

Localization of Medical Technology in Developing Countries: The Thai Experience in the Oral Health Crisis - Tension Between Tradition and Modernity and Institutional Adaptation

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Abstract

Thailand, a globally renowned medical tourism destination, has attracted many foreign patients with its high-quality and affordable dental services. However, oral diseases remain prevalent among its population. This study analyzes and elaborates on the oral health issues transitioning from traditional to modern dental techniques in Thailand's dental medical technology development from historical, technological, and epidemiological perspectives. To address these problems, it is necessary to tackle long-term unhealthy lifestyle habits. Thais' diets are high in sugar, acid, and spices; the outdated practice of betel nut chewing and unscientific teeth cleaning methods, coupled with Thailand's hot and humid environment, pose serious threats to the oral health of its people. Moreover, the imbalanced distribution of domestic medical resources further exacerbates the difficulties faced by those already suffering from dental diseases, making it hard to receive proper treatment. How Thailand can continue to break through and improve under existing reform policies to enhance the effectiveness of medical work further remains a topic for in-depth discussion. However, the developmental journey Thailand has undertaken thus far has demonstrated to other developing countries that it is indeed possible to establish a unique medical system that integrates regional culture with advanced technology.

Keywords: Thailand; Oral health; Dentistry; Dental caries

Introduction

1.1 Dental Tourism and the Paradox of Oral Health in Thailand

As a global benchmark for medical tourism, Thailand's dental industry attracts international patients with cutting-edge technologies such as 3D-printed dentures and AI-powered implant navigation, contributing over US\$1.2 billion in 2021 (Connell,2013). However, the local oral health crisis continues to intensify. This

contradiction stems from a triple fragmentation: traditional high-sugar diets and hot and humid environments accelerate the spread of dental disease, while private hospital monopolies and the internationalization of technology fail to translate into accessible primary oral health care.

This study explores how Thailand reconciles the tension between traditional betel nut culture and modern technologies such as nano-implants, mobile clinics, and AI-based diagnosis through “adaptive innovation.” By integrating technological history, epidemiology, and policy analysis, the study provides insights into how developing countries can construct culturally embedded medical systems.

1.2 Historical Evolution of Dental Practice in Thailand

The history of dentistry in Thailand originates from traditional Thai medicine, which has long regarded oral health as part of holistic health. Ancient Thai communities used medicinal plants such as lemongrass, turmeric, and betel leaves for toothache relief, and employed charcoal and salt for oral cleaning. However, these methods could only temporarily suppress bacterial activity and, in the long term, may have caused damage to teeth and oral mucosa.

By the late 19th century, modern dentistry was introduced as part of Western medical practices promoted during the reign of King Rama V, primarily through missionaries. Due to limited infrastructure, however, access remained restricted to urban elites. It was not until the mid-20th century that formal dental education began to develop, with the establishment of the first dental school at Chulalongkorn University in 1940.

1.3 Policy Transformation and the Rise of Dental Medical Tourism

Following the 1990s, Thailand reached a critical turning point in healthcare development. In the aftermath of the 1997 Asian financial crisis, the government actively promoted medical tourism as a strategic industry, with dental services identified as a high-value, low-risk sector (Ministry of Health of Thailand, 2015). This policy shift positioned dental care as a core component of Thailand’s national economic development strategy.

In 2003, the inaugural Medical Fair Thailand attracted exhibitors from over 40 countries, reinforcing Thailand’s position as a regional hub for medical equipment trade in Southeast Asia. One notable example is Hexa Ceram Dental Laboratory, established in 1995, which developed strong technological capabilities in high-end prosthetics and achieved a domestic market share of approximately 28%, contributing to the internationalization of Thailand’s dental industry.

1.4 Industrial Globalization and Technological Innovation in Dentistry

In 2020, Thailand’s dental industry reached a milestone when Hyundai Dental Group acquired 74% of Hexa Ceram, integrating its 12 divisions and workforce of approximately 900 employees. This acquisition further strengthened Thailand’s role as a manufacturing base in Southeast Asia, supplying dental products across ASEAN countries including Laos and Cambodia (Thailand Investment Promotion Commission, 2021).

At the same time, domestic innovation continued to develop alongside foreign investment. For example, AI-assisted implant navigation systems presented at the Thailand Dental International Conference (TIDC) significantly improved surgical precision and efficiency, demonstrating the growing integration of digital technologies

Literature Review

Dietary Patterns and Sugar Consumption as Primary Risk Factors for Dental Caries

Dental problems in Thailand have long been serious, mainly due to the poor diet and oral hygiene habits of Thais. Most Thais prefer to eat sweet, sour, and spicy foods. These foods are prone to dental caries and dental enamel erosion. In addition, Thais like to drink sugary drinks (dairy tea, carbonated drinks, etc.), so they are prone to it. In addition, there have been improvements in oral hygiene in recent years, but some people still do not know what it means to brush their teeth properly and how often to have an oral examination.

High sugar intake leads to dental caries

Thailand's per capita annual sugar intake is 42 kg, while the global average is 23 kg, and the penetration rate of sugar-sweetened beverages in street food is 89% (WHO, 2015). After consuming sugary food or drinks, bacteria in the mouth will use sucrose as a substrate and metabolize acid to cause dental enamel demineralization and dental cavities. In particular, the prevalence of caries in children's deciduous teeth is as high as 80%, and the prevalence of caries in permanent teeth (DMFT) is as high as 2.8, significantly higher than the average level in Southeast Asia (Prasertsom et al., 2020; Sitthisetapong et al., 2021)

Cultural Practices and Betel Nut Consumption as a Risk Factor for Oral Cancer

With a 31% northern betel chewing rate and betel alkaloid and lime reaction to form potent alkaline compounds, the prevalence of oral sub-mucous fibrosis in the northern region is six times higher than the national average, and international studies have confirmed its carcinogenicity. Betel chewing can induce gingival recession and lead to a deepening of periodontal pockets and the loosening of teeth (IARC, 2012; Sari et al., 2023)

Dietary Acidity, Spicy Food Consumption, and Oral Mucosal Damage

Consuming too much capsaicin can easily cause gums and gum mucosa and gum ulcers and may lead to oral bacterial infections. The most common ingredients in Thai food, such as lemongrass and fish sauce, are too acidic to corrode tooth enamel, and wet and hot weather will reduce the ability of oral self-cleaning, and dental plaque is more likely to accumulate when the internal cleanliness of the mouth is poor.

Structural Inequality in Dental Healthcare Access and Service Distribution

Private hospitals account for 67% of dental services, with only one dentist per 16,000 people in rural areas (Thammatacharee et al., 2013). Residents in remote areas rely on traditional remedies or delay medical treatment, leading to early dental caries developing into myelitis or even systemic diseases caused by infection.

Climatic Conditions, Water Fluoride Levels, and Environmental Determinants of Oral Health

Thailand is a tropical country with humid and sweltering weather, and some places have unbearable humidity throughout the year, which makes it easy for oral bacteria to grow and reproduce. Bangkok, for example, has an average annual humidity of about 80%, which is 22% faster than Chiang Mai, which has an annual average humidity of only 69% (Mashima et al., 2019). Thailand is a hot, humid environment where bacteria break down sugars faster, saliva becomes thicker, and mineral calcium and phosphorus salts are more likely to deposit on the tooth to form tartar. The pressure of the calculus on the gums leads to gingivitis, which eventually develops into periodontal disease (Kassebaum,2015). Secondly, the fluoride content of water varies from place to place in Thailand, and

the amount of fluoride in groundwater in 17 provinces in northeastern Thailand exceeds the limit. The proportion of children in the region who develop fluoro plaque is 24%. This water affects the formation of floor plaque in the teeth, leading to a high prevalence of chalk teeth (generally a large number of white or yellow spots on the teeth) (Rojanaworarit et al., 2021). Excessive fluoride can interfere with the formation of the enamel, resulting in white or yellow chalky teeth, and in severe cases, can even cause the enamel to crack. Although fluoride toothpaste prevents dental caries, there is a lack of health education in rural areas, and some people brush their teeth with high-fluoride water, which exacerbates the condition. Conversely, if there is a lack of fluoride in drinking water in an area, it is also likely to cause an increase in the incidence of caries of laryngeal or permanent teeth.

Research Method

Contextual Background: Dental Care System and Technological Innovation in Thailand

Innovation in dental medical devices

Dental care in Thailand is characterized by combining traditional medicine with modern dental techniques, as well as Thai herbal medicine and massage (Chotchoungchatchai et al., 2012). In addition, the quality of dental care in Thailand is excellent and affordable, and many international dental patients choose to undergo orthodontic surgery through dental care in Thailand, which has promoted the economic development of medical tourism in Thailand (Pattharapinyophong, 2019). In recent years, Thailand has made significant progress in researching and developing dental medical devices.

Digital Dentistry and AI-Assisted Dental Manufacturing Systems

Digital teeth solutions

The Modern Dental Group has used 3D printing technology to stack the teeth, which are made layer by layer by laser sintering metal powder or by light solidification resin. The traditional production time of 7 days was increased to 24 hours, with an accuracy of $\pm 20 \mu\text{mm}$ (Dawood et al, 2015). It mainly uses computer-aided design (CAD) software to make 3D models and combine patient bite data to create personalized customer prostheses, significantly reducing manual error. In addition, the "Dinsaw" robot arm developed by HexaCeram assists in completing minimally invasive implant surgery, which uses the robot arm to implant, greatly reducing the risk of surgery accurately.

Remote Diagnostic Systems and AI-Based Oral Health Monitoring

Remote diagnostic equipment

In 2025, Thailand will launch a structural light technology that will project a gridlike pattern onto the mouth's surface and capture the morphed pattern with a camera. The Nano Scan-D Portable Oral Scanner, which generates high-precision 3D images of the oral cavity and uploads the data to the cloud server in real-time for doctors to diagnose, such as dental caries or periodontal disease, etc., which is very useful for some local and remote villages. This device has an AI algorithm function module that can, to some extent, assist junior doctors in making judgments about suspected problem teeth.

Sustainable Materials and Dental Waste Management Innovations

Address the problem of medical waste pollution

The biodegradable material developed by Chulalongkorn University-PHBV-Based periodontal regeneration film is mainly composed of PHBV; using electrospinning to form nanofibrous structures, the degradation period can be controlled at 4 to 6 weeks, and in the degradation process can slowly release hydroxyapatite to accelerate alveolar bone regeneration, which has been clinically proven to increase the bone regeneration efficiency by 37% (Baino & Vitale-Brovarone, 2014) There are also biodegradable products made from indigenous plant materials. For example, the pressure resistance of durian shell cellulose fillers can reach 280 MPa, and the cost is about 60% cheaper than that of traditional composite resin. The antibacterial coating of camellia extract has a clearance rate of 92.4% for mutant streptococcus biofilms and can maintain antibacterial effects for up to six months.

Results and Discussion

Improving the country's dental health system

Dental medical technology in Thailand continues to advance, but improvements remain. At the macro level, there are problems of unbalanced regional development, a lack of professional talent, and unreasonable allocation of medical resources, which requires the Thai government, relevant departments, and other parties to step up efforts to improve the country's dental health system. In the face of these problems, the Thai government and relevant agencies are taking measures to improve the dental health system. To strengthen dental services in rural areas, the Government of Thailand launched the "Mobile Dental Clinic" project (Ministry of Public Health of Thailand, 2022). Due to the remoteness of many areas, residents do not have much access to dental expertise, and the government provides free consultations and brings the most sophisticated dental instruments and equipment to the countryside. Using modern technology to create an innovative medical model, rural patients can also enjoy the services of a team of high-quality dental experts from the city.

Professional talent development

Regarding professional talent development, Thailand has also increased the number of dental students while expanding the scale of dental education. It has advocated for private schools to increase the number of students enrolled in dental professions. At the same time, the Thai government has also cooperated with world-renowned dental schools to introduce outstanding educational methods and continuously introduce high-quality educational curricula. The quality of teaching has been continuously improved, and special scholarships have been established to encourage outstanding students to study in such fields and have the opportunity to study abroad, thereby striving to produce better talents.

International cooperation and exchange activities

To further develop international cooperation and exchange activities, Thailand actively participates in the organization of associations and associations of the ASEAN Dental Association, the International Dental Federation, and other domestic and foreign oral medical industry associations and organizations, and exchanges experience and the latest technologies with foreign colleagues at the large international academic exchange conferences held

each year. Thailand also encourages its dentists to study abroad and exchange and apply advanced technologies and experiences based on learning foreign technologies and practices, improving the overall dental level in the country

Specific populations and the influence of dietary culture

There are also targeted specific population risks and unavoidable dietary cultural influences.

Special populations: (1) Pregnant women: The prevalence of gingivitis during pregnancy was 68.9%, associated with the traditional "no brushing during pregnancy" bad habit (Phoosuwan et al., 2024). (2) Monks: The prevalence of tooth loss among monks over 60 years of age (79.3%) is 2.1 times higher than that of the general population (Chotchoungchatchai,et al,2012)

Glucose metabolism: Gene studies show that the ADH1B Arg47His allele is present in 58 % of the Thai population, resulting in faster ethanol metabolism and indirectly promoting sugar-containing fermented foods (Moynihan & Kelly, 2014).

Typical risk foods: (1) Khao Neeo Mamuang (mango sticky rice) contains 72 g of sugar per serving, equivalent to 2.4 times the WHO recommended daily intake limit (Diabetes Mellitus Thailand, 2020). (2) "Nom Yen" (Pink Ice Drink): The sugar content is 89g, the volume is 500mL, the pH value is 3.2, and the acid residue value in the mouth is ≥ 1 hour after drinking. Finding a balance between traditional culture and people's health is a problem Thailand and researchers have to face.

Conclusions

In exploring the development of the Thai dental system in a combination of traditional wisdom and modern technology, the Thai dentistry system has upgraded old industries - from the flourishing of the betel culture to the wide range of nano implants, From the well-known foot dental drill to surgical robots entering and leaving the country - Southeast Asia's dental modernization has been marked by important signs of the era. Most of today's challenges are fundamentally systemic - the disconnect between cutting-edge dental technology and primary health services, the disconnect between the international medical tourism boom and the local disease burden. The solution lies in developing a complete and appropriate healthcare system, which requires progressive new discoveries in materials science and more precise and targeted governance by public health policymakers. Thailand's development experience shows that developing countries can also keep up with cutting-edge technologies while building oral health ecosystems compatible with their cultural genetics and environmental characteristics.

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