of Hospital Infection Control, Pharmacy, Medical Affairs, and the Microbiology Laboratory. Regular multi-departmental meetings were convened to monitor progress, coordinate efforts, and refine operational procedures (Figure 2). Structured, tiered training programs were introduced to strengthen the clinical knowledge of medical staff and improve compliance with microbiological testing protocols. Training modules were tailored to specific clinical roles and delivered through multiple channels, including director briefings, head nurse meetings, and part-time staff seminars. Training sessions focused on updating knowledge of hospital infection epidemiology and relevant clinical guidelines, as well as providing case-based analyses of non-compliant practices, particularly in departments with suboptimal performance. Multidisciplinary collaboration was promoted to enhance clinical specimen submission and testing. The Pharmacy and Laboratory Departments jointly educated physicians on diagnostic antimicrobial stewardship, rational antimicrobial use, and standardized specimen submission procedures. The Hospital Infection Control Department revised the accountability framework to incorporate stricter performance evaluations and feedback mechanisms. Incentive and penalty structures were introduced to encourage compliance and sustain adherence to quality standards (Supplementary File 1). In addition, the hospital's information management systems were integrated and optimized to enhance operational efficiency. System functionality was upgraded to automatically intercept microbiological testing requests submitted prior to the concomitant administration of critical antimicrobials. Relevant microbiological test items were also incorporated into the appendix of the special action guide, supporting improved clinical decision-making.

Performance Indicators

The effectiveness of the FOCUS-PDCA model was assessed by comparing pre- and post-intervention performance across three key indicators: (1) overall microbiological testing rate prior to antimicrobial therapy, (2) microbiological testing rate for HAI diagnoses, and (3) microbiological testing rate prior to the concomitant use of key antimicrobials.

Statistical Analysis

Statistical analyses were performed using SPSS version 20.0. Continuous variables were expressed as mean ± standard deviation, and differences between independent groups were assessed using the two-sample *t*-test. Categorical variables were presented as counts and percentages, with group comparisons conducted using the chi-squared (χ^2) test. A two-tailed p-value of <0.05 was considered statistically significant.

Results

Baseline Pre-Antimicrobial Therapy Microbiological Testing Rates

A baseline analysis was conducted to evaluate microbiological testing rates among inpatients receiving systemic antimicrobial therapy prior to the implementation of the FOCUS-PDCA quality improvement model. The results indicated suboptimal compliance with diagnostic stewardship standards, with all evaluated indicators falling below the thresholds set by the National Special Action Guide. Specifically, the overall microbiological testing rate prior to antimicrobial therapy was 44.49% (below the national target of ≥50%), the submission rate for HAI diagnoses was 72.63% (below the recommended threshold of ≥90%), and the submission rate prior to concomitant use of key antimicrobials was 89.76% (below the threshold of 100%) (Table 2).

Impact of Intervention on Overall Pre-Antimicrobial Therapy Microbiological Testing Rates

Following implementation of the FOCUS-PDCA-guided quality improvement intervention, the overall pretreatment microbiological testing rate among inpatients receiving systemic antimicrobial therapy increased significantly. The post-intervention submission rate reached 69.94%, compared with a baseline rate of 44.29% (OR: 0.64; 95% CI, 0.63–0.65; p<0.001), demonstrating enhanced compliance with diagnostic stewardship protocols (Table 3).

Impact of Intervention on Microbiological Testing Rates for HAI Diagnoses

Post-intervention, the microbiological testing rate for etiological specimens associated with suspected or confirmed HAI increased to 90%, compared with 72.63% at baseline. This improvement was statistically significant (OR: 0.81; 95% CI, 0.74–0.88; p<0.001), meeting the national target of ≥90% for infection-related diagnostic testing (Table 4).

Impact of Intervention on Microbiological Testing Rates Prior to Concomitant Use of Key Antimicrobials

The microbiological testing rate prior to the concomitant use of key antimicrobials increased from 89.76% at baseline to 96.47% post-intervention. This difference was statistically significant (OR: 0.91; 95% CI, 0.88–0.95; p<0.001), indicating improved compliance with antimicrobial stewardship protocols in high-risk antibiotic regimens (Table 5).

Discussion

Global antimicrobial consumption has been steadily increasing, with a reported 90.9% rise in per capita use between 2000 and 2015[2]. This upward trend contributes to widespread antimicrobial misuse and the escalating problem of antimicrobial resistance (AMR). Antimicrobial-resistant organisms have been associated with approximately 4.95 million deaths globally[3], highlighting the urgent need for effective antimicrobial stewardship strategies. Consequently, antimicrobial stewardship has become a global health priority, emphasizing the importance of timely and appropriate microbiological testing prior to initiating antimicrobial therapy. Submitting clinical specimens prior to antibiotic administration is a cornerstone of diagnostic stewardship, as it guides targeted therapy, reduces unnecessary empirical antimicrobial use, and helps mitigate the development of resistance. International guidelines, including those from the Centers for Disease Control and Prevention in the United States and Nigeria, recommend that antimicrobial prescriptions be guided by microbiological test results[4]. Despite this, improving microbiological testing rates prior to antimicrobial therapy remains a significant challenge. Most existing studies in this area are descriptive and provide limited evaluations of structured, evidence-based interventions[5]. To address this gap, the present study employed the FOCUS-PDCA cycle model, a structured framework for CQI first introduced in the United States in the 1990s, to enhance microbiological testing rates prior to antimicrobial therapy. This comprehensive framework facilitates root cause analysis, targeted intervention design, and systematic performance evaluation, thereby optimizing healthcare process[6,7]. The FOCUS-PDCA model extends the traditional PDCA cycle by incorporating five additional preparatory steps.

In this study, the FOCUS-PDCA cycle model was systematically applied to improve the submission rate of microbiological specimens prior to antimicrobial therapy. Key interventions included identifying factors influencing testing rates, revising submission workflows, developing and implementing tailored interventions, providing specialized training for healthcare professionals, optimizing information systems, and introducing performance-based accountability mechanisms. These multifaceted initiatives significantly increased the overall microbiological testing rate from 44.29% to 69.94%, surpassing the national special action improvement target of 50%. The post-

intervention rate of 69.94% was also substantially higher than the 43.23% average reported by tertiary general hospitals in the National Sentinel Hospital Information Monitoring System in 2022[8]. However, these rates remained lower than those reported in international settings[9]. Additionally, the microbiological testing rate for HAI-associated diagnoses reached 90%, meeting the national standard of ≥90.00%.

Similarly, the submission rate prior to the concomitant use of key antibiotics increased to 96.47% post-intervention. While this represents a notable improvement, it remains below the 100% target set by the National Health Commission. This shortfall may be attributed to persistent reliance on empirical antibacterial therapy—particularly in urgent or severe cases—a lack of clinician awareness regarding the timing and clinical importance of pathogen collection before treatment, and prevailing misconceptions that diminish the perceived value of routine microbiological testing. In some instances, specimens are submitted without clear diagnostic rationale or with poor coordination between sampling and antimicrobial administration, leading to delays, reduced diagnostic utility, and non-compliance with submission standards. Effective management of bacterial infections depends on the timely collection and processing of microbiological specimens, including pathogen isolation, cultivation, and identification, and antimicrobial susceptibility testing. Results from susceptibility testing provide the basis for precise antimicrobial selection and individualized patient management. Furthermore, routine microbiological specimen submission plays a critical role in the early detection of multidrug-resistant bacteria and other clinically significant pathogens, enabling timely infection prevention and control measures and improving outcomes for both individual patients and the healthcare system. While significant improvements were achieved in pre-antibiotic and HAI-related microbiological testing rates—meeting national standards—the submission rate prior to the concomitant use of key antibiotics remained below the 100% benchmark, highlighting the need for continued efforts to achieve full compliance. Future interventions should focus on optimizing the timing of specimen collection, standardizing diagnostic and therapeutic protocols, and strengthening multidisciplinary oversight. Cultivating a culture of evidence-based, rational antibiotic prescribing is essential for combating AMR and improving healthcare quality.

Study Limitations

This study has some limitations. The post-intervention observation period was shorter than the pre-intervention period, which may have introduced bias in outcome comparisons. Therefore, the effectiveness of the proposed management model requires further investigation and validation through long-term, multicenter studies to provide more robust and generalizable evidence for clinical practice.

Conclusion

The systematic implementation of the FOCUS-PDCA quality improvement model—supported by coordinated interdepartmental collaboration and enhanced integration of information technology into clinical workflows—significantly improved microbiological testing rates prior to the initiation of antimicrobial therapy in hospitalized patients. These improvements in diagnostic antimicrobial stewardship are critical for promoting evidence-based antimicrobial prescribing, which helps combat AMR and ultimately enhances patient outcomes and overall healthcare quality. Ongoing refinement and expansion of these strategies are essential to ensure sustained compliance with national and international standards for diagnostic and antimicrobial stewardship.

Ethics

Ethics Committee Approval:

Informed Consent:

Footnotes

Authorship Contributions

Surgical and Medical Practices: T.C., H.G., Concept: L.Z., Design: M.W., Data Collection or Processing: Y.H., Y.L., Analysis or Interpretation: T.C., H.G., Literature Search: T.J., Writing: T.C.

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*During the preparation of this work theused ChatGPT in order to improveauthors language. After using this tool, the authorsreviewed and edited the content as neededand take full responsibility for the contentof the publication.

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FİGÜR AÇIKLAMALARINI KIRPAR MISIN

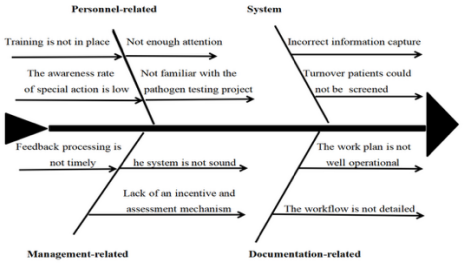

Figure 1 Reason Analysis of Quality Management

Figure 1. Root cause analysis of quality management factors affecting microbiological testing rates prior to antimicrobial therapy

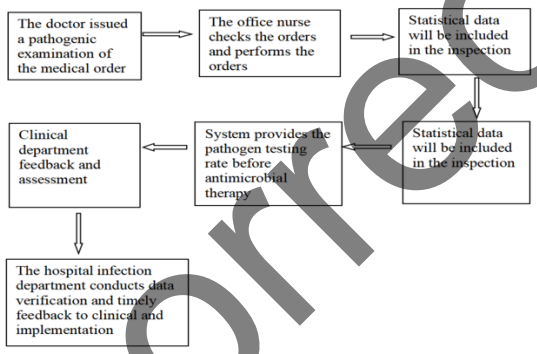

Figure 2 Improved pathogen testing process before antimicrobial therapy

Figure 2. Optimized workflow for microbiological testing prior to antimicrobial therapy following implementation of the FOCUS-PDCA quality improvement model
FOCUS-PDCA: Find, Organize, Clarify, Understand, Select, Plan, Do, Check, Act

Table 1. Improvement plan and implementation scheme

Problem	Causation	Countermeasure scheme	The person in charge	Execute time	Place of execution
What	Why	How	Who	When	Where
The rate of etiological examination for antimicrobial drugs in hospitalized patients is not up to standard	Insufficient training efforts	Develop a specialized training program, conduct hierarchical training, and ensure that all staff are informed	The Hospital Infection Control Department	February–May	Conference room
		Online training and assessment of all clinical departments	The Hospital Infection Control Department	February–June	Clinical departments
		Monitoring doctors and nurses in the clinical departments of the hospital	The Hospital Infection Control	June	Clinical departments

			Department		
		Internal training of the department	Director of each section and part-time duty personnel	January–June	Clinical departments
	Insufficient attention to medical staff	Multidisciplinary combination to strengthen the awareness of clinical inspection	Hospital infection department, Pharmacy Department, microbiology room	January–June	Clinical departments
		Establish an effective reward and punishment mechanism	Hospital infection department	Mar	Hospital infection department
	Information support	Information exchange meeting	Hospital infection department, Information section	April	Hospital infection department
		Add the function of pathogen inspection and reminder before issuing antibiotics	Hospital infection department, Information section	April–May	Information section
		Supplement and improve the information system etiology project	Hospital infection department, Information section	April	Information section
		Internal verification of the information ensures the accuracy of the data	Hospital infection department	June	Information section

Table 2. Pathological testing of hospitalized patients before intervention before antimicrobial use

Project	Number of cases investigated	Number of test cases before use	The inspection rate is (%)
Antimicrobial use before treatment	22299	9875	44.29
Diagnosis of nosocomial infection was related	296	215	72.63
Combined use of key drugs	469	412	89.76
The total amount amounted to 23064 units, with 10502 units being utilized effectively, representing a utilization rate of 45.53%			

Table 3. Pre-intervention and post-intervention microbiological testing situation before antibiotic use in hospitalized patients

Time	Number of survey cases	Number of cases sent for inspection beforehand	Inspection rate (%)	χ^2 value	OR (95% CI)	p value
Pre-intervention	22299	9875	44.29	1987.49	1	<0.001
After intervention	12822	8839	69.94		0.64 (0.63-0.65)	
OR: Odds ratio, CI: Confidence interval						

Table 4. Intervention-related changes in the etiological examination of hospital-acquired infections among inpatients before and after the intervention

Time	Number of survey cases	Number of cases sent for inspection beforehand	Inspection rate (%)	χ^2 value	OR (95% CI)	p value
Pre-intervention	296	215	72.63	15.84	1	<0.001
After intervention	130	117	90		0.81 (0.74-0.88)	
OR: Odds ratio, CI: Confidence interval						

Table 5. Microbiological testing before and after intervention for combined use of key antibiotics

Time	Number of survey cases	Number of cases sent for inspection beforehand	Inspection rate (%)	χ^2 value	OR (95% CI)	p value
Pre-intervention	469	412	89.76	22.39	**1**	<0.001
After intervention	425	410	96.47		0.91 (0.88-0.95)	
OR: Odds ratio, CI: Confidence interval						