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FUTURE-ADAPTIVE DENTAL CLINIC DESIGN: A PARADIGM FOR DYNAMIC EVOLUTION

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With the rapid advancement of digital technology and healthcare services, the spatial design of dental clinics is evolving from fixed models towards dynamic systems requiring continuous updating. This study proposes that future clinic design should prioritize adaptability across four key dimensions: spatial flexibility, digital integration, optimization through user feedback, and green, healthy environments. Through modular design, intelligent technology applications, and post-occupancy evaluations, clinics can achieve long-term, incremental improvements. This paper also examines potential challenges encountered in practical implementation alongside proposed solutions, aiming to provide guidance for the sustainable development of dental clinics.

Key words: dental clinic, interior design, future adaptability, iterative mechanisms, modularity, digitalization.

INTRODUCTION

The field of dental healthcare is currently undergoing significant transformation. The emergence of new technologies, such as digital scanning and AI-assisted diagnosis, coupled with heightened patient expectations regarding treatment experience and comfort, renders the fixed spatial layouts of traditional clinics ill-suited to meet evolving demands. Clinic spaces should no longer be conceived as static containers designed for a single iteration, but rather as living entities capable of continuous adaptation in response to user feedback, technological upgrades, and functional shifts. This transition necessitates designing with future changeability in mind from the outset. This paper explores how systematic design strategies can help dental practices maintain vitality and competitiveness throughout their long-term operation.

PURPOSE

This study primarily aims to achieve three objectives: firstly, to clarify the specific content and direction of future adaptive design for dental clinics; secondly, to propose practical improvement strategies by drawing upon successful experiences from other healthcare institutions; and thirdly, to identify key challenges likely encountered during implementation alongside corresponding approaches, thereby providing practical guidance for clinic managers and designers.



RESULTS AND DISCUSSION

The adaptability of future dental practices fundamentally lies in their inherent capacity as complex systems to navigate uncertainty. This necessitates a shift in design thinking from pursuing ultimate perfection towards cultivating potential for continuous evolution. It is worth noting that, owing to the relative scarcity of publicly documented, systematic spatial innovation cases within the dental practice sector, this paper has deliberately drawn upon more forward-thinking and mature practice examples from other healthcare institutions throughout its argumentation. Although these cases vary in spatial scale and service complexity, their core logic and design principles for navigating change, integrating technology, optimizing processes, and achieving sustainability offer high transferability and inspiration for dental practices. This study identifies and articulates four interrelated dimensions of adaptability, collectively forming a dynamic framework for design and operation.

Firstly, enhance spatial flexibility to accommodate potential changes. Adaptability forms the foundation for future-proofing. Modular design proves an effective approach to achieving this. For instance, the VA Medical Center Modular Eye Clinic employed factory-prefabricated modules assembled rapidly on-site, significantly minimizing disruption to normal hospital operations (Fig.1). The implication for dental clinics is this: during initial design, consider employing movable or adaptable partitions, reserve ample equipment conduit interfaces, and plan functional zones that are easily reconfigurable. This enables the addition of treatment rooms or introduction of new specialties at lower cost and in shorter timeframes, allowing spaces to be rearranged like building blocks.



Fig.1. VA Medical Center Modular Eye Clinic (Georgi, USA)

Secondly, digital integration is advocated to enhance spatial intelligence. Digitalization extends beyond acquiring new equipment; it involves embedding technology within spatial layouts and operational workflows [1]. At the infrastructure level, high-speed, stable networks must be pre-planned, with space and power reserves allocated for future servers and storage devices. Regarding service processes, clinics may draw inspiration from The Chinese University of Hong Kong Medical Centre's approach, which integrates functions like registration, payment, and enquiry through a unified digital platform to boost efficiency. Dental practices may install self-service kiosks in waiting areas and reserve interfaces for future AI diagnostic systems within consultation rooms. The ultimate goal of digitalization is



to create spaces that are perceptive and responsive, thereby enhancing clinical efficiency and patient experience.

Subsequently, feedback-driven optimization should be implemented to maintain alignment with genuine requirements. Effective design does not conclude upon completion but should undergo continuous refinement through usage [2]. It is recommended that clinics establish regular evaluation mechanisms, systematically gathering feedback on spatial experiences from patients and healthcare staff via questionnaires, interviews, and other methods. Drawing inspiration from Samsung Medical Centre's implementation of RFID and sensor-based logistics tracking – which reduced nursing workload by over 30% while enabling continuous process optimization – dental clinics may similarly conduct periodic Post-Occupancy Evaluations (POE) and surveys post-renovation. Based on feedback, incremental refinements such as adding storage lockers, replacing waiting chairs, or enhancing acoustic and lighting environments can be implemented, thereby establishing a feedback mechanism that maintains long-term adaptability.

Finally, ensure low-carbon health and cultivate a healing environment. Prioritizing environmental sustainability and health has become a vital responsibility for modern healthcare spaces [3]. This necessitates designing with passive energy-saving strategies, such as maximizing natural light and ventilation, while selecting low-VOC, easy-to-clean eco-friendly materials to safeguard indoor air quality. For instance, Singapore's KTHP Hospital significantly reduced air conditioning energy consumption by optimizing building layouts to enhance natural ventilation, while implementing rainwater harvesting systems to achieve water resource recycling (Fig. 2). Dental clinics should establish monitoring systems for metrics such as energy consumption and air quality, pursuing long-term operational goals of energy efficiency, health, and comfort.



Fig.2. Khoo Teck Puat Hospital (Singapore)

Despite clear direction, practical implementation faces considerable challenges. The most prominent conflict lies in achieving flexible spatial configurations while strictly adhering to infection control protocols. Furthermore, the substantial upfront investment in modularization and digitalization, coupled with extended payback periods, necessitates comprehensive cost-benefit analysis. Compatibility issues within information systems, data security concerns, and mechanisms for continuously gathering feedback and implementing improvements also present obstacles requiring resolution. Moving forward, the industry must collectively explore: developing design guidelines that balance infection control with



flexibility; clarifying the value of long-term investments through practical case studies; constructing standardized digital platforms that facilitate seamless integration; and establishing low-cost, high-efficiency mechanisms for continuous improvement.

CONCLUSIONS

The future dental practice's core competitiveness will partly hinge upon the capacity of its spatial systems to undergo continuous evolution. By establishing a framework integrating spatial resilience, digital intelligence, feedback loops and green health, clinics can transform from static treatment venues into comprehensive platforms dynamically adapting to technological advancements, service requirements and patient needs. This evolution demands designers, managers and all stakeholders to embrace long-termism and iterative thinking, shaping genuinely future-oriented healthcare environments through continuous refinement.

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АДАПТОВАНИЙ ДО МАЙБУТНЬОГО ДИЗАЙН СТОМАТОЛОГІЧНИХ КЛІНІК: ПАРАДИГМА ДЛЯ ДИНАМІЧНОЇ ЕВОЛЮЦІЇ

З розвитком цифрових технологій та медичних послуг, дизайн простору стоматологічних клінік переходить від фіксованої до динамічної системи, яка потребує постійного оновлення. Дослідження виділяє чотири ключові напрями адаптації: знучкість простору, цифрову інтеграцію, оптимізацію на основі відеуків та створення екологічно чистого та здорового середовища. Використання модульного дизайну, інтелектуальних технологій та оцінювання після введення в експлуатацію дозволяє забезпечити поступове вдосконалення клінік. Також аналізуються виклики впровадження та пропонуються практичні рішення для сталого розвитку стоматологій.

Ключові слова: стоматологічна клініка, дизайн інтер'єру, адаптивність до майбутніх змін, ітеративні механізми, модульність, цифровізація.