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A Comparative Study on Application of Different Management Models for Surgical Instruments in Central Sterile Supply Department

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ABSTRACT: Objective This study aims to analyze the application effects of different management models in the Central Sterile Supply Department (CSSD), providing a reference for hospitals in selecting appropriate management models. **Methods** A systematic literature search was conducted in Web of Science, PubMed, CINAHL, the Cochrane Library, Scopus, Embase, China National Knowledge Infrastructure (CNKI), Wanfang Database, VIP Database, and China Biology Medicine disc (CBM). The search employed a combination of keywords and free-text terms, followed by a summary analysis. The search timeframe spanned from the inception of each database to July 31, 2025. **Results** A total of 22 articles was included, involving nine management models: the centralized management model, scientific management theory model, integrated care model, refined management model, whole-process quality control (QC) model, Plan-Do-Check-Act (PDCA) cycle model, defect management model, quality collaboration management (QCM) chain model, and three-chain (3C) model. Based on their primary focus, these nine models were categorized into three orientations: process-oriented, QC-oriented, and responsibility chain-oriented. By analyzing their theoretical foundations, implementation processes, and typical cases, the commonalities and differences among the models were examined. Furthermore, the suitability of each model for hospitals of different scales was assessed based on their respective characteristics. **Conclusion** A horizontal analysis indicates that while the various CSSD management models have different emphases, their core objective is to improve CSSD management quality and instrument sterilization effectiveness. A vertical analysis reveals a developmental trend towards refinement, automation, and intelligence. All nine management models are suitable for large and medium-scale hospitals. However, only the scientific management theory and the PDCA cycle are suitable for small hospitals. Different hospitals should select appropriate management models based on their resource configurations and actual needs, and continuously refine them by integrating modern technologies to achieve efficient CSSD operation.

KEY WORDS: Central Sterile Supply Department; Surgical instrument; Management model

The Central Sterile Supply Department (CSSD) is a vital hospital department responsible for ensuring the quality of medical devices and controlling nosocomial infections. Its primary functions include the recovery, cleaning, disinfection, packaging, sterilization, storage, and distribution of sterile items, notably surgical instruments. With the increasing variety of surgical instruments and expanding scope of clinical departments, risks within the CSSD are also rising. Numerous uncertain factors, such as non-standardized processes, unclear responsibilities, and complex instrument structures, can easily lead to nosocomial infections and subsequent medical disputes. Traditional management models often exhibit shortcomings in quality control (QC), creating an urgent need for professional, standardized, and scientific models to enhance management quality. Consequently, many scholars domestically and internationally have intro-

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duced different management models based on various management theories. Although these models differ significantly in their implementation paths and characteristics, research indicates that their application can achieve an effective cleaning rate for surgical instruments exceeding 95%[1-2]. Existing comparative analyses of different CSSD management models are often single-dimensional, lacking multi-dimensional comparison and systematic analysis. In response, this study conducts a horizontal analysis of nine common management models: the centralized management model, scientific management theory model, integrated care model, refined management model, whole-process QC model, Plan-Do-Check-Act (PDCA) cycle model, defect management model, quality collaboration management (QCM) chain model, and the three-chain (3C) model. Based on the focus of their mechanisms of action, these nine models are categorized into three types: process-oriented, QC-oriented, and responsibility chain-oriented. Additionally, a vertical analysis is performed for each management model to examine its development trends. Furthermore, the suitability of each model for different hospital scales is analyzed based on the model mechanisms, providing a basis for hospitals to select and optimize management models. The review is structured as follows.

1 Materials and Methods

1.1 Defined research purposes

The research purposes were defined according to the population, intervention, comparison, outcome (PICO) framework. The population (P) was surgical instruments processed by the CSSD. The intervention (I) was a specific type of management model applied within the CSSD. The outcome (O) consisted of indicators related to surgical instrument processing, such as the instrument sterilization qualification rate. Through literature review, the research purposes were determined as follows: What are the characteristics and application effects of different CSSD management models? What types of hospitals are different CSSD management models suitable for? What are the development trends of different CSSD management models?

1.2 Literature inclusion and exclusion criteria

Inclusion criteria: Literature related to the application effects of CSSD management models; literature for which the full text was accessible; study design: randomized controlled trials.

Exclusion criteria: Guidelines, policy documents, research protocols, research proposals, etc.; literature in languages other than Chinese or English; literature with incomplete data extraction; literature assessed as having a high risk of bias in quality assessment; duplicate publications.

1.3 Literature search

A systematic search was conducted in the following databases: Web of Science, PubMed, CINAHL, the Cochrane Library, Scopus, Embase, China National Knowledge Infrastructure (CNKI), Wanfang Database, VIP Database, and China Biology Medicine disc (CBM). The search employed a combination of keywords and free-text terms, followed by a summary analysis. The search timeframe spanned from the inception of each database to July 31, 2025.

English search terms were: "Central sterile supply department" OR "sterile supply center" OR "sterilization and supply center" OR "disinfection supply centre" OR "Central Supply" OR "CSSD" OR "Hospital supply center" OR "Sterilization supply center"; "management mode" OR "management model" OR "management pattern" OR "management" OR "management modes" OR "management system" OR "management model" OR "management approach" OR "cleaning management model"; "Forceps" OR "Speculum" OR "Surgical Clamps" OR "Surgical Clips" OR "Surgical Hooks" OR "Surgical Plugs" OR "Surgical Scissors" OR "Trocars" OR "Surgical Valve" OR "Tantalum" OR "Clips" OR "Surgical Instrument".

Chinese search terms were: "消毒供应中心" (Central Sterile Supply Department), "管理模式" (management model), "手术器械" (surgical instruments).

1.4 Literature screening

The retrieved literature was imported into the software NoteExpress to remove duplicate publications. Subsequently, three individuals trained in literature management screened the titles, abstracts, and full texts according to the inclusion and exclusion criteria to determine the final included literature. In cases of disagreement during the screening process, a third researcher was consulted to make the final decision on inclusion.

1.5 Data extraction and analysis

An Excel spreadsheet was created to extract data from the finally included articles. The extracted content included: orientation type, management model, literature first author, study type, sample size, hospital scale, and post-implementation evaluation indicators.

2 Results

2.1 Literature screening results

This study initially retrieved 644 articles. Preliminary screening by reading titles and abstracts resulted in 259 articles. Further screening by reading the full texts selected 61 articles. After excluding 39 articles assessed as having a high risk of bias in quality assessment, 22 articles were finally included, as detailed in Figure 1.

2.2 Basic characteristics of included literature

The 22 included articles pertained to the following management models: centralized management model, scientific management theory, integrated care model, refined management model, whole-process QC model, PDCA cycle, defect management model, QCM chain, and 3C model. Based on their orientation, they were categorized into three major types: process specification, quality control, and responsibility mechanism, as detailed in Table 1.

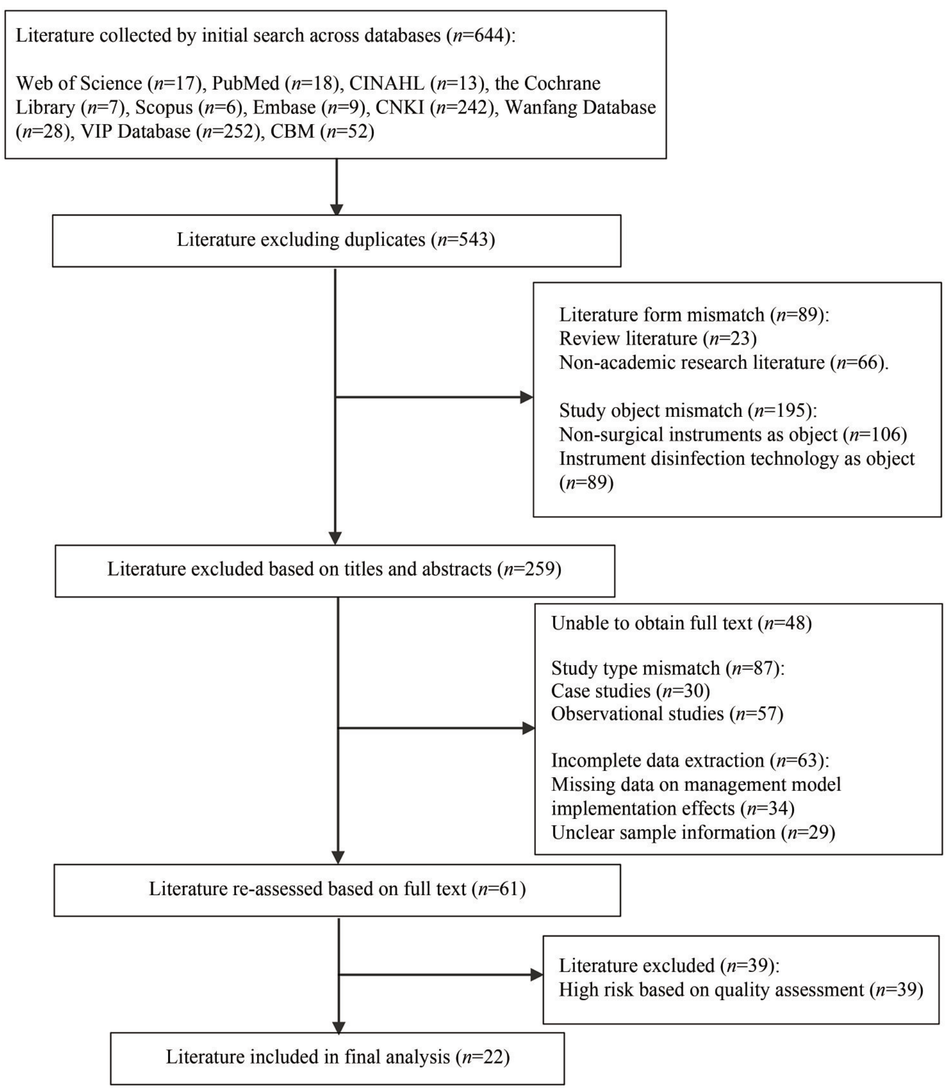

Figure 1 Literature Screening Flowchart

Table 1 Characteristics of Included Literature (*n*=22)

Orientation Type	Management Model	Literature First Author	Sample Size	Hospital Scale	Post-Implementation Evaluation Indicators
Process specification	Centralized management	QIN X J, ZHAO Y H, YANG L Y, 2022[3]	240 (Control/ Intervention: 120/120)	Tertiary grade A general hospital	①③④⑤
	Centralized management	LI A Q, REN X F, TANG S, et al, 2023[4]	200 (Control/ Intervention: 100/100)	Tertiary grade A general hospital	①③④⑤⑥
	Centralized management	YANG R Z, 2024[5]	80 (Control/ Intervention: 40/40)	Tertiary grade A general hospital	②⑤
	Scientific management theory	LIN Y, ZHU X Q, LI H L, 2020[6]	894 (Control/ Intervention: 447/447)	Tertiary grade A general hospital	①③④⑥
	Scientific management theory	GUO Z Y, JIANG D X, LI Y, et al, 2024[7]	200 (Control/ Intervention: 100/100)	Tertiary grade A hospital of traditional Chinese medicine	②③⑤
	Integrated care	XU H L, WU J, 2024[8]	144 (Control/ Intervention: 74/70)	Tertiary grade A general hospital	①③④⑤⑥
	Integrated care	ZHANG Y, ZHANG X Z, 2024[9]	160 (Control/ Intervention: 80/80)	Tertiary grade A general hospital	①③④
	Integrated care	HOU X Y, 2025[2]	200 (Control/ Intervention: 100/100)	Secondary specialty hospital	①③④⑤⑥
Quality control	Refined management	ZHAO M R, 2021[10]	300 (Control/ Intervention: 150/150)	Tertiary grade A general hospital	②⑤⑦
	Refined management	CHEN S M, LI X L, WU Z F, et al, 2023[11]	600 (Control/ Intervention: 300/300)	Tertiary grade A general hospital	①③④⑤
	Refined management	WU Y Q, 2025[12]	600 (Control/ Intervention: 300/300)	Secondary specialty hospital	①③④⑤⑥
	Whole-process QC	GENG H X, TANG J H, 2025[13]	2 000 (Control/ Intervention: 1 000/ 1 000)	Tertiary grade A general hospital	②③⑤
	Whole-process QC	ZHANG Q, HUANG Q, ZHANG W W, 2023[14]	680 (Control/ Intervention: 340/340)	Tertiary grade A general hospital	①③④⑥
	PDCA cycle	HUANG W Z, 2020[18]	1 277 (Control/ Intervention: 689/588)	Tertiary grade A general hospital	①③④⑤⑥
	PDCA cycle	WANG Y F, 2023[19]	600 (Control/ Intervention: 300/300)	Tertiary grade A general hospital	①③④
	PDCA cycle	ZENG C R, TANG X Y, 2023[20]	300 (Control/ Intervention: 150/150)	Tertiary specialty hospital	①③④
Responsibility mechanism	Defect management	YANG L Y, XUN Q, XU J, et al, 2022[21]	1 213 (Control/ Intervention: 611/602)	Tertiary grade A general hospital	①②④⑤⑦
	Defect management	LI S R, LI H Y, NIU C, et al, 2025[22]	726 (Control/ Intervention: 363/363)	Tertiary grade A general hospital	①③④⑤⑥
	QCM chain	WANG X P, LIANG Z M, ZHANG X, 2024[23]	105 (Control/ Intervention: 53/52)	Tertiary grade A general hospital	①③④⑤⑥
	QCM chain	QIU L J, DONG C H, 2024[24]	400 (Control/ Intervention: 200/200)	Tertiary grade B general hospital	①③④
	3C model	CHEN Y Y, GUO Y M, MO H X, et al, 2024[25]	156 (Control/ Intervention: 48/108)	Tertiary grade A general hospital & Secondary grade A general hospital	①③④⑤⑥
	3C model	ZHU X T, 2022[26]	172 (Control/ Intervention: 86/86)	Tertiary grade A general hospital	②⑤⑦

Evaluation indicators: ① Cleaning and disinfection effect; ② Cleaning qualification rate; ③ Sterilization qualification rate; ④ Satisfaction of medical staff with instrument management; ⑤ Nosocomial infection rate; ⑥ Quantitative disinfection and cleaning effect; ⑦ Improvement in medical staff competency.

2.3 Different management models and their applications

2.3.1 Process-oriented management models

Process-oriented management models center on organizational workflows and aim to standardize work content. They involve reordering, standardizing, and integrating segmented work. Their application effectively reduces error rates and significantly improves CSSD work efficiency.

2.3.1.1 Centralized management model and its application

The centralized management model has been formally incorporated into the Chinese national regulatory system since 2009. This model integrates decentralized resources by centrally coordinating and processing all reusable surgical instruments requiring disinfection or sterilization in the hospital through the CSSD. Its core lies in centralized information processing, centralized work monitoring, and zonal management, ultimately improving management efficiency and quality.

The First Affiliated Hospital of Zhengzhou University[3] adopted the centralized management model for surgical instrument cleaning in its CSSD. Post-operative instruments were collected by CSSD receiving personnel, with different cleaning methods selected based on instrument category. The qualification rate for surgical instrument disinfection increased from 84.17% to 98.33%. Chinese PLA General Hospital[4] established a centralized management team, assigned dedicated personnel for specific tasks, and enhanced training. The qualification rate for surgical instrument cleaning increased from 83% to 99%. Tianjin Baodi Hospital[5] introduced fully automated cleaning equipment. The qualification rate for surgical instrument disinfection and sterilization increased by 30% compared to before. It also reduced the workload for medical staff, lowered their error rates, and decreased label filling error rates from 20% to 2.5%.

The centralized management model covers complex instruments from multiple departments, making it applicable to large hospitals, such as tertiary Grade A hospitals, and medium-scale hospitals. However, small hospitals are limited by factors such as space constraints and insufficient equipment, which restricts the implementation of centralized management. Furthermore, although the model improves work efficiency by centralizing instrument processing, its initial implementation requires training medical staff to adapt to the unified instrument handover process. Some departments may exhibit resistance due to reduced convenience of use.

2.3.1.2 Scientific management theory and its application

Scientific management theory was initially proposed by Frederick Winslow Taylor in the United States and applied in industrial production. The CSSD gradually incorporated its concepts during its development. This model focuses on establishing, implementing, evaluating, and improving standard systems as its core, aiming to achieve standardized and efficient organizational operation.

Based on standards and norms for organizational management, Sichuan Provincial People's Hospital[6] optimized workflows to achieve standardization, regularly held staff training, and strengthened work supervision, thereby improving the cleaning quality of surgical instruments. Specially, the brightness appearance rate of surgical instruments after cleaning and disinfection increased from 91.28% to 99.78%, and the nosocomial infection rate associated with instrument use decreased from 2.01% to 0.45%. While emphasizing standardized operation, the scientific management theory continuously introduces new technologies. Shenzhen Traditional Chinese Medicine Hospital[7] adopted standardized pre-treatment combined with fully automated washers, which shortened cleaning time and improved cleaning effectiveness. The qualification rate for surgical instrument cleaning increased from 83.3% to 100%.

Scientific management theory has low implementation costs, and its standard processes are easy to replicate, making it suitable for various types of hospitals. It effectively improves instrument cleaning quality by strengthening standard implementation. However, standard formulation must consider clinical practicality; otherwise, it may inadvertently increase the workload of medical staff.

2.3.1.3 Integrated care model and its application

The integrated care model, first proposed by the Ministry of Health of the People's Republic of China (National Health Commission of the People's Republic of China for now) in 2009, emphasizes a "one-way flow" workflow, focusing on continuous quality improvement and process control. Its core involves reasonably simplifying operational steps, allocating resources, and improving work management efficiency.

Liaocheng Hospital of Traditional Chinese Medicine[8] and The 7th People's Hospital of Zhengzhou[9] implemented a system with dedicated personnel responsible for the reception, cleaning, packaging, sterilization, and monitoring of surgical instruments. The entire process utilized an information system for traceability, ensuring tight connections between all links. The qualification rate of surgical instruments was increased by over 20% in both hospitals. Binzhou Bincheng District People's Hospital[2] further strengthened the intelligent equipment, using advanced instruments such as pre-vacuum high-pressure steam sterilizers and temperature sensors, to effectively improve overall work quality. The qualification rates for instrument cleaning, sterilization, and packaging all increased by over 10%.

The integrated care model has high requirements for information technology and personnel operational skills. Any interruption or issue in a single link may reduce overall management efficiency and quality. Small hospitals often lack sufficient professional personnel and the financial resources to support information-based operations, making this model unsuitable for them, particularly for primary-level hospitals. It is better suited for large and medium-scale hospitals. It closely connects all links of surgical instrument processing, optimizing the workflow while improving efficiency. However, in inter-departmental collaboration, issues such as vaguely defined responsibilities and inadequate communication may arise.

2.3.2 QC-oriented management models

QC-oriented management models employ various methods, guided by the objective of improving quality, to enhance work and management standards. They facilitate high-quality operation of the CSSD and improve the quality of surgical instrument cleaning, sterilization, and related processes.

2.3.2.1 Refined management model and its application

The concept of refined management originated from a corporate management model in the Japanese automotive industry in the 1970s. It focuses on refining work processes and quantifying management goals as its core, aiming to improve management efficiency and work quality.

Tianjin Huanhu Hospital[10] strengthened staff awareness of refined management through training. In addition, it established quantitative and visual inspection requirements for daily operation links of surgical instruments, such as cleaning, disinfection, and sterilization. Fujian Cancer Hospital[11] optimized the organizational structure, scheduled shifts and formed groups based on the principle of separation of duties, and established a QC management team, while controlling details throughout the entire instrument processing workflow. This achieved clear responsibilities for each group and efficient management. Studies from both hospitals showed that the qualification rates for surgical instrument cleaning, disinfection, and sterilization increased to over 98%, and medical staff satisfaction reached over 95%. Maoming Occupational Disease Prevention Institute[12] introduced intelligent technology into the surgical instrument workflow, providing QR codes and databases, uploading information to an official online platform for unified management. This facilitated information consultation, reduced staff workload, and increased staff engagement by 28%.

The refined management model requires sufficient human resources, technological support, and financial backing. This model is applicable to large and medium-scale hospitals, but is generally unsuitable for small hospitals due to their limited funds and personnel, which would impose an operational burden. The refined management model effectively improves work quality by strengthening detailed management and control of all process links. However, the initial stage requires significant investment of human and material resources for data collection and detail control, resulting in higher costs. Thus, hospitals need adequate resources to support its implementation.

2.3.2.2 Whole-process QC management model and its application

The whole-process QC model focuses on improving nursing quality as its core. It starts from an overall perspective, optimizes all work links, emphasizes full participation, and implements quality supervision, effectively enhancing management quality.

The Supply Room of Kaifeng Central Hospital Wufulu Branch[13] strengthened quality control over each link of surgical instrument recovery, cleaning, classification, packaging, sterilization, inspection, and distribution, improving the work quality of the entire workflow. Their qualification rates all reached over 97%. HuaiHe Hospital of Henan University[14] further finely classified recovered surgical instruments, stored them in dedicated baskets, and performed targeted cleaning, improving the cleaning and sterilization quality of surgical instruments. The qualification rates for instrument cleaning and sterilization both exceeded 98%, and medical staff satisfaction with instruments increased to 100%.

The whole-process QC model optimizes all work links from an overall perspective. It requires investment in human and material resources, resulting in relatively high costs. It is suitable for large and medium-scale hospitals but not for small hospitals with limited resources. This model systematically standardizes workflows, comprehensively improving work quality. However, its implementation difficulty is high due to the requirement for full participation. Clinical departments may face increased QC tasks, potentially reducing medical staff motivation.

2.3.2.3 PDCA cycle and its application

The PDCA (Plan-Do-Check-Act) cycle was first proposed by Walter A. Shewhart, known as a founder of modern quality control, and was further developed by Dr. W. Edwards Deming[15-16]. Focusing on systematic continuous improvement, the PDCA cycle analyzes problems, implements targeted improvements, and accumulates experience through the four closed-loop stages of "plan, do, check, and act"[17].

Yunfu People's Hospital[18] and Tianjin Yongjiu Hospital[19] implemented per the four stages of the PDCA cycle. Plan stage: Identify problems in previous instrument management and formulate targeted improvement plans. Do stage: Conduct training on the improvement plan for CSSD and operating room nursing staff, and record implementation in real-time. Check stage: Head nurses inspect instrument management and record existing problems. Act stage: Evaluate the implementation effect of the plan. If problems are successfully resolved, accumulate and solidify successful experiences into standard processes or systems. Unresolved problems and newly identified problems are incorporated into the next PDCA cycle. The PDCA cycle improved instrument management quality and increased efficiency. At Yunfu People's Hospital[18], the qualification rates for surgical instrument cleaning and sterilization both increased by over 2%. At Tianjin Yongjiu Hospital[19], sterilization time was reduced by approximately 2 hours. Zhongshan Second People's Hospital[20] optimized the barcode traceability system through the PDCA cycle, achieving full-process traceability of instrument processing and improving traceability for medical safety. The qualification rate for instrument disinfection and sterilization increased by 17.60%, and clinical department satisfaction increased by 6.5%.

The PDCA cycle is conducive to continuously promoting CSSD work quality and increasing qualification rates for instrument disinfection and sterilization. Moreover, hospitals of all types can apply this model because a PDCA cycle is relatively easy to initiate and implement. However, since the PDCA cycle period can be long, a lack of effective supervision may lead to difficulties in executing plans, necessitating strengthened oversight.

2.3.2.4 Defect management model and its application

The defect management model focuses on problem-driven defect improvement. It covers the processes of surgical instrument cleaning and disinfection with a defect tracking mechanism, timely analyzes defect causes, proposes targeted solutions to correct defects, and evaluates the effect for continuous improvement.

Wuxi No. 2 People's Hospital[21] established a management team and applied a defect tracking mechanism to the cleaning and disinfection management of CSSD surgical instruments to timely identify problems, analyze causes, propose improvement plans, and monitor improvement progress. This not only improved the efficiency of surgical instrument cleaning but also enhanced medical staff's standard and preventive awareness. The qualification rate for surgical instrument disinfection increased to over 97%, and medical staff's infection awareness rate and standard implementation rate both increased by over 20%. Subsequently, The First Affiliated Hospital of Zhengzhou University[22] further improved the precision of medical staff's operational skills through discussion sessions and skill competitions, increasing the qualification rate for surgical instrument disinfection to over 98%.

Implementing the defect management model requires a certain volume of defect sample data. Insufficient samples make it difficult to conduct root cause analysis, which can easily lead to inaccurate analysis and ineffective defect resolution. Small hospitals typically have limited defect sample volumes, making them less suitable for implementing this model. Large and medium-scale hospitals possess sufficient defect sample data, facilitating its implementation. By starting from problems, this model identifies root causes and resolves them through defect tracking, effectively addressing recurring defects caused by imperfect quality inspection and monitoring mechanisms in traditional models. However, analyzing defects requires strong analytical capabilities. Analysts with insufficient ability may focus on surface issues, resulting in ineffective resolution.

2.3.3 Responsibility chain-oriented management models

Responsibility chain-oriented management models start from clarifying responsibility divisions. They improve clinical collaboration efficiency through the interaction of work management chains, establishing an orderly management system for the CSSD.

2.3.3.1 QCM chain and its application

The quality collaboration management (QCM) chain focuses on whole-process control, is based on full participation, constructs a multi-chain system to achieve closed-loop control of the entire process, refines responsibilities down to individuals, and forms an "operation-supervision-accountability" mechanism.

The Second People's Hospital of Qinzhou[23] established three chains: a sterile chain for surgical instruments, a staff responsibility chain, and a clinical service chain. It strengthened supervision and control over each chain to ensure their effective operation. This increased the qualification rates for surgical instrument recovery, packaging, distribution, cleaning, disinfection, and sterilization by over 13% each. The Fifth Hospital of Xiamen[24] further refined this model by strengthening the pre-treatment link, performing pre-soaking and pre-brushing for heavily soiled instruments. This increased the qualification rate for surgical instrument cleaning by 1.58% and reduced the bacterial detection rate from 2% to 0%.

The QCM chain requires multi-departmental collaboration to jointly form a collaborative management chain, thus it is applicable for large hospitals with many departments. Medium-scale hospitals, having fewer departments, can apply it to key departments rather than across the entire hospital. Small hospitals are generally less suitable for this model because they have few departments, simple work scenarios, low demand for chain collaboration, and often insufficient personnel. The QCM chain involves full-cycle monitoring and multi-chain collaboration, helping to improve work quality. However, multi-chain collaboration requires frequent communication and is prone to buck-passing among departments, necessitating further clarification of responsibility divisions.

2.3.3.2 3C model and its application

"3C" stands for responsibility chain, service chain, and sterile chain. This model centers on a "quality management team", whose members jointly formulate management regulations and conduct quality supervision and service over the entire sterile chain process.

The First People's Hospital of Zhaoqing and The Third People's Hospital of Zhaoqing[25] applied the 3C model. The Responsibility Chain clearly centered on the Quality Management Team for formulating regulations and supervising implementation. The Sterile Chain specified that surgical instruments be processed strictly according to standardized procedures. The Service Chain specified a patient- and clinical medical staff-centered service chain. The Quality Management Team conducted overall quality control, with the three chains closely connected, effectively improving surgical instrument cleaning and sterilization and medical staff satisfaction. The overall score for surgical instrument management quality increased by 2.14 points, and departmental staff satisfaction increased from 83.61% to 95.16%. Nanyang Central Hospital[26] further introduced fully automated intelligent washers for cleaning, improving instrument management quality and increasing cleaning efficiency and economic benefits. The qualification rates for instrument cleaning, packaging, and sterilization all increased by over 9%, cleaning time was shortened by 1~2 hours, and cost-effectiveness improved, saving approximately CNY 135, 600 per month.

The three chains are conceptually straightforward, making the model applicable to both large and medium-scale hospitals. However, small hospitals have few departments, insufficient personnel, and low demand for chain collaboration, making this model generally unsuitable for them. The 3C model effectively promotes inter-departmental communication and collaboration, improving team efficiency. However, the three chains are closely connected and may have overlaps, which could potentially lead to vague divisions of responsibility.

3 Discussion

3.1 Horizontal analysis of similarities and differences among three orientated management models

Within the same time dimension, focusing on the three orientated management models in the CSSD, a horizontal analysis was conducted centering on core objectives, mechanisms of action, implementation paths, and application effects, highlighting the differences and commonalities among different models. The aim was to clarify the applicable hospital types and core advantages of each model, providing a basis for model selection in practice.

Horizontal analysis revealed differences in core objectives and other aspects among the three orientated management models.

3.1.1 Process-oriented management models

Process-oriented management models focus on optimizing workflows and standardizing operational links, concentrating on reorganizing and standardizing work segments. The centralized management model emphasizes the unified allocation and centralized processing of dispersed resources, i.e., uniform collection and centralized processing of surgical instruments by CSSD personnel. Scientific management theory focuses on establishing and implementing a standard system, promoting operational compliance through measures such as system improvement, professional training, and assessment/evaluation. The integrated care model integrates the advantages of the first two, emphasizing tight connections between all links of instrument processing, combined with fixed personnel assignments to enhance efficiency across all links.

3.1.2 QC-oriented management models

QC-oriented management models focus on precisely improving work quality and reducing risks, concentrating on process control and continuous quality improvement. The refined management model achieves detail control through refining processes and quantifying goals. The whole-process QC model emphasizes full participation and global optimization, utilizing QC teams to supervise the entire process. The PDCA cycle focuses on closed-loop iteration, solidifying experience and solving problems through the spiral improvement of "Plan-Do-Check-Act". The defect management model is problem-driven, avoiding repeated errors through defect tracking and targeted rectification.

3.1.3 Responsibility chain-oriented management models

Responsibility chain-oriented management models focus on "clarifying responsibility division and strengthening collaboration efficiency", relying on work management chains to achieve responsibility transfer. The QCM chain constructs a multi-chain system and implements an "operation-supervision-accountability" mechanism. The 3C model achieves precise connection between quality management and clinical services through the deep integration of the responsibility chain, service chain, and sterile chain. These management models have different emphases, while their essence is to improve CSSD management quality through different paths.

Analysis based on the mechanisms, characteristics, and the hospital scales applying these models concludes that large and medium-scale hospitals, which possess sufficient human resources, technological support, financial backing, and large sample data, meet the different application conditions of these nine management models. Therefore, all nine models are suitable for large and medium-scale hospitals. Small hospitals have limited human and material resources and few departments, making it difficult to meet the application conditions for most models. However, scientific management theory and the PDCA cycle are relatively simple, easy to implement, and have low costs, making them suitable for small hospitals.

3.2 Vertical analysis of development trends of CSSD management models

Taking a single CSSD management model as the study object, a vertical analysis was conducted across different time periods to identify its evolutionary characteristics in technology application, management focus, and implementation logic. The core focus was on "models evolving with technology and changing according to clinical needs", ultimately extrapolating future development trends to provide directional guidance for industry management upgrading.

With the continuous development of modern technology, various management models show developmental trends towards refinement, automation, and intelligence. For example, in the study by YUAN Lu *et al.* [27], an information-based traceability system was applied to manage workflows, achieving full-process traceability and addressing process breakpoints and vague responsibilities in traditional models. Furthermore, in the study by GUO Zhuying *et al.*[7], fully automated washers were introduced, improving instrument cleaning efficiency and increasing medical staff satisfaction. These studies indicate that CSSD management is gradually transitioning from mere "system implementation" to "technology-driven precision management". The deep integration of technology and management has become a key pathway to enhancing the core capabilities of the CSSD.

4 Conclusion

The management models in the CSSD facilitate effective mitigation of the adverse effects associated with unqualified cleaning of surgical instruments[28]. The three orientated management models have different goal requirements and mechanisms of action. Among them, the process-oriented models focus on process standardization; the QC-oriented models center on improving work quality; and the responsibility chain-oriented models prioritize the interaction of work management chains. Different management models within each type differ in their implementation paths. Different hospitals should select and apply management models in a targeted manner, considering their own resource configurations and actual needs[29]. In addition, with the continuous development of advanced technologies such as intelligence and automation, hospitals should integrate these modern technologies to promote the continuous optimization of management models in practice, aiming to improve departmental work efficiency, optimize management systems, and increase medical staff satisfaction. This study only investigated nine common CSSD management models and did not cover less studied models. Future research should include other management models for comparative analysis. Furthermore, future efforts should increase research on the integration of informatization, intelligent technology, and management models, exploring the universality and durability of effects when applying informatization and intelligent technology to management models in hospitals of different scales.

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