INVESTIGATING STRATEGIES TO DEVELOP AND RETAIN THAI HEALTHCARE PROVIDERS' BRAND LOYALTY FOR THAI DENTAL X-RAY DEVICES

BY

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ABSTRACT

In addition to the increasing prevalence of Non-Communicable Diseases in Thailand, which presently account for 74% (400,000 lives annually) of all deaths within the country, and the health challenges of Thailand's ageing population, the COVID-19 pandemic has been a wake-up call highlighting the urgent need for a self-sufficient national medical care supply chain.

In Thailand, the market for medical equipment was worth 4.47% of the country's total gross domestic product in 2021 and is expected to increase 10.0% annually from 2022-2026. At present, only 3 out of 10 of the major medical device companies operating in Thailand are owned by Thai shareholders, and the country's position as an Original Equipment Manufacturing country faces issues of low-profit margins, a lack of bargaining power, and higher labour costs, none of which encourage the growth of businesses in a sustainable long-term way.

As part of the necessary actions to address these shortfalls, it is proposed that good branding and market awareness are imperative to help Thailand's medical device industry successfully transition to Original Brand Manufacturing. In this work, the study of which X-ray devices brands are used in Thai dental clinics, and why, has been chosen due to their major role in public dental health, national wellbeing, wellbeing tourism, and the sizeable market potential of Thailand developing high quality X-ray devices of

its own. Furthermore, this work investigates ways to add extra value, provide a higher quality of care and allow dentists to make safer, more informed treatments for their patients. The main objective of this study is to examine the facets of brand awareness and brand image which impact the purchasing behaviour of Thai dental practitioners. Through detailed secondary research, semi-structured qualitative interviews with dentists who have experience purchasing dental X-ray units and those that use them, and thematic analysis of the results, this study expects to provide insights into the current medical device ecosystem that can be used to increase market awareness and design new branding guidelines to lead Thai X-ray device brands towards a sustainable and resilient future for their business ecosystem stakeholders.

Keywords: Branding Strategy, Country-of-Origin Brand Image, Medical Device, Dental X-ray, Original Brand Manufacturing (OBM), Wellness Industry

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Naphat Jittavisutthikul

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LIST OF ABBREVIATIONS

Symbols/Abbreviations	Terms
ACP	American College of Physicians
ALARA	As Low As Reasonably Achievable
ASEAN	Association of Southeast Asian Nations
B2B	Business-to-Business
BCG Economy	Bio Economy, Circular Economy, and Green Economy
BMA	Bangkok Metropolitan Area
BSc	Bachelor of Science
CAD	Canadian Dollars
CAGR	Compound annual growth rate
CBBE	Customer-Based Brand Equity
CBCT	Cone-Beam Computed Tomography
COO	Country-of-Origin
CE Mark	Conformité Européenne Mark
CEO	Chief Executive Officer
CRM	Customer Relationship Management
CST	Corporate Social Responsibility
CT	Computed Tomography devices
CX	Customer Experience
DBD	Department of Business Development
DDS	Doctor of Dental Surgery
DfS	Design for Sustainability
ECG	Electrocardiogram devices
EEC	Eastern Economic Corridor
EEG	Electroencephalogram
EPA	Environmental Protection Agency (USA)
Est.	Established
EUR	Euro

FDA	Food and Drug Administration
GDP	Gross Domestic Product
KMITL	King Mongkut's Institute of Technology Ladkrabang
LMIC	Low and middle-income countries
MD	Managing Director
MNC	Multinational company
MSc	Master of Science
MoPH	Ministry of Public Health
MRI	Magnetic Resonance Imaging
μSv	Microsieverts
N/A	Not available
NESDC	National Economic and Social Development Council
NSTDA	National Science and Technology Development Agency
NCDs	Non-Communicable Diseases
No.	Number
NTP	National Toxicology Program
OAP	Office of Atoms for Peace
OBM	Original Brand Manufacturer
ODM	Original Design Manufacturer
OEM	Original Equipment Manufacturer
ONESDC	Office of the National Economics and Social Development Council
PET	Positron Emission Tomography devices
PSS	Product-Service Systems
PhD	Doctor of Philosophy
R&D	Research and Development
RU	Rangsit University
SME	Small and medium-sized businesses
SPAC	State Bureau of Pharmaceutical Administration of China
THB	Thai Baht
TGA	Therapeutic Goods Administration

USFDA	US Food and Drug Administration
WHO	World Health Organization

CHAPTER 1
INTRODUCTION

1.1 Research Rationale

The COVID-19 pandemic has highlighted the urgent need for national self-sufficiency in terms of medical care. In Thailand, the market for medical equipment is responsible for 4.47% of the country's total gross domestic product (GDP). In addition to this, the industry as a whole is quickly growing, with a growth rate of 6.5% each year (Ken Research, 2022), A major issue with regard to this is that the industry is predominantly dependent on foreign companies that have established their manufacturing bases in Thailand. At present, only three out of ten of the largest medical device companies in Thailand are predominantly owned by Thai shareholders. (Krungsri Research Center, 2021).

According to the findings of existing research by Jantarakolica (2015), Thailand’s export manufacturing industry is predominantly an original equipment manufacturing (OEM) and original design manufacturing (ODM) location for foreign trading partners. As a result of its present positioning, the industry faces issues such as low bargaining power, low profit margins, and higher costs of labour, none of which are conducive to the growth of businesses in a way that is sustainable over the long term. To address this issue, Thai manufacturers need to make the transitions to Original Brand Manufacturer (OBM) and Original Design Manufacturer (ODM) (which design ready-to-manufacture products for OEMs to produce). By doing this Thailand can develop its own device designs and build its own original brands.

Because of the present situation, the existing research into business-to-business (B2B) branding in the medical device sector has been lacking, particularly in the Thai context. This study is being undertaken to help to address this shortfall.

1.2 Aim

The aim of this study is to design a brand strategy to develop the brand image and market position of Thai X-ray devices amongst Thai healthcare providers, through investigating the brand awareness, brand image, and the purchasing behaviour of dental clinics in Thailand.

1.3 Objectives

The objectives of this study are to:

1) Examine the brand awareness, brand image, and purchasing behaviour of Thai dental providers with regard to X-ray device brands in the Thai market in order to understand the current medical device ecosystem.

2) Study successful case studies of X-ray brand strategies around the world in order to apply the findings and insights gained towards the Thai market.

3) Analyse the gaps in the current market for the development of Thai-owned X-ray device brands.

4) Design a branding strategy to improve brand loyalty towards Thai brands for the sustainable and resilient growth of the Thai medical device industry and its ecosystem.

1.4 Expected Outcomes

The expected outcomes for this present research are to precisely identify brand awareness, brand image, and purchasing behaviour from the perspective of Thai dental care providers. The existing best practices of X-ray device brand strategies in the global industry will be outlined and discussed along with their potential adaption into Thai context, as will Identifying and suggesting possible areas for improvement and measures that can be taken to address the challenges that are limiting the Thai X-ray device brand growth and customer retention. The insights obtained will be used

to design a new branding strategy to develop Thai X-ray device brands towards a sustainable and resilient future for their business ecosystem stakeholders.

This research intends to help fulfil the current research gap in the branding aspect of medical devices industry, especially for applications in the Thai context. The parties expected to be able to benefit from the findings of this paper include the national economy, X-ray device manufacturers and retailers, policy makers, healthcare workers and students, technology-based Small and Medium-sized Enterprises (SMEs), and those who are interested in the development of public health resiliency.

CHAPTER 2
REVIEW OF LITERATURE

2.1 Thai Medical Device Industry

In 2019, Thailand's medical device industry was valued at 4.47% of the country's Gross Domestic Product (GDP) (Krungsri Research, 2021), and it is expected to grow 6.5% per year over 2022-2023. According to Ken Research (2022), it is predicted to increase at a 10.0% compound annual growth rate (CAGR) each year from 2022-2026.

2.1.1 Trends Supporting the Industry's Growth

The growth of the Thai medical device industry is supported by the following factors: Firstly, the rising prevalence of non-communicable diseases (NCDs), which in Thailand, account for over 74% (400,000 lives annually) of all deaths within the country, costing the economy 1.6 trillion Thai Baht (THB) annually (WHO, 2021). Oral care impacts health, and dental diseases increase the prevalence of NCDs and poor general health (Wolf et al. 2021). Peres et al., (2019) note that oral diseases disproportionately impact low and middle-income countries, of which Thailand is one; therefore, improving dental care will help reduce the prevalence of NCDs and mitigate injuries or deaths caused by poor dental care.

Secondly, the ageing population requires more complex and frequent medical procedures, including long-term geriatric care, in which the treatment of elders often involves addressing multiple health problems, leading to more complex service and procedure requirements (Kumlin, 2020). Thailand has been a fully-aged society since 2022, one of the first developing nations with over 20% of its population aged 60 years and over (Department of Older Persons, 2020). The ageing of the population is expected to result in Thailand becoming a fully-aged society by 2040 (**Figure 2.1**). Therefore, Thailand needs to develop its capabilities with regard to becoming self-reliant within the healthcare industry (NSTDA, 2021). Being able to offer

improved dental care will help dental procedures to be more effectively and efficiently carried out for members of the ageing population.

Figure 2.1 Changes in Thailand's Population Demographics from 2020 to 2040. (PopuationPyramid.net, 2023).

Thirdly, medical tourism also has to be taken into account. Thailand has the fourth largest medical tourism industry in the world, and the resurgence in medical tourism is driving growth in Thailand's medical devices market with regard to quality healthcare and medical equipment (Ken Research, 2022). Medical infrastructure is also highly developed for Thai therapeutic treatment in accordance with modern

medicine, suitable climate, and environment (Future Market Insights, 2022), helping provide a unique selling point for patients seeking holistic treatment. The proposed improved operational safety aspect as related to dental X-ray brands could additionally provide a unique selling point for Thai brands and help Thailand become a world leader on this issue.

2.1.2 Public Sector

Hence, as a result of the trends shown in Thailand, the government sector has put forth policies and agendas pushing for these issues to become a priority, including the Bio Economy, Circular Economy, and Green Economy (BCG) Economy Model, which was introduced to aid in post-pandemic recovery (NSTDA, 2021). The BCG model provides emphasis on the application of science, technology, and innovation, increasing the capabilities of these three pillars and nurturing Thailand's competitive advantages in the area of biological and cultural diversity. The model is explored further and strategically focuses on the promotion and development of four sectors: Agriculture and Food; Wellness and Medicine; Energy, Materials and Biochemicals; and Tourism and the Creative Economy (NSTDA, 2021).

One of its eight target sub-sectors within the wellness and medicine sector, specifically, focuses on the development of medical devices. Its main goals are as follows (Komchadluek, 2022):

1) Create public health resilience and independence.

2) Reducing social inequality in accessing healthcare.

3) Increase investment in the medical device industry to drive economic growth.

4) Develop the potential of Thai medical device entrepreneurs.

Similarly, another government initiative, this time to promote the development of an innovation cluster, is the Eastern Economic Corridor (EEC) which is located in the Chonburi, Rayong, and Chachoengsao provinces of Eastern Thailand (Rastogi, 2018). This has secured an investment capital of over 600 million THB, and its area of focus includes 10 sectors, one of which is Medical and Comprehensive Healthcare (EEC Office, 2019).

Lastly, written in Dimension 3 of Plan 13 of the Office of the National Economic and Social Development Council (NESDC), is that council's goal to provide security for the elderly population, which includes initiatives such as improving the quality of life and wellbeing of elderly people through reducing the percentage of population of elderly who exist in poverty to less than 4% (the current situation is 7.2%), increasing the elderly's access to long term national public healthcare scheme to 70% or higher, and promoting suitably designed living space renovations (NESDC, 2022). Within Plan 13 documents, there is also encouragement given to the idea of purchasing and using good quality, safe, and economical medical products manufactured domestically, especially by public healthcare institutions and medical schools, through tax incentives and the inclusion of Thai medical products with international standards as a requirement for medical institutions and medical services. As indicated by the above, the scene is set for disruptive change which the Thai medical industry could substantially benefit from.

2.1.3 Private Sector

Thailand is the greatest importer and exporter of medical devices amongst the Association of Southeast Asian Nations (ASEAN) countries (EEC Office, 2019). Due to its strategically advantageous location in the heart of Southeast Asia it has strong export opportunity within the region. Krungsri Research Center (2021) found that Thailand's main medical device exports are single-use products such as latex gloves, syringes, and needles. The demand for medical devices connected to the healthcare and hygiene sector is found to be increasing in both Thailand and abroad. This is likely set to continue as the world's population ages. In 2020, the value of Thailand's medical device exports was approximately $5 billion (Bangkok Post, 2021). This was in part due to Thailand being one of the world's major exporters of surgical gloves and masks, both of which were crucial for the medical sector during the COVID-19 crisis. The key export destinations include the United States of America, Japan, the Netherlands, and Germany. Most of these are countries that have set up manufacturing plants in Thailand, therefore reflecting the presence of multinational companies within the Thai medical device industry (Bangkok Post, 2021).

There are 965 manufacturers of medical devices that were registered with the Department of Business Development as of June 2021. 98.0% of them are small and medium-sized businesses (SME), which collectively generated a 19.1% share of total revenue. Large manufacturers make up another 2.0% of the economy and account for 80.9% of overall revenue, demonstrating a large disparity amongst large versus small players. The vast majority of large manufacturers are owned by multinational companies (MNCs). Kawasumi Laboratories (Thailand), Hoya Optics (Thailand), and Nipro (Thailand), are some of the companies that fall under this category. In the meantime, information provided by the Food and Drug Administration reveals that there are more than 2,000 registered importers of medical devices, more than twice the number of producers (Krungsri Research Center, 2021).

The manufacturing of Irradiation, electromedical, and electrotherapeutic equipment is categorised under the C category (Manufacturing) by the Department of Business Development. (DBD DataWarehouse, n.d.). There are various sub-categories to this:

Sub-category 26600: The business activities of companies registered under this sub-category includes the production of radiation generators and tubes (e.g., for use in manufacturing for the diagnosis, treatment, scientific research), Beta-ray, Gamma-ray, X-ray, or other types of radiation generators. The production of Computed Tomography devices (CT Scanner), Positron emission tomography devices (PET Scanner), Magnetic Resonance Imaging devices (MRI Scanner), ultrasound devices, electrocardiogram devices (ECG), Endoscope devices (using a camera to the see the inside of a patient's organs), medical laser devices, Defibrillators, hearing aids, including the production of food and milk irradiation devices.

Sub-category 33132: "Repair of irradiation, electromedical, and electrotherapeutic equipment". This is comprised of: Repairing and maintenance of irradiation devices, electromedical and electrotherapeutic devices, radiation meters/monitor devices, and other devices as outlined in Sub-category 26600.

Sub-category 32501: "Manufacture of medical instruments and supplies (except dental instruments and supplies)". This is comprised of: Producing medical furniture; surgical or medical equipment for use in operation room; medical

devices for surgery; fabric used in surgery; sterile thread and fabric; sterilizing devices for operation rooms; devices for distillation and centrifuging of solutions; furniture used in medical, surgical, or veterinary; e.g. surgical bed, examination bed, equipped patient bed, metal implants, medical syringe, needles, and tubes; bone surgery equipment and transplant equipment, optometric glass, thermometers, as well as other materials for optometry usage e.g. prescription glasses, sun glasses, prescription glass lenses, safety glasses, etc.

As of 19 December 2022, according to Thailand Department of Business Development (DBD), there are 851 companies registered as Sub-category 32501, with a total registering capital of 18,035 million THB. 53 new companies were registered in this sub-category in 2022. Of the 851 companies, Essilor Luxottica (Thailand) Co., Ltd. had the largest registered capital (3.2 billion THB). Thai companies (companies with 100% shareholders of Thai nationality) makes up 38.22% (725) of all companies in this category, with a capital of 6.89 billion THB, while foreign companies (partly-owned or fully-owned by investors of non-Thai nationalities) make up the remaining 61.78% (126), with 11.14 billion THB in investments. In 2022, investment values by investor nationality are as follows: Thai (48.11%), Japanese (18.47%), French (18.40%), Singaporean (4.67%), and Chinese (2.90%).

The top 5 companies with regard to manufacturing of Irradiation, electromedical, and electrotherapeutic equipment with the highest profits in 2022 are:

1) Nipro (Thailand) – 7.57 billion THB
2) Kawasumi Laboratory (Thailand) – 2.64 billion THB
3) GE Medical Systems (Thailand) – 2.24 billion THB
4) Reckitt Benckiser Healthcare Manufacturing (Thailand) - 2.01 billion THB
5) Emerald Nonwovens International – 1.85 billion THB

It is proposed in this present work that it is important to be fully aware of potential health issues related to the operation of Dental X-ray devices, as “The developments in medical imaging using ionising radiation have implications for radiation protection of the staff, the public and the patient” (The European

Commission, 2012) and addressing these issues properly may be one factor in helping to build brand presence for Thai Dental X-Ray Devices.

2.2 Purchase Decisions and Procurement Process

2.2.1 Distribution Methods in Thai Healthcare Market

Krungsri Research Center (2021) also outlines that the distribution channels of manufacturers and importers in Thailand are as followings:

1) Distribution to intermediary companies, representatives, or retailers: This includes distribution to businesses that are within the same commercial network (parent/child company) as the producer or importer, as well as distribution to general stores in order to reach domestic target clients. These players often have a basic understanding of healthcare and the ability to use a variety of distribution channels relevant to target customers.

2) Direct distribution to healthcare providers: Distribution straight to public healthcare institutions (in accordance with the government procurement process. While purchases under 100,000 THB can be completed under an agreed price, purchases 100,000 THB to 2 million THB must go through a price checking process, and purchases 2 million THB upwards must go through a process of competitive bidding). On the other hand, public healthcare institutions are not regulated by the government procurement process and does not go through the same price checking and bidding process.

3) Distribution to international markets: The vast majority of the products that are distributed are single-use devices, particularly medical rubber gloves. The United States of America, Japan, and Germany are the predominant markets (Krungsri Research Center, 2021).

2.2.2 Literature Gap on Thai Private Healthcare Providers

In hospital settings, multiple stakeholders are involved in purchasing hospital equipment, especially for large-scale durable devices. In public hospitals, devices costing over 10,000 THB must go through a bidding process. Therefore, the

research regarding expensive, highly technical, and life-saving medical devices is important in the context of a country with an emerging public health system (Hamilton, 2017). Looking at imports, these were mostly durable medical items and single-use devices (a combined 80.7% of total import value) e.g., ultrasound equipment, X-ray machines, electrocardiogram (ECG) and electroencephalogram (EEG) monitors, and ophthalmological equipment. This situation demonstrates Thailand's current dependency on foreign medical device imports (Krungsri Research Center, 2021).

Existing literature related to the medical device purchasing process in the Thai context is limited. Pornpasertphon (2021), found that hospital policy had the greatest influence on purchase decisions. Followed by economic conditions, the COVID-19 situation, dealer service, personnel needs, and relationship with the distributor. Whilst the majority (90%) of Thai medical device producers are Small and Medium Enterprises (SMEs) (Krungsri Research Center, 2021), research in large private hospital settings is being conducted by collecting information from procurement staff in hospitals, who are unlikely to have experience using said devices, therefore lacking representation of the majority of the medical device ecosystem population.

Therefore, the literature gap shows an untapped potential market, small private clinics whose decision-makers are playing multiple roles in their clinic; healthcare professionals, service providers, business owners, procurement officers, and staff managers. A major way that Thai manufacturers can stand out amongst the sea of multinational corporations is by building positive brand image perception amongst their B2B customers.

2.2.3 Product-Service Systems (PSS)

The concept of Product-Service systems (PSS) was defined by Goedkooop (1999) as a group of products and services which are provided to customers in order to fulfil their needs. This represents a shift from selling products as tangible goods by transferring the ownership to the customers towards a model where services could be offered to replace products (Product Substituting Service) or changes from an analogue to digital (such as analogue to digital camera systems). This concept was developed as a part of Dutch policy to encourage sustainable economic growth.

PSS may also play a role in the development of a Circular Economy, which can be described as an economy which aims to restore material or products within the system for as long as possible, regenerate the surrounding environment, and enhance value through design (Ellen Macarthur Foundation, 2023).

It is important to get a good understanding of the product-service systems that are in place both within the medical industry and elsewhere in order to develop appropriate strategies. It is also highly worthwhile considering if there are any systems from other industries, or for medical industries, either outside or within Thailand, that can be built on, or adapted, to provide a level of uniqueness for Thai X-ray device manufacturers that can make their products stand out favourably from their competitors.

As an example of a different approach that should be seriously considered for adaption and adoption by Thai manufacturers of these products is that developed by Riversimple, which is a British company owned by a motorsports engineer. It has developed hydrogen cars with zero emissions with a unique subscription pricing model that allows customers to rent a car on a fixed price and an additional variable mileage price, with all with fuel and maintenance costs included. The company sells to both B2B and B2C clients, and their models are available to individual consumers and commercial organizations looking for multiple vehicles. Riversimple is also planning to expand their subscription coverage, including insurance and spare parts instalments into the monthly payment (Riversimple, 2022).

In the context of dental X-ray devices as the industry currently stands, there are not any companies with a similar business model to Riversimple who manufacture and release their own products while providing a subscription model of their devices. Rather, customers can only purchase the device through one-off payment, or through making regular instalments to pay the purchase price. Many hospitals or clinics experiences a shortage of medical equipment, including diagnostic equipment, especially during the COVID-19 surge in Thailand (Nation, 2021).

Kane et al.'s 2017 study recommends that in the design process of non-critical (do not require extensive sterilisation between uses) and high-value medical devices, such as imaging equipment, could enhance its ability to become

more closed-loop (reducing waste and improving recovery of materials) by adopting modular design of the machine components to promote its ability to be maintained or refurbished throughout its lifecycle.

Developing rental services could also have to potential to shift the mindset of healthcare providers and business owners, from having the burden of purchasing multiple expensive durable medical devices which not all facilities will utilise 100% of the time, towards creating a sharing economy between community healthcare providers, allowing these services to become more accessible to patients in lower- and middle-income communities. Not only are there environmental and social benefits, but if Thai X-ray device manufacturing companies can adopt best practices in designing with maintenance and refurbishing in mind, there are also financial opportunities to sell parts or maintenance services to customers, rather than a one-off payment. Moreover, referring back to section 2.1.2, government incentives in Thailand also include investment benefits amongst BCG-related industries (which include medical devices) such as the exception of Corporate Income Tax for 3-10 years, exemption in import duties of machinery and raw materials, 25% reduction on the installation and construction of facilities, etc., (BOI, 2020).

In the case of PSS in Thailand, the camera company 'Canon' recently released a new service for users to rent a camera day-by-day, with prices starting from 300 Baht, and a security payment of 50% of the rental price, which will be returned afterwards (MarketingOops, 2023). Similar to the camera industry, rental services for X-ray devices are nowadays available through third-party companies. There are still opportunities in the market for the adoption of this concept by official dental X-ray brands who would understand the components of the machine better than third-party technicians and instil more trust in customers by offering reliable services.

These two examples from Riversimple and Cannon are a part of the trending shift towards a product-service system business model, which it has been noted could move the consumerist economy towards circular economy and functional economy models (Cherry & Pidgeon, 2018). This shift will reduce the barrier towards entry for customers who might be sceptical or unwilling to fully invest in expensive equipment, as well as providing a unique selling point in the market, unheard of from

existing dental X-ray brands. Therefore, it is suggested that Thai dental X-ray device brands have the potential to increase the outreach of their dental X-ray products, retention of customers through after-sales services, and improving the public image of the brand though adopting a circular mindset and revised business model.

2.3 Case Studies of X-ray Machines in Private Dental Clinics

2.3.1 Study Rationale

To investigate this issue, case studies of dental clinics were initially undertaken due to the prevalence of clinics owners who are licensed dentists, thereby fulfilling the requirement of the interviewee leading multiple roles in the clinic.

2.3.1.1 Background of The Thai Dentists

As aforementioned Moreover, background research of the Thai dentistry scene (**Figure 2.2**) confirmed this decision and revealed that half of all dentists in Thailand are working in the private sector, and that most dental clinics in Thailand are individually owned by dentists. In 2015, there were 13,215 dentists in Thailand, comprising of 5,140 (38.9%) dentists who work in the Ministry of Public Health (MoPH), 1,553 (11.8%) in other government services, and 6,522 (49.4%) in the private sector (Bureau of Sanatorium and Art of Healing). The average number of new dental graduates is between 600 and 800 every year. The ratio of dentists to the total population was 1:4,913 (compared to an average of 1:2,000 in most developed nations). As of September 2017, Thailand had approximately 4,556 dental clinics, approximately 35% of which are based in Bangkok, and more than 50% are located in Bangkok and the Central Region (Infodent, 2020).

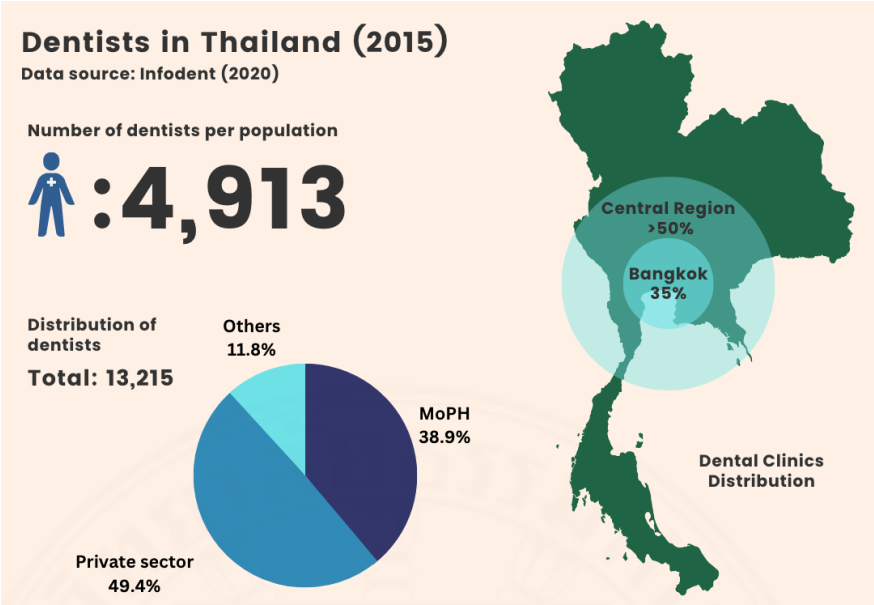

Figure 2.2 An infographic Showing the Thai Dentistry Scene in 2015.
Image: Naphat Jittavisutthikul.

The universities/colleges providing higher education degrees on dentistry in BMA region which are accredited by the Dental Council of Thailand are as follows (see **Table 2.1**):

Table 2.1 Number of New Dental Graduates Per Year in BMA Region.

Institution	Department	Location	Graduates/year
Bangkok Thonburi University	Faculty of Dentistry	Thawi Watthana, Bangkok	No graduates (program est. in 2019)
Chulalongkorn University	Faculty of Dentistry	Pathumwan, Bangkok	237 (2018)
King Mongkut's Institute of Technology Ladkrabang	School of Dentistry	Ladkrabang, Bangkok	No graduates (program est. in 2021)
Mahidol University	Faculty of Dentistry	Salaya, Nakhon Pathom	109 (2020)

Table 2.1 Number of New Dental Graduates Per Year in BMA Region. (Cont.)

Institution	Department	Location	Graduates/year
Rangsit University	College of Dental Medicine	Mueng Pathum Thani, Pathum Thani	15 (2021)
Srinakharinwirot University	Faculty of Dentistry	Watthana, Bangkok	59 (2020)
Thammasat University	Faculty of Dentistry	Khlong Luang, Pathum Thani	120 (2021)
Walailak University	International College of Dentistry	Phaya Thai, Bangkok	N/A
Western University	Faculty of Dentistry	Lam Luk Ka, Pathum Thani	N/A
Total graduates:			583

The average number of new dental graduates is between 600 and 800 every year, therefore graduates in BMA region covers the majority of dental graduates in the country, therefore studying the BMA dentists will be able to represent the entire population. This excludes the dentists who graduate from non-BMA dental institutions and move to city centres for jobs/opportunities, and also vice versa.

2.3.1.2 Background of Thai Dental Clinics

Thonglor Dental Hospital Co., Ltd., Dental Corporation PLC., LDC Dental PLC., and Bangkok Smile are some of the major chains of dental clinics in Thailand. These companies are market leaders due to their numerous dental service branches, availability of dental professionals and specialists, and modern dental equipment and materials. Consequently, the private sector plays a crucial role in the provision of services, particularly in Bangkok and municipal districts (Infodent, 2020). Certain companies such as Bangkok Smile also provide dental tourism services with information on hotels nearby their clinic branches and popular tourist attractions,

thereby targeting international customers who are interested in holistic care of their dental and mental health (Bangkok Dental, n.d.). The inclusion and promotion of safety procedures as well as the bio-friendliness of the devices may be able to further target international tourists who are interested in the wellness aspects of their treatment, as well as dental clinics who are interested in treating this group of customers and increasing customer loyalty.

2.3.1.3 Background of Thai Dental Equipment

The estimated value of dental equipment and materials, which includes prosthetic teeth and dental plaster used in dental clinics and hospitals, is 178 million euros (EUR) [6,595 million THB], or 28.3% of the overall estimated market value of Thailand dental equipment and oral care items. The Medical Device Control Division, Food and Drug Administration, Ministry of Public Health, Royal Thai Government, regulates the importation of dental equipment. The Thai FDA recognises medical devices that adhere to the following standards: USFDA, CE Mark, PAB, TGA, and SPAC (State Bureau of Pharmaceutical Administration of China - China). Although the majority of dental equipment is imported into Thailand, the majority of oral care products, such as toothpaste and dental consumables such as plaster, are supplied by companies with local production capabilities. Europe, the United States, Japan, South Korea, and China are the leading importers of dental equipment (The Dental Association of Thailand) (Infodent, 2020).

2.3.2 Dental Imaging Devices

Dental X-Ray devices are selected as medical devices of interest due to their importance in helping dentists provide dental services and also because of their availability in most private dental clinics as mentioned earlier. Additionally, there is the potential to fill the identified market gap that could transform the Thai medical device industry towards OBM and ODM addressing demands that are currently being fulfilled by imports.

A market report by Markets and Markets (2020) found that the dental imaging market was worth 2.6 billion USD (89 billion THB) worldwide in 2020, and is

expected to reach 4.1 billion USD (140 billion THB) by 2025. This represents a CAGR rate of 9.0%. While North America currently takes the largest market share, the Asia Pacific region has the highest growth rate due to increased disposable income amongst locals, growing dental tourism, and less regulated laws and guidelines compared to other regions, making the market a rapidly emerging one. The largest share of the dental imaging market by usage type was found to be implants, attributed by the rise in usage of the dental CBCT devices, and also goes in-line with the rising aging population, as the average age of patients who get dental implants are 52 (Hip Creative, 2023).

2.3.2.1 What are Dental X-rays

X-rays are a type of natural and man-made electromagnetic radiation wave which have a higher level of energy than visible lights, that allows them to pass through most objects (NIH, 2022). X-rays were first discovered in 1895 by a German physics professor Wilhelm Conrad Roentgen who was studying cathode-ray tubes. When solid objects are placed between the X-ray source and an image receptor, it will block the beam, showing varying degrees of black or white, depending on the density and structure of the object. This allowed Roentgen to see the bones (which were denser) hidden behind flesh. Soon after, experiments were undertaken on the use of X-rays for different applications, such as diagnosis and treatment. The effects that X-rays have had with regard to diagnosis in the medical field are everlasting to this day (Linton, 1995).

As aforementioned, complicated dental procedures, which are increasing in demand, require high-tech devices to be able to properly provide diagnosis and treatment planning in a safe and effective way. The imaging devices found in dental clinics include (but are not limited to) the extraoral X-ray (such as Cone-Beam Computed Tomography (CBCT) (**Figure 2.3**) and panoramic X-rays), Intraoral X-rays (**Figure 2.4**), and Intraoral scanners (no radiation).

Figure 2.3 CBCT X-Ray Scanner (Thongvigitmanee, 2023)

Figure 2.4 Intraoral X-Ray Scanner (Wikipedia, 2023)

The dental CBCT machine, or Cone-Beam Computed Tomography for dentistry, is a device able to provide imaging of the panoramic (2-Dimensional), CBCT (3-Dimensional), and Cephalometric view of the teeth, jaw, nerve, nasal cavity, and surrounding facial structures. It is able to provide 3D views of objects with minimal distortions due to the rotating X-ray source in the shape of a cone beam which rotates around the body in order to capture multiple images that are combined to provide a 360-degree view (Thongvigitmanee et al., 2013).

CBCT devices are suitable for aiding in root canal surgery, maxillofacial (jaw and facial area) surgery, dental implants, wisdom teeth removal, draining abscess and infection, or procedures that require visualisation of the inner structural morphology) (Venkatesh & Venkatesh Elluru, 2017).

The 3 modes of external imaging can be explained as following:

Panoramic mode (**Figure 2.5.1**) (2-Dimensional front view) – stitches together an overview of the entire mouth in a single image. It has the least dosage out of the three modes.

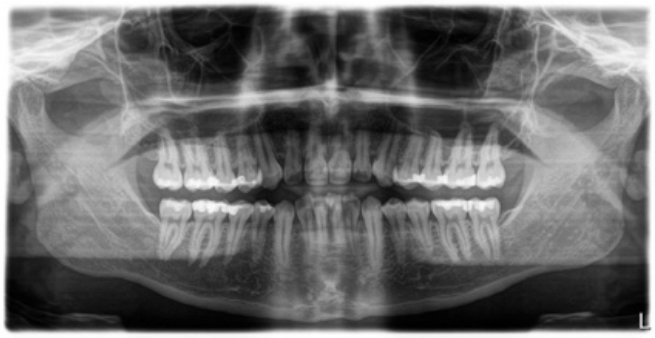

Figure 2.5.1 Panoramic X-ray (Wikipedia, 2021)

CBCT mode (**Figure 2.5.2**) (3-Dimensional) – stitches together 2D image slices taken around the head, providing a 360-degree view of the mouth, jaw, skull (field-of-view size can be adjusted).

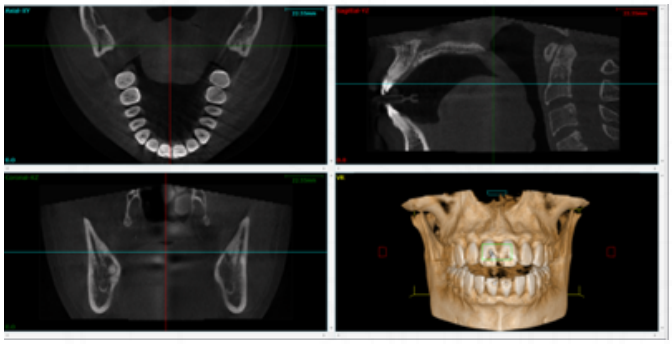

Figure 2.5.2 CBCT X-ray (Wikipedia, 2013)

Cephalometric mode (**Figure 2.5.3**) (2-Dimensional Side view) – Provides a full side view of the teeth in relation to the jaw/skull area. It is the least commonly found mode of most dental X-ray devices as it is used in a special niche field of surgery; Otorhinolaryngology (surgery of the ear, nose, and throat).

Figure 2.5.3 Cephalometric X-ray (Wikipedia, 2014)

2.3.2.2 Product and Service Comparisons Between Brands

A two-decade review article from 1996 to 2019 by Gaêta-Araujo et al. (2020), found 279 dental CBCT models in total, produced from 47 manufacturers and located in 12 countries. The country with the most CBCT models is South Korea, with 72 as of 2019. Thailand currently has one brand of CBCT device: the DentiiScan 2.0, produced by PiXAMED Co. Ltd., which is able to capture panoramic images in standing position. In contrast, most models (111 out of 279) are 2-in-1, able to capture 2 kinds of imaging in one device (Panoramic & CT), the second-highest type (106 out of 279 models) of models are able to capture 3-in-1 imaging (Panoramic & CBCT and Cephalometric).

The J Morita 3D R100 produced by J Morita: This manufacturer states that their CBTC devices follow the 'As Low As Reasonably Achievable' (ALARA) approach with regards to their radiation emissions whilst ensuring appropriate image quality. This device in particular has a dose reduction mode that reduces the effective dose exposed to patients by up to 54% for a full dental CT scan (87 microsieverts (μSv) in dose reduction mode compared to 161 μSv in normal mode). Whereas the panoramic and Cephalometric scans uses a fraction of the dosage, at 10 μSv and 1 μSv, respectively. Their CBCT devices also feature, image layer adjustment, fast orbiting times, and segmented panoramic and cephalometric imaging in order to reduce radiation exposure. They further note that "From both a clinical and ethical perspective, it is advantageous for dentists to ensure that their patients incur the lowest possible radiation exposure." This is a factor that also needs to be properly addressed for the dental staff that take the actual X-rays of the patients (Morita, 2023).

The table below (**Table 2.2**) shows the comparison in different extraoral image modalities and product lines amongst a sample of dental X-ray brands available from the brand's official website. It is also important to note that most extraoral X-rays sampled here are able to produce more than one image modality in one machine. Notably, Dentsply Sirona is the only brand which has adopted modular design in their products. The intraoral X-ray devices and software are also outlined in **Table 2.3**, as well as the servicing policies in **Table 2.4**.

Table 2.2 Comparison of Extraoral X-ray Devices from Sampled Brands

Company	Product	CBCT	Panoramic	Cephalometric
Acteon Group	X-Mind® Prime 3D	✓	✓	✓
	X-MIND® Trium True Low Dose	✓	✓	✓
	X-Mind® Prime 2D		✓	
Asahi Roentgen	Auge Solio Series	✓	✓	✓
	Solio X Series	✓	✓	
Carestream	CS 8100SC		✓	✓
	CS 8100SC 3D	✓	✓	✓
	CS 8200 3D	✓	✓	✓
	CS 9600	✓	✓	✓
PiXAMED	DentiiScan 2.0	✓		
	DentiiScan Duo	✓	✓	
J Morita	3D Accuitomo 170	✓		
	Veraview X800	✓	✓	✓
	Veraview IC5 HD		✓	✓
	Veraviewepocs 2D		✓	✓
	Veraviewepocs 3D R100	✓	✓	✓
KaVo	KaVo OP 3D	✓	✓	
	KaVo OP 3D (Ceph)	✓	✓	✓
	KaVo OP 3D Pro Large Panel	✓	✓	
	KaVo OP 3D Pro Small Panel	✓	✓	
	KaVo OP 3D Pro Large Panel (Ceph)	✓	✓	✓
	KaVo OP 3D Pro Small Panel (Ceph)	✓	✓	✓
	KaVo OP 3D Vision	✓		
Dentium	Bright CT-1TC	✓	✓	✓
	Rainbow CT	✓	✓	✓

Table 2.2 Comparison of Extraoral X-ray Devices from Sampled Brands. (Cont.)

Company	Product	CBCT	Panoramic	Cephalometric
Dentsply Sirona	Axeos	✓	✓	✓
	Orthopos E		✓	✓
	Orthopos S 2D		✓	✓
	Orthopos S 3D	✓	✓	✓
	Orthopos SL 3D	✓	✓	✓
	Orthopos SL 2D		✓	
Vatech	A9	✓	✓	
	Green 16	✓	✓	✓
	Green 18	✓	✓	✓
	Green 21		✓	
	Green X	✓	✓	
	PaX-i 3D	✓	✓	✓
	PaX-I 3D Smart	✓	✓	
	PaX-i 3D Smart SC	✓	✓	✓
	PaX-i Insight NC	✓	✓	✓
	PaX-i Insight NP		✓	
	Smart Plus	✓	✓	✓

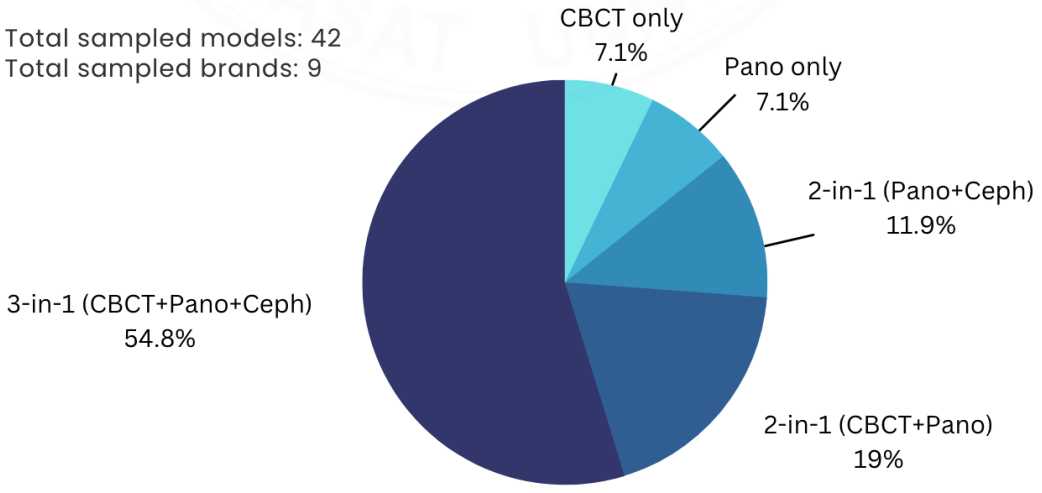

Figure 2.5 Chart Showing the Distribution of Dental X-ray Models Sampled.

Table 2.3 Intraoral X-ray Devices and Software Offered by Each Brand.

Company	Intraoral X-ray devices	Software
Acteon Group	SOPIX® digital X-ray sensors	Action Imaging Suite (AIS)
	SOPIX Plug-in ® & SOPIX Plug-in 2 ®	
	X-Mind® Unity intraoral X-ray	
Asahi Roentgen	Alula Series	NEOPREMIUM2
Carestream	CS 2100	CS Imaging 8
	CS 2200	CS 3D Imaging Software
PiXAMED	-	DentiPlan
J Morita	Veraview iX	i-Dixel WEB
KaVo	KaVo Focus	Cliniview
	KaVo Nomad Pro	
Dentium	Intraoral Sensor Wireless IOXW	Davinci
Dentsply Sirona	Heliodent Plus X-Ray Generator	Sidexis 4
Vatech	EzRay Air Chair	Davis
	EzRay Air Portable	
	EzRay Air Wall	

Table 2.4 Company Servicing Policies.

Company	**After-sale service policies**
Acteon Group	Warranty and software length unknown (not listed on the website), but warranty extension is available. Customers can send requests directly in the international website and receive service from local office. Training sessions are also available for customers to learn about installing and repairing their own products.

Table 2.4 Company Servicing Policies. (Cont.)

Company	After-sale service policies
Asahi Roentgen	All X-ray equipment have a service life of 10 years after the date of shipment. It is recommended that the devices are replaced once service life is over as “deterioration of electrical parts and/or mechanical systems, failure is likely to occur”. Repairs by the company may not be available for products exceeding its service life.
Carestream	Regular service package information unavailable. Optional service package called ‘CS Advantage’ is available, which extends the product’s warranty length, covers repair fees for product malfunctions/failure, up-to-date software, unlimited access to online training, live telephone technical support, installation services, etc. The add-on option ‘CS Upstream’ (only available for certain models) system monitors the machine in real-time, collects data and detects issues (as well as predictive support), and automatically notifies the company/dealer to launch an action plan to resolve the issue.
PiXAMED	Contact form, phone number, and email available on website. Service information unknown.
J Morita (SiamDent)	Contact form, phone number, and email available on website. X-ray devices have a 3-year warranty period.
KaVo	Remote support is available with technician upon appointment. Original factory repairs ‘KaVo Box’ are also available in some countries where customers can “shop” for repairs with fixed prices for listed products (X-ray repair prices are on a case-by-case basis). Pick-up and delivery of the parts/device is free (Thai customers must contact local dealers instead).

Table 2.4 Company Servicing Policies. (Cont.)

Company	After-sale service policies
Dentsply Sirona	Upgrades are available to add new imaging modes (CBCT/Ceph.) so customers can purchase the basic X-ray model and keep-up to date with technology or expand later on. The local office offers after-sales servicing, and free product demonstration at its showroom upon booking.
Vatech	Contact form available on website. Service information unknown.

Prices are obtained from surveying booths at the 2022 Bangkok International Symposium of Implant Dentistry (BIS), brands' websites, and official retailers/dealers. Prices, promotions, and warranties are given based on general conditions only, and are subject to change depending on factors such as clinic locations, number of purchases, and other conditions given by each company (See **Table 2.5**).

Table 2.5 Price and Warranty Comparisons Between Brands.

Company	Model	Price	Warranty and Maintenance
Acteon	X-Mind Prime 3D	1,400,000 THB (Discounted at 1,300,000 for BIS only)	N/A
	X-Mind Trium (3-in-1)	2,000,000 THB	
Dentium	Bright CT-1TC	1,400,000 THB	3 years sensor warranty, 5 years machine warranty, Maintenance every 6-12 months.
	Rainbow CT (3-in-1)	1,500,000 THB	

Table 2.5 Price and warranty comparisons between brands. (Cont.)

Company	Model	Price	Warranty and Maintenance
HDX Will	Eco-X	1,590,000 THB (6 months instalment payment available or 2-year instalment available for 1,740,000 THB)	2 years warranty, Maintenance every 6 months.
PiXAMED	DentiiScan Duo	1,500,000 THB (Discounted at 1,200,000 for BIS only)	N/A

2.3.2.3 Communication Channels

Individual word clouds were created from the information provided on the home page of each dental X-ray device companies' website (**Figure 2.6.1** to **Figure 2.6.7**). Overall, most companies often mentioned the name of the brands, name of products. Companies whose top keywords were their brand name focused on the overall communication of their brand, as opposed to brands with product names as their top keyword who communicated more about the benefits of their products. Only two companies included testimonials from their users. The companies that mentioned the brand's Country-of-Origin were all Asian companies (Korea's Vatech and Thailand's PiXAMED). Overall, the most frequently appearing keywords include the brand name (39 times), product/service name (27), "Dental" (16), "Product" (16), "New" (9), "Treatment" (7).

Contents found in the websites were similar but varied only in the order of content categories. The contents are such as the following, from most frequently appearing to least: images of the devices and people operating them, product information, contact information, company statements and slogans, news and articles related to company events, service policies, and educational material for training. It is also important to note that the Thai company featured lower resolution images used on its site which may not fully communicate the professional image a

medical device brand should portray. Moreover, another difference between the other brands is the exclusion of images which showed people using the devices. Showing interactions with the machine shows that the product is human-centric. Most brands display a mix of people, machines, and X-ray images to show their commitment to users, increase memorability of the devices, and showcase the quality of their scans.

Figure 2.6.1 J Morita (SiamDent)

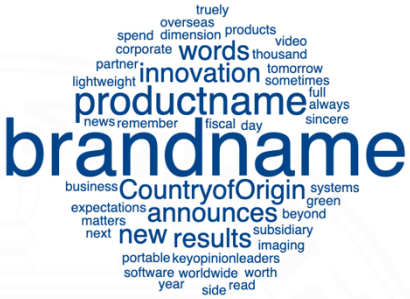

Figure 2.6.2 Vatech

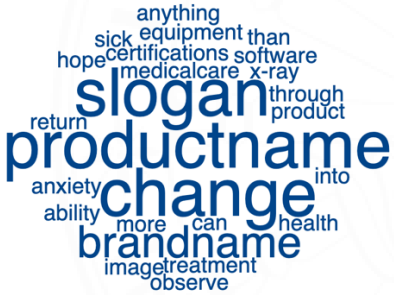

Figure 2.6.3 Asahi

Figure 2.6.4 PiXAMED

Figure 2.6.5 Kavo

Figure 2.6.6 Sirona

Figure 2.6.7 Acteon

Much of the marketing strategies such as mass sale-promotions utilized by the consumer product market is highly regulated in the medical industry, some considered unethical and unapplicable (Ladha, 2007). In Thailand, the advertisement of medical devices is regulated under the Medical Device Act B.E 2551 (2008). Many medical brands prefer to directly communicate to physicians instead of mass marketing channels: television, radio, printed media, internet media, and talk shows; all of which requires an approval and issue of an advertising license by the Food and Drug Administration (FDA) (IntBizTH, 2022). Advertising efforts from dental X-ray brands operating in Thailand (those sampled here are from Acteon (USA), Dentium (South Korea), Sirona (USA) Kavo (Germany) and Dentiiscan (Thailand)), to communicate and connect to their current and potential customers include: medical conferences where the brand gains awareness through specialised content at medical or dental events; providing knowledge sessions to dental professionals or students for the development of their careers; Giving back to society through donating medical devices; and developing trusting relationships with clients post-purchase.

2.4 The Journey from OEM to OBM

The majority of Thailand's medical device industry produces single-use disposable devices. As shown by Jantarakolica (2015), the Thai export market, in general, is Original Equipment Manufacturing (OEM), which faces issues of low-profit margins, lack of bargaining power against global players, and higher labour costs.

Therefore, the industry must transform into Original Design Manufacturer (ODM) then into Original Brand Manufacturer (OBM) in order to reach its true potential.

2.4.1 The Need for Transitioning

The notion of the need for transitioning from OEM to OMB within the medical device context was confirmed by Hamilton & Vatananan-Thesenvitz (2017), in which it was recognised that Thailand's lower position on the supply chain as an OEM gives organisation little opportunity for becoming a research and development (R&D) partner, and for the development and ownership of an original brand in the future, limiting the industry's growth as a whole.

2.4.2 Definitions of OEM, ODM, and OBM

Original Equipment Manufacturing (OEM) is defined as a type of subcontracting, where product specifications are made from the clients' requirements. Original Design Manufacturing (ODM) is when the manufacturer develops their own product design and process, then produces it themselves. They may then sell the product under another firm's brand. Lastly, Original Brand Manufacturing (OBM) involves processes from OEM and ODM, in addition to designing their own branded products, managing sales, marketing, and distribution themselves (Hobday, 1994).

2.4.3 Barriers to Achievement

Often, latecomer OEMs (firms who are new faces in an already saturated/developed market) tend to avoid expanding their business activities to ODM and OBM, although this risk aversion strategy allows them to have a stable growth in the short and medium term, but long term they will face market pressure due to the price offer of lower-tier emerging economies who continue to offer lower wages and cost options (Lee & Mathews, 2012).

With regards to findings from other countries, in Taiwan, some of the barriers towards the transition from OEM to OBM includes government-implemented industry policies. Failed transitions were due to the firm's smaller size, technological capabilities, dependence on external subcontracting client's orders, knowledge of promotion and marketing, and brand power amongst consumers (Chu, 2009). Additionally, in a study of South Korean government policies to promote domestic

SMEs' growth by Kim & Lee (2008), found that most of them have been ineffective. For example, policies set to promote the sales and consumer adoption of machine tools produced by domestic SMEs was unsuccessful due to the preference of large machinery assembly firms which avoided these products with the belief that domestic products were of uncertain quality compared to imported products.

2.4.4 Country-of-Origin Branding

For developing countries, it is found that consumers often find/consider international products to be of higher quality than domestic products, while the opposite is true for developed countries (Batra et al., 2000). With regards to the Thai context, Speece (2000), found that to Non-Thais, a product being labelled "made-in-Thailand" is not considered a problem per say, but that there is greater resistance towards that product for Thais and Thai brands. During times of economic crises, (Speece & Pinkaeo, 2002) found that Thai companies and many Thai companies try to push the notion of "buy" Thai, but the results varied due to the reasoning behind it. Companies that advertised consumers to "buy" Thai because they should be loyal to their country (promoting ethnocentrism) mostly failed to incentivise their customer. Whereas companies who were able to explain why Thai products were of better quality and had superior benefits to non-Thai products, were more successful in capturing customer's purchase.

2.4.5 Existing Solutions and Limitations

So the question is what should domestic firms do when competing as a latecomer? When SMEs follow the same paths as existing large firms, latecomers typically always remain behind. New strategy creations are also necessary as smaller firms often become subject to intellectual property lawsuits by larger firms as they grow. As Lee et al. (2015) outlines, the transition to OBM requires the following capabilities:

1) Absorption capabilities – The firm's ability to recognise, capture (absorb), and apply the value founding in new technologies and innovation towards their own technological development (Sancho-Zamora et al., 2022) (Cohen & Levinthal, 1990).

2) Design capabilities – The firm's ability to develop, test, and certify original design without using similar designs from other firms.

3) Marketing capabilities – the firm's ability to market their brand, products, and services independently of relying solely on outsource.

Lee et al.'s 2015 study also suggests that the SME must relocate their production to another "lower-tiered" developing country once they have started to grow the basis of their business. This allows them to further stabilise their economic growth. However, studies (Li & Wang, 2020) (Wang et al., 2019) have shown that relocating the production facilities to another country to exploit another country's lax environmental regulations is simply moving the problem elsewhere for another country to deal with. It is also found that the total amount and intensity of these emissions caused by manufacturing plants in such situations increase after relocating and are negatively correlated with the strictness of regulation in the country of relocation. Where corporate citizenship also takes into consideration of the company's employees and suppliers and its impact on the surrounding environment (Willmott, 2003), the sole act of relocation without considering the development and impact of the host country does not reflect best practices.

2.5 Business-to-Business (B2B) Branding

2.5.1 Branding in Consumer Markets

Literature involving branding in the B2C context has been widely explored. Keller's (2001) model of the Customer-Based Brand Equity (CBBE) outlines a strong brand as one that firstly, is able to build an established identity through awareness where the customer not only knows about the brand widely, but deeply enough as well; secondly, creates strong and relevant brand memorability and associations towards the brand; thirdly, generating positive responses from its consumers; and fourthly, strengthening relationship with customers and building active brand loyalty.

2.5.2 Branding in Industrial Markets

The idea of branding was created primarily within the context of retail and wholesale consumer markets (Leek & Christodoulides, 2011). In contrast, in industrial markets branding was perceived as being emotional, and as a result, it has been typically considered that it brought very little benefits to the "logical" business-to-business (B2B) operations (Kuhn et al., 2008). Moreover, not all aspects of the aforementioned model could be applied towards the industrial B2B market where buyers are not making judgement for personal use, especially with the added context of the healthcare industry where staff work long shifts, and often stakes could be higher, related to the life-or-death of patients who are seeking treatment. Additionally, it needs to be taken into consideration that working conditions may not be conducive to good health or work efficiency, where mistakes are more likely to arise and make staff lax in undertaking recommended safety procedures. Therefore, the first point of “widely-known” may not be applicable (as with other niche products where the market is relatively smaller and more specialised) and trust is one of the more relevant aspects.

Seyedghorban et al. (2016) found that branding is becoming an increasingly essential aspect in the B2B sector. This is because the buying decisions of industrial purchasers are influenced by brands (Kuhn et al., 2008). Another aspect that contributes to the relevance of branding is the increasing similarity in quality that is often being supplied in B2B marketplaces. Branding is becoming ever more important as it allows companies to differentiate themselves from the numerous other businesses in the market (Leek & Christodoulides, 2011). This is some that Thai X-Ray Manufacturers still have to address.

While branding is important in affecting the purchase decisions of B2B customers, Leek & Christodoulides (2011) found that industrial buyers have often been sceptical and unbelieving as to what the benefits of branding actually are. So, the second point of Keller’s model in brand associations might be affected in a lesser degree as industrial buyers do not find branding as relevant as the more tangible value from the product/service itself. Hence, functionality was seen as the foundation of brand value from the B2B buyer’s perspective, yet Leek & Christodoulides (2011) also

found that there were also emotional components involved in building a strong relationship between industrial suppliers and B2B buyers that enhanced loyalty beyond a transactional action.

2.5.3 Branding in Medical Businesses

Medical businesses can differentiate themselves in the marketplace by cultivating powerful brands. However, many medical practitioners were found not to be familiar with the practice of branding health care services (Mkhize, 2015), and many B2B businesses have not given branding the same level of importance as their pricing and operational strategies. On the perspective of the company and their hires, Kilgannon, (2012) found that a majority of the medical technology (MedTech) companies did not know what branding is and even fewer have tried to implement it towards their company. Furthermore, 26% of them believe branding was the responsibility of the marketing department/staffs, 11% believed it was their Chief Executive Officer (CEO)/ Managing Director (MD)'s responsibility and did not concern them or their daily operations. This shows that the attitude of employees in MedTech markets often does not prioritise branding.

In Khosravizadeh & Vatankhah & Maleki (2017)'s systematic review of 54 papers related to branding and healthcare services, it is found that the most important dimension in brand building was brand equity (factors including brand awareness, internal leadership, brand ethics, service quality, brand trust).

Customers' purchasing decisions for services are made with less uncertainty when they have a recognisable brand to consider (Berry, 2000). Establishing credibility and reliability for a brand is absolutely necessary in order to construct brand equity (Juntunen et al., 2011; Marquardt et al., 2011). In the medical context, trust and reliability is important due to the seriousness and sometimes life-threatening nature of the medical field (Kemp et al., 2014). Above all, the ability of a healthcare establishment to build trusting relationship with its customers allows them to make informed decisions (DeGeetern, 2009). Quality assurance through certification, standards testing, and evidence-based marketing could begin to address scepticism and build trust.

2.5.4 Corporate Social Responsibility of B2B Brands

According to Willmott (2003), it is found that environmental initiatives of a company can be linked to the degree of commercial success it obtains. Direct impacts include the increased development of innovation and more efficient production methods; improved perception of risk towards shareholders and investors, therefore the overall brand perception; and reeling in consumers who specifically seek for environmentally conscious brands. Corporate citizenship focuses on the holistic development of the company's interaction towards the various stakeholders a business might have impacted on, not for the sake of philanthropy, but out of genuine vision, including its attitude towards internal corporate governance, culture, employees, and external communities, shareholders, and the environment.

Jensen et al.'s 2019 study also supports this notion, where it's found that consumers can often sense if companies are conducting Corporate Social Responsibility (CSR) in a self-serving, financially driven way, as well as some consumers who become suspicious of over-the-top CSR that mistakes CSR as a marketing tool instead of genuine interest of the greater good. Therefore, they propose that companies try to find a balance in the middle between these two styles, by investing in CSR through focusing on activities that link to the company's business activities or minimising/mitigating the negative impact it had on society.

Vesal et al. (2021) found that in the context of B2B brands in emerging countries, there is a greater requirement for companies to be environmentally conscious due to the larger scale of operations compared to consumer firms, and that signalling a sustainable firm's image towards their clients through Customer Relationship Management (CRM) can help brands become more preferable and of better reputation, providing a tool to improve market performance.

The conceptual framework developed from the findings and insights gained from the secondary research undertaken for this work is shown in **Figure 2.7**.

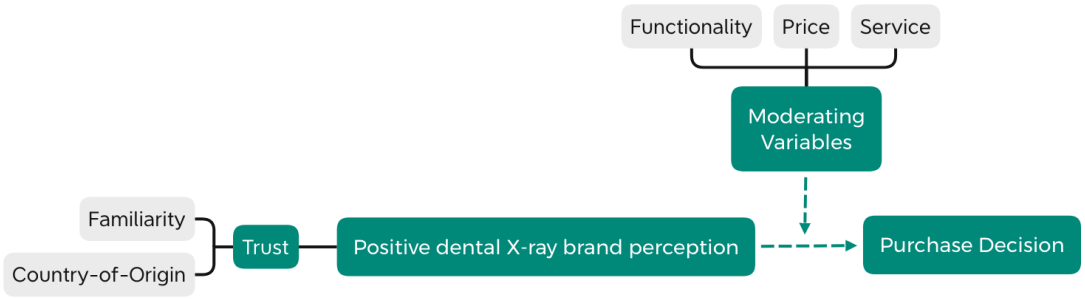

Figure 2.7 Conceptual Framework

2.6 Sustainability in the Medical Device Industry

2.6.1 Climate Change and the Healthcare Industry

With the rapidly growing trends and demand for the healthcare and wellness sector worldwide accelerated by the pandemic exposing the vulnerability of the public health system and fragility of the global health network, the industry is found to be predominantly a rapidly growing one, worth $4.9 trillion USD in 2019, falling to $4.4 trillion in 2020, due to the prevalent impact from the COVID-19 pandemic despite the increasing reliance on healthcare services during the period. Post-pandemic, it is projected to bounce back to an average growth of 9.9% annually, reaching a total of almost $7.0 trillion in 2025 (Deloitte 2022), (Global Health Care Outlook, 2022), (Global Wellness Institute, 2021).

The wellness economy represented 5.1% of global economic output in 2020 (GWI, 2021), and the medical device industry specifically is worth 1.2% of the Thai GDP (Krungsri, 2021). The sheer size of this industry also means that it creates a large environmental footprint. Healthcare accounts for 4.4% of the global greenhouse gas emissions (Choi, 2022). The impact the healthcare industry has on the environment includes waste production, chemical usage, energy usage, single-use materials, infectious waste, and pollution from radiation. As outlined by Barbero et al. (2017), encouragement from both the public and private sector and end-users alike, are moving suppliers towards more sustainable products, services, and systems. It is found that design plays a crucial role for sustainable innovation in healthcare (Jones, 2013).

It will also play a crucial role in ensuring medical and dental equipment is more bio-friendly.

Climate change and environmental impact have always been interconnected to the health complications that arise from living in an unsuitable environment. As an example, in 2016, the American College of Physicians (ACP) found that some effects of climate change on the health of a human population include higher rates of respiratory disease, heat-related illness, prevalence for water-borne or vector-borne (e.g., mosquito) diseases. Moreover, those who are elderly, poor, or sick, are typically found to be even more vulnerable to these potentially devastating effects from climate change. This is especially concerning in the context of a developing nation with high poverty rates, marginalised communities, and rapidly aging society, where the population may be living in a high-density area, with limited public healthcare access, and unstable environment such as informal settlements. And these are simply accounting for the direct impacts of climate change, not mentioning other indirect impacts which also put further strain on the nation's public healthcare system.

Addressing, mitigating, and adapting to the impact of climate change will provide substantial benefits to human health. Therefore resiliency towards these public health threats could be improved through the development of a better dental healthcare ecosystem, as mentioned before, by Peres et. al (2019) it is shown that appropriate medical and dental care is linked to the prevention of a majority of deaths. It can also reduce the economic burden placed on individuals and healthcare systems.

2.6.2 Existing Literature Examining Solutions

One of the earlier examples of literature on the design considerations to lessen the impact of material production on the environment can be found in Papanek's 1985 book 'Design for the Real World' which pointed out the danger of irresponsible design that does not take real users, operational conditions, and environment into account.

However, some of the major challenges in reaching a more sustainable development in the medical industry is due to the technical complexity of medical devices, regulations and ethical issues in ensuring standards and safety for users, the lack of existing methodologies of sustainable design in the medical context,

and the interdisciplinary nature which requires medical designers to be well-versed in both the arts and sciences, understanding of the human condition and universal design (Barbero, 2017).

For a more localised context, in “The Adoption of Green Dentistry in Thailand” by Agrasuta (2013), found that most dentists had never heard of the concept of green dentistry, and a review of their medical practices found them to not be very environmentally conscious. But when introduced to the term ‘Green Dentistry’, they show a positive attitude towards it, especially for practices that have low implementation effort, showing that there is a possible gap for the development of sustainable medical practices and adoption willingness from the perspective of healthcare providers, and potential towards increasing a positive brand value amongst its B2B customers. It is proposed that the same may be true with regard to the promotion of more bio-friendly dental devices that will be of benefit to both staff and patient alike and help build brand differentiation, awareness, and trust.

2.6.3 Sustainability of X-ray Machines

In 2016, the European Commission announced that there is a global recognition for making health systems more sustainable though improving effectiveness, accessibility, and resiliency from the perspective of policy makers. This transition is deemed necessary, as the world faces an increase in chronic diseases and long-term geriatric care.

The use of Digital X-ray machines are able to reduce the amount of harmful chemicals released into the environment as they do not require requires chemicals to wash the films used in a traditional X-ray process. However, medical devices producing radiation create concern about their possible impact towards people and the environment.

In Thailand, the regulation of radiation usage relies on the Office of Atoms for Peace (OAP) and the Department of Medical Sciences, Ministry of Public Health. In Thai law, medical devices producing radiation for the use in diagnosis and treatment are not heavily regulated as they are considered to be “non-radioactive” devices due to the source of radiation, which are produced from electrical currents and not from organic sources, making them different from devices emitting Gamma

rays, which ARE regulated in Thailand. In international law and regulation, however, US National Toxicology Program (NTP); the International Agency for Research on Cancer (IARC) (part of the World Health Organisation); and the US Environmental Protection Agency (EPA), all consider both X-rays and Gamma rays to be carcinogenic to humans, and therefore have limits in place to regulate medical X-ray usage to prevent harm (American Cancer Society, 2022).

Claus et al., (2012) found that patients who get dental X-ray scans, especially at a high frequency and at a younger age, may have increased risk of intracranial meningioma (a tumor located in the membrane area surrounding the brain and spinal cord. A study of 96 dental surgeons by Shrivastva (2019) found that though radiographic scans were widely available, the lack of reinforcement of safe radiation practices may pose a hazard, not only to the patient but to staff undertaking X-rays as well. Only 20% of dentists stood behind lead shields whilst running X-ray equipment. Safety equipment, radiation protective structures, and personal radiation dosimeters should be utilized to ensure staff do not receive harmful levels of radiation (Salama et. al., 2016).

X-ray devices with electrical sources of radiation also contains potentially dangerous components such as copper, tungsten aluminum, lead, and flame-retardant plastic parts, all of which can be dangerous to people and surrounding environment if not properly disposed of correctly. There are no existing systems for managing the disposal of X-ray machines in Thailand, or even laws relating to the environmental pollution regulation caused from general electronic waste (Wongwatthanakarn, 2020).

2.6.4 Industry Practices

Looking at the current efforts of public companies producing X-ray devices to become more environmentally conscious, then analysing and categorising them according to the 4 ‘Design for Sustainability’ (DfS) approaches by (Ceschin & Gaziulusoy, 2016) it is found that most, if not all of the devices are at the ‘Green Design and Eco design’ level, focusing on lowering the environmental impact of a product through the design of the product’s functionality. The authors argue that this is one of the more simplistic levels of DfS, potentially promoting green consumerism where the

environmental benefits gained from the design is offset by the increase in consumption.

Within the context of dental X-ray devices, as with many other X-ray devices in general, the majority of energy consumption is found in the product use stage, therefore the behaviours of users play a role in the overall environmental impact of these medical devices. According to a 2016 report by the Canadian Coalition for Green Healthcare, it is found that the average energy cost for running an X-ray equipment could range from $100 CAD (2,450 THB) with no scanning (running on standby mode) to $400 CAD (9,820 THB) per year. While CT devices could cost anywhere between $3,000 to $6,000 CAD (73,650 – 147,300 THB) per year. It is found that in the ready-to-scan mode, the CT device uses approximately 4.8 kW of energy, and in its lowest power consumption mode 0.7 kW. (Canadian Coalition for Green Healthcare, 2016).

For example, HDX Will, a South Korean imaging medical device brand released a line of dental CBCT machine ‘ECO X’ model series, whose features include an ‘Eco Scan’ mode, aimed to reduce the total scan time and the level of radiation exposure (HDXWILL, 2023). Italian brand NewTom’s ‘New Tom 5G XL’ model also provides an Eco Scan mode, but it is not advertised as an environmentally conscious option, rather promoted in the perspective of benefit from low radiation dosage and scan time which especially suitable for paediatric dental imaging due to children being less tolerable to radiation compared to most adults from a physiological perspective, and from a behavioural perspective of how children are often unable to stay completely still during scans, the short scan time allows for less chance in blurred scan outcomes due to movements (Ricci et al., 2019). Generally, the risks associated with radiation exposure from dental imaging devices is “extremely small”, but nevertheless must be carefully considered in those who are more sensitive towards radiation, such as pregnant patients or children, as well as the choice of exam type (CBCT, Panoramic, Cephalometric, intraoral etc.) as the amount of radiation exposed between image modalities, Field-of-View size, and settings widely differs. It is suggested that the ALARA principle should be continually adopted in dental practices, and that

the dosage guideline to minimise the risk of carcinogenic effects is below 100 millisieverts (Lurie, 2019).

When dental practices become more aware of the risks associated with cumulative X-rays, they may be more discerning about when X-rays are actually required, adopting the ALARA (As Low As Reasonably Achievable) principle for radiation safety. They also may be more inclined to use machines and practices that lower radiation dosages. Such an approach will also lower the energy use of devices thereby helping make them more sustainable, saving expenditures for all parties, and reducing potential health risks.

CHAPTER 3
RESEARCH METHODOLOGY

3.1 Qualitative Research

Qualitative semi-structured interview is being used in order to capture the complex and abstract nature of the subject of brand perception. The semi-structured format allows for further exploration of different themes which can provide a wider view of the issue, through open-ended questions that do not limit the answer of the interviewees.

3.1.1 Criteria for Selecting Interview Participants

In order to gain an understanding of the medical device purchasing process, criterias for choosing X-ray devices, and brand perceptions, dentists who own dental clinics were interviewed (the criteria that had to be met for them was that they are a licensed dentist and the owner of a dental clinic in Bangkok Metropolitan Area (BMA) which accounts for over 50% of total dental clinics in Thailand). The snowball sampling method was used to select the interviewees. The initial starting interviewees were chosen by contacting dentists (university hospital members and local clinics surrounding the university) at different universities that have a dentistry faculty (1-2 from each university/college) to try to ensure that the users were not closely related to each other amongst their social circle due to graduating from the same university and having same colleagues/professors/seniors/juniors which might cause their brand perception to be skewed towards their surrounding environment.

The target dentists were also required to meet at least one of the following three criteria for establishing their interest in dental X-Ray brands:

- The dentist’s associated clinic contains at least one purchased dental X-Ray machine.
- The dentist has taken part in the process of evaluating between dental X-Ray brands in order to procure the machines for their associated clinic.

- The dentist expresses intentions of purchasing a dental X-Ray machine for their practice.

After interviews with the dentists were conducted, further interviews were collected on clinic owners (non-dentists) and dental assistants in order to gain a more complete overview of the entire ecosystem and the stakeholders who help run the system. The clinic owners must meet the criteria that they also interact with the dental staff (rather than being just a funding investor who does not manage business operations). The dental assistant must have direct experience working with the X-ray machine and taking patients for a scan.

Interviews were conducted in Thai, recorded, transcribed, then translated for further coding and analysis. The questions for dentists and clinic owners are based on the 5-step purchase decision process (Problem Recognition, Information Search, Alternative Evaluation, and Choice) developed by John Dewey in 1910, which is the most widely accepted model of the customer purchase decision (Bruner & Pomazal, 1988). Questions for dental assistants focused on the user flow and how they interacted with the device and patients.

3.1.2 Data Analysis Methods

Inductive thematic analysis was done according to the framework developed by Braun & Clarke (2006), consisting of six phases of analysis including: getting familiar with the gathered data, generating initial blocks of codes, grouping into themes, reviewing set themes, defining and naming the themes, and then writing a report. As defined by Braun, inductive refers to the process of exploring widely during the interview process then visualising and summarising into themes. Whereas thematic refers to identifying existing themes from literature and exploring them based on gathered initial information.

3.2 Sample Size

Guest et al., (2006), who developed the data saturation method used in this study, found that there are almost no guidelines that exist for determining non-probabilistic sample sizes. Purposive samples are the most prevalent kind of non-probabilistic sampling, and their size is often determined by the concept of "saturation," or the point at which no new information or themes can be noticed in the data. In their study, they define a theme as something that captures an important aspect about the data in relation to the research question and represents some level of patterned response or meaning within the data set. The researchers found the point of saturation and offer non-probabilistic sample sizes for interviews based on evidence from the data set that saturation occurred during the first 12 interviews, and found the presence of rough building blocks of the themes from only six interviews.

For this present research, the author expected to undertake interviews with around 10 dentists, five dental assistants and five dental clinic owners. 20 people in total. This number was estimated taking into account similar studies which had methodologies that included qualitative interviews conducted on medical personnel, such as Ginsburg's 2004 study on evaluating medical devices based on human-factors which conducted interviews on a total of 17 nurses and anesthesiologists, and Kilgannon's 2012 study which interviewed 8 medical technology companies on their adoption of branding towards their B2B clients.

CHAPTER 4
RESULTS AND DISCUSSION

4.1 Data Collection Results

Dental practitioners were contacted through a combination of channels: contacting dental clinics, university dental professors, social media sites, walk-ins at clinics, and contacting the Royal Dental Association of Thailand. In the end, seven dentists and two non-dentists were available for interviewing about the purchasing decision of dental X-ray devices, two of which were recommended from an interviewee, and all nine of them matched at least one or more criteria of interest, meaning they were suitable and knowledgeable experts working with dental X-rays in clinics in the BMA region. Four dental assistants were contacted, through the dentist's recommendation or contacting additional clinics, after finishing the first set of interviews with dentists.

In total, 13 interviews **(Table 4.1)** were conducted through phone, in-person, and video conference. An overview of the thesis topic was explained to the interviewee, and permission for recording their voices for purposes of data analysis was given by the interviewees. The interview sessions ranged from 12 to 44 minutes, which were due to the normal unexpected nature of the dentist's busy scheduling. Some questions from the interview questions that had been created (and are shown within the Appendix) were added, swapped, or omitted to aid with the flow of conversation depending on their answers.

Table 4.1 Profile of the Interview Participants

Interview	Occupation	Education	Experience	Brands mentioned
Person A	Dentist, Dental clinic owner	DDS, MSc	17 years	Did not remember any names

Table 4.1 Profile of the Interview Participants (Cont.)

Interview	Occupation	Education	Experience	Brands mentioned
Person B	Dentist, Dental clinic owner, University professor	DDS, MSc, PhD	15 years	Sirona, JMorita, DentiiScan
Person C	Dentist, Dental clinic owner, University professor	DDS, MSc, PhD	9 years	Carestream
Person D	Dentist, Dental clinic owner	DDS	5 years	Acteon
Person E	Dentist	DDS	5 years	Vatech, Asahi
Person F	Dentist, Dental clinic owner, University professor	DDS, MSc, PhD	17 years	Sirona
Person G	Dental clinic owner, University dental equipment procurer	BSc	15 years	J Morita, Sirona
Person H	Dental assistant	Highschool diploma, Dental assistant certificate	4 years	HDX Will
Person I	Dental assistant	Highschool diploma	6 months	Dentium
Person J	Dental clinic owner	N/A	12 years	Sirona
Person K	Dental Assistant	Highschool diploma	3 years	Did not remember any names

Table 4.1 Profile of the Interview Participants (Cont.)

Person L	Dentist	DDS	8 years	Bemems, Vatech
Person M	Dental assistant	Highschool diploma	5 years	Bemems, Vatech

Table 4.2 The Brands Mentioned in the Interviews

X-ray Brands	Country-of-Origin	No. of mentions amongst interviewees
Acteon	USA	1
Asahi	Japan	1
Bemems	South Korea	2
Carestream	USA	1
DentiiScan	Thailand	1
Dentium	South Korea	1
HDX Will	South Korea	1
J Morita	Japan	3
KaVo	Germany	1
Sirona	USA	4
Vatech	South Korea	3
Unknown	China	2
Unknown	Japan	1

4.2 Interview Results Discussion

4.2.1 Attitude of Dentists Towards Branding

The attitude of dentists towards branding and how much it influences their purchase decision ranges from not having a brand preference to having brand preferences that have to take into consideration value for money as well. Familiarity is a key aspect for brand awareness and interest amongst dentists. All of the people interviewed stating that word-of-mouth (WOM) from friends and colleagues who have purchased an X-ray machine before, and WOM was what got them to notice and evaluate the brand to consider purchasing, through gauging real user experiences.

Other channels that allowed them to gain interest in brands were familiarity (through the devices and brands they were taught to use in dental school) and dental/medical conferences, where brands will often set up booths offering real product demos and host talk sessions by specialists.

4.2.2 Country-of-Origin Brand Perception

Through the interview process, it was found that most dentists did not remember the brand names of dental X-ray equipment readily. Some did not remember at all, while all of them remembered the country associated with the brand almost instantly. "I don't remember the name but it's from _ country ...", showing that country-of-origin (COO) was often the first and only identifiable characteristics of a dental X-ray brand in a dentist's eyes, followed by its name. COO was also used as a categorizer, for dentists to distinguish between different "grades" of products, where they place a higher level of trust in a brand for being from Europe and North America, followed by Japan and South Korea, and the least being Chinese and Thai brands. This trust however, can be offset by the perceived value-for-money of the X-ray from level of performance, longevity of the device, economic pricing, or service quality.

Trust was an aspect mentioned frequently amongst interviewees, with company experience, COO, and familiarity through word-of-mouth being the top three determinants for establishing trust and loyalty towards a dental X-ray brand. The longer the company has existed, the higher degree of trust is placed upon the brands and expected quality of product and services. The country-of-origin of the dental X-ray brand was able to influence initial trust, whereas the country where the parts were manufactured did not have an influence, as long as they were certified and able to sell in Europe/USA/Japan/South Korea, the product will be associated with those standards in the dentists' minds.

Unprompted, cars were used as an analogy to explain how the COO of brands influence their views on the product and service. From a functional perspective, one dentist said that "It's like a car. European cars or Japanese cars no matter, they all drive the same. you just have a few different functions.", meaning all brands were able to perform the same basic function of producing X-ray imaging. Another dentist also compared the service aspect to cars, "The issue with European

cars is that the spare parts are expensive, so people switch. No one wants to replace them often because it costs millions. That's why people buy Toyota, because it's easy to maintain, parts are cheap, and repair centres are everywhere.", showing that in a product where long use life is expected, many prefer a reliable brand where maintenance are cheap and accessible. On the other hand, another dentist said "It's not like a car you know? There's no variety. It's not like there's colours and seat types, [for X-ray] large or small there's not much size difference", meaning that in their perspective, X-ray devices are similar in outward appearance, therefore there aren't a lot of aspects to choose from, unlike a car where there are many different models and options, varying visual designs and styles.

4.2.3 Attitude Towards Price and Renting

In terms of functional factors, all of the dentists highlighted the importance for sharp image quality, essential for diagnosing and planning treatment for patients. Sharper image quality eased the dentists' work, reduced likeliness of misdiagnosis, and were needed for complex treatments. To a dental business, being able to treat a wider range of conditions and diseases meant a wider range of customers, and more income. Therefore, they must balance between the highest quality of imagining they are able to afford, compared to the treatment options they are planning to offer.

To study the possibility of a subscription/renting business model for dental X-ray manufacturers, questions were asked to gauge the dentists' attitude towards renting, which was found to also vary, as some (a majority of the younger dentists) thinks that renting is helpful towards cost reduction in their dental clinic businesses. "Renting them would be really helpful because X-Ray machines are probably one of the highest sunk costs in a dental clinic business." Neutral viewpoints from other dentists found that renting would be alright as long as the brands were of satisfactory quality but would prefer 1st hand products if available. "1st hand products are mostly up-to-date and better quality, so I'm more interested in 1st hand. But If there's no budget for it ... It's fine if the brand is alright." This customer segment is open-minded to renting models, but may be wary of certain brands they deem less trustworthy. Establishing transparency of the refurbishment process and quality

guarantees may reassure them that the device is still up to standard and will be able to provide a high-quality experience as with any first-hand device. Educating them about the service life of components or offering bonus repairs and/or preventative maintenance may further persuade them to gain trust towards the brand's service.

Lastly, a dentist who was more experienced found renting to be unnecessary (likely because the price of dental X-rays have decreased over the years and options have increased, therefore experienced dentists find the price nowadays to be less expensive). "In this era of cheap X-Ray devices I don't think anyone would rent one? If you're gonna rent, won't financing it and paying in instalments be better?". This shows a difference in views of the dentists from different generations. For this group of customers, it will be essential to address their scepticism of the renting model. Showing the benefits that flexible short- and long-term rental models can provide through properly communicating available options to customers is key. For example, short-term rentals may be useful in the case that an existing device breaks down, and it is still in the process of being fixed, so that they will be able to provide continuous service to their customers. Whereas long-term rentals might be beneficial to clinics who are looking to begin or expand their services, the upfront cost for the machine and risk of investing in a device unsuitable for them is lessened. While open-ended rental periods could provide an extra level of flexibility.

4.2.4 Recommendations for Thai Brands

In the last section of the interviews, dentists were asked to recommend to Thai dental X-ray device brands and policy makers, what would improve sales and recognition towards Thai brands in their opinions.

What seems to be the consensus amongst them is that gaining the general public's awareness towards the brand will be the important first step in established as a trustworthy Thai choice amongst competitor brands. "The more unknown it is to people, the more it's unable to be trusted." All except 3 of the dentists interviewed had heard of the Thai brand of dental X-ray 'DentiiScan' before.

The dentists recommend that Thai brands should place emphasis on developing a customer-centric mindset in their personnel, during the product development stage in order to better understand customer needs and manufacture a

device that are suitable for its users. As a dentist said, "There's both advantages and disadvantages to the word "Thai Brand". The advantage of a Thai brand is that all the functions, height, step size, etc. should be most suitable for Thai people, in terms of ergonomics, right. I think everything, 'cause it's developed for Asians, so it creates a unique point unlike others." This shows that it is perceived by some that there is still room for improvement in terms of product ergonomics for Thai users. However, the brand should also take into account the device's suitability for a wider audience if it wishes to expand its customer base internationally and tap into medical tourism as effectively as possible.

At the pre-purchase stage, product trials and demos are seen as vital towards establishing trust towards the quality of newcomer brands. "No matter the country, if it's a new brand, there is no history for us to see, no older models to compare. So, for us to want to try it, there would need to be a demo. Just one scan or a few films is not enough, maybe we could try for a month to see." Through the interviews undertaken, it was found that this is already the norm in the industry, where customers can request/book a demo session with the real device at company headquarters or certain medical conference events. Currently, the Thai brand is offering only demos of its software. To provide a more convenient and better experience than competitors, it may be beneficial to look into the use of mobile vans that allow the device to reach a wider audience, attracting potential customers.

Next, in the purchasing stage, expanding product availabilities into the service market, such as renting or subscription models could allow a larger group of dental businesses, including clinics with lower-middle capital to offer a wider range of dental treatments to their clients. "With the economic situation, dentists are trying to reduce their equipment cost as much as possible. If the basic function is there, and you can rent as you like, and better service. The low-mid market would be interested."

Lastly, once customers have started to use the products it is found that maintenance services, spare part availability and cost effectiveness of those parts will become crucial to the longevity of a customer's loyalty towards the brand. It is recommended that the Thai brands should manufacture the parts domestically, thereby reducing cost and improving accessibility, as well as developing the technical

skills and know-how along the supply chain. "If we manufacture domestically then there's no import tax. When it's cheaper, people want to use it, as long as the function is the same."

Moreover, it is important to note that in the promotion of Thai brands, pushback and be avoided by promoting the quality and benefits associated with a Thai brand on par with any other brand from another country. Instead of existing efforts to promote Thai products just for the sake of being loyal. Many dentists interviewed expressed distaste in Thai products in general because they found that many Thai products have been “pushed” towards them just because they were Thai and without much other persuasions, they felt that they were forced to buy something of lesser quality. The primary research conducted in this study went in accordance to Speece’s 2000 study which states that Thai products that advertised their superior quality rather than ethnocentrism were more successful.

4.2.5 Other Factors

Other factors that impacted the dentists’ purchase decisions to a lesser degree includes longevity of device, energy consumption, level of radiation, and disposal methods (in order from most important to least important). Many dentists find longevity to be important as X-ray devices are an expensive investment, a long use life through maintenance and fixing is preferable to replacing the machine. “Personally, longevity should be the main factor because the budget could be divided into yearly or daily costs. sometimes we buy something expensive, with lots of function but it ends up breaking shortly. With X-Ray machines, you want to invest in it and forget about it.”

Energy consumption was also one of the factors considered considerably, as it also relates to the dental clinics’ operating/variable cost “If the electricity usage could be reduced, it reduces the operating cost, X-ray scans uses a lot of electricity so it may disrupt the other electrical equipment.”

As for radiation levels from X-ray equipment, none of the dentists are concerned about choosing “I’m not that concerned about radiation safety because there’s an organisation that comes check the radiation levels already. If the radiation was at a dangerous level it wouldn't have been sold.” All the dentists said they trust

that brands have already tested radiation safety, moreover they trusted the department of Medical Sciences. It is also important to note that generally, a higher radiation dosage produces higher quality scans, and vice versa for low dosage. Although with advancements in the medical imaging industry, some brands have released low radiation modes that maintains a relatively sharp imaging, which is possible due to image reconstruction algorithms and adaptive dosage. With the fact that most dentists prefer high-quality sharp images to aid the accuracy of their diagnosis, this might explain why radiation dosage might not presently be the top priority for dentists. Moreover, the duty of protecting patients and employees from the machine's radiation currently falls to the dental assistants who operate the machine and interact with patients. This suggests a potential gap for the inclusion of radiation safety education such as the ALARA principle for both the manufacturer and users' sides, promoting communication with clients and being concerned about the wellbeing of the equipments' users, rather than one-sidedly promoting as much usage as possible in cases which may not be needed. It is possible that the adoption of fixed-rate and variable-rate pricing models based on the amount of usage, such as those seen by Riversimple may be adapted towards the X-ray brand to increase the user's mindfulness of each scan. Moreover, research and development must be further conducted to design low radiation models while improving imaging quality, as some international brands have already started to address this issue with their products.

Lastly, none of the dentists were concerned about the method of disposal for after a device has been used to the end of its life, or replaced by newer technology. "I don't know actually. I haven't reached that stage yet but I think I would contact the brand I bought it from to ask them to dispose or consult them. I don't know the details of what they do with the machines after. But it's not something I would factor when buying." Many clinics in Thailand still use analogue dental X-rays which use films and developer and fixer solutions, while having upgraded to digital systems, the old devices are still kept without disposing them. Many dentists cited that they would probably "contact the brand", "sell to a 2nd hand user", or "sell as junk".

4.2.6 Dental Assistants

Through the interviews, it was discovered, as expected, that most dentists did not regularly operate the machine (hardware) but interacted more with the image acquisition/displaying/diagnostic program (software); so a key point for the dentists was for the software to be easy to use, store information, and export it. Moreover, some of the dentists interviewed also take into account the opinions of their dental assistants who regularly operate the machine and interact with patients.

Further interviews were conducted with dental assistants who have experience operating dental X-ray, which provided less information compared to the interviews with dentists. Most assistants were unable to give insights into some of the questions, especially about the brands. For example, when mentioning the word “brand”, the dental assistants would start to become apologetic, stating that they “don’t know about brands”, and that it’s “up to the dentists”. As such, they were also unable to provide answers about the various branding dimensions and purchasing factors.” All of the assistants stated that they have never heard of or interacted with Thai brands of dental equipment and so could not provide their opinions on comparisons.

However, the dental assistants were able to provide various pain points from the operator’s point of view, such as the unfamiliarity towards newer technology, long wait time for 3D X-rays compared to 2D X-rays, the preference for “the least number of clicks” to operate the machine with user-friendly software, and the struggles they face when handling patients and giving out instructions for the scan. Overall, the assistants were mostly neutral about the way X-ray machines currently function, “of course there are sometimes issues but in the end it is up to the dentist’s preferences.”

On the subject of safety, three of the dental assistants interviewed showed proper radiation safety procedures which includes putting lead aprons on the patients and exiting the X-ray room before pressing scan remotely, as well as expressing diligence in being cautious around radioactive equipment. One dental assistant admitted that sometimes, when small children are taking X-rays, they will have to stay in the room and hold the child still in order to obtain a clear scan. All of

them mentioned that planning (the room and lead walls), installing, and disposing the equipment were “up to the dentist”. One stated “I wouldn’t dare throw something so expensive away.”

It is recommended that the user-flow of products should be tested on those who do not have a traditional dentist background, as it reflects the nature of most dental assistants in Thailand, and ensures that the software and hardware are as user-friendly as possible.

4.2.7 Customer Journey and Touchpoints

From the interview process and secondary research collection, information was compiled in order to provide guidelines to develop and retain customer loyalty towards the brand. The complete customer journey of someone interacting with a dental X-ray brand could be identified as such:

1) Brand awareness – This stage could begin even before the dentist becomes a dentist, such as the brands they came in contact in when studying dentistry or brands available at their institution. They may also hear about brands and products through attending medical conferences or through WOM. As the Thai X-ray brands are still lesser known, gaining awareness is the first step in growing a loyal customer base. A combination of red market approach (Investing in promotion through the main channels such as medical conferences and social media platforms) and blue market approaches (engaging with educational and medical institutions in the provincial areas such as sponsoring equipment to aid in learning dentistry, or providing educational courses and lectures related to X-rays and dentistry) may be advisable to increase the effectiveness and dispersion of WOM.

2) Needs recognition – The dentist may be interested in opening up a new clinic, or to purchase one to replace/add to their existing clinic.

3) Information search – Although the dentist may have some brands in their minds at the moment, they check the market as to what is up-to-date. They evaluate what they want, the level of service they would like to offer clients and find products that fit their needs the best. It is suggested that online channels (such as the website or social media pages) are regularly updated with professional images and content to communicate the brand personality and its products and services.

Nowadays, many dental clinics also promote their business through online channels whereas in the past, brands would have to send in-person sales to each location, therefore it would present new opportunity to build a relationship and connection with potential customers.

4) Contact the brand(s) – Or vice versa, a brand may reach out to them if the dentist is also from a well-known institution (e.g., already working in a university hospital and planning to open their own clinic). Here they will contact sales from the brand or official retailers/dealers, they will be given more information as in stage 3, often through physical brochures rather than online resources. Additionally, an opportunity that the Thai dental X-ray brand must make available is to make device trials and demo sessions accessible to its potential customers.

5) Clinic location evaluation – The company will contact the dentist to evaluate the X-ray room to determine if the size is suitable and that lead-lined walls are built to regulation standards to ensure radiation safety. In accordance with industry standards, most brands offer to contact the Department of Medical Science, MoPH, as a complementary service to get the certification to ensure the X-ray equipment is installed correctly and can be used safely. Some also offer free protective equipment or lead shields.

6) Purchase decision and payment terms – Once the dentist has decided on the product and price, additional fees (installation, maintenance, insurance, etc.), and the payment terms and methods. It is suggested that rental or trial periods could increase the customer's willingness to try the product as it reduces the barrier to entry and level of risk in the investment.

7) Installing and training – Installing the machine and software, as well as instructing clinic personnel.

8) Using the machine on real patients – The important stage in gaining positive notion towards the product itself. If the product is reliable and able to perform as expected (as mentioned, this could also happen at the product trial stage), the user/purchaser will gain incentives to advocate towards their friends and colleagues. Often, dentists may promote their clinic through social media sites to show patient cases they have worked on by posting 'before and after' pictures of patients

and their X-ray scans; this is a good opportunity to promote the quality and real-world usability of the product, as well as keeping in contact with existing users. The user-friendliness of the device should also be tested on people operating the X-rays without medical backgrounds, often the real users (dental assistants) may not have studied dentistry as with the dentists who purchase the device.

9) Service and Maintenance – One of the most memorable stages throughout the customer journey, which could easily last decades, the question is not "if it breaks down" but "when it breaks down". If the brand is able to resolve the situation well through timeliness and providing quality repairs, it will lead to repurchase or upgrades with the same brand, or further recommendations by loyal users. Moreover, preventative maintenance can be done regularly to reduce unexpected issues, as well as recommend the suitable period before a component should be replaced, resulting in a decrease in the product breaking down while users are actively using the device, thereby reducing downtime and improving user experience.

10) Disposal – Often times, a dental X-ray device is not disposed of, but used less and less until the clinic no longer requires it, or the technology become obsolete. The device could also be sold 2nd hand to companies that offer to buy these devices. Most users do not consider method of disposal to be a part of their purchase decisions. However, if Thai brands are able to surpass others in this previously unconsidered stage of the product lifecycle, it will further show the level of professionality and the brand's ability to become a one-stop service for "all things X-ray".

4.3 Coding and Thematic Analysis

The codes from the interviews were highlighted from certain phrases or similar ideas that appeared frequently in the responses of multiple interviewees, then the themes were generated inductively through identifying and grouping codes together. In total, 5 main themes were identified (Trust, Branding, Service and Maintenance, Price, and Functionality), as well as 16 sub-themes and 34 codes (**Figure 4.1**).

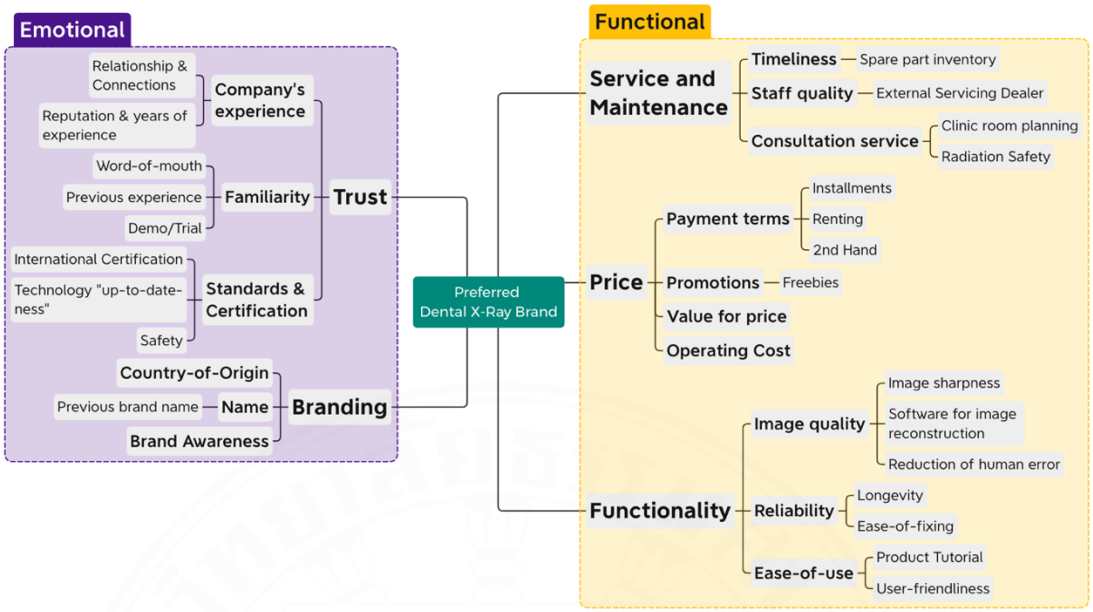

Figure 4.1 Diagram Showing Relationship Between Themes

The new codes and reoccurring (same) codes gathered from the dentists' interviews (target of interest) were compiled into a bar graph (**Figure 4.2**) to determine data saturation (new codes) and depth of each interviewee's answers (total codes). The number of new codes discovered from each interview were 18, 7, 5, 4, 0, 2, and 1, respectively, from 1A to 7G.

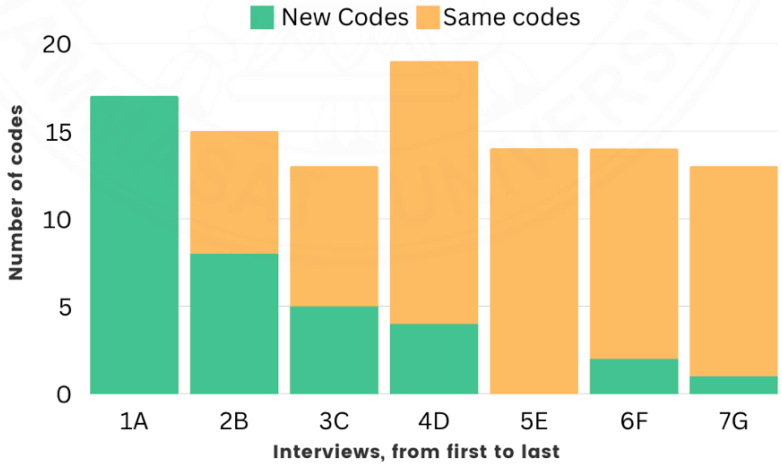

Figure 4.2 Data Saturation from Codes Generated in Each Interview

The breakdown of each theme, sub-themes, and code can be seen in the table below (the full: Preliminary codes are generated inductively through identifying

and grouping codes together. At this stage, 5 main themes have been identified (Trust, Branding, Service and Maintenance, Price, and Functionality), as well as 16 sub-themes and 34 codes. The breakdown of each theme, sub-theme, and code can be seen in **Table 4.3**.

Table 4.3 Summary of Themes and Sub-themes from Thematic Analysis

Themes	Subthemes
Trust	Company's experience, Familiarity, Standards and
Service and	Timeliness, Staff Quality, Consultation Service
Price	Payment Terms, Promotions
Functionality	Image Quality, Reliability, Ease of Use
Branding	Country-of-Origin, Name, Brand Awareness

4.4 Strategic Guidelines

4.4.1 Brand Communication

The brand must communicate the brand's rich history and experiences in the market in order to gain trust. If it does not yet have these it should seek to develop them. However, in the case of a newcomer brand who is currently lacking in customers, it may also be possible to gain user case studies from university hospitals or community clinics as a way to understand the specificities of a community and their requirements. This is an aspect that international brands may have a hard time achieving. To understand an underserved community's needs in terms of dental equipment, prevalent diseases, regulations, cultural boundaries, local holistic treatments, and any other issues that a user may have is important. As a dentist pointed out, "The advantage of a Thai brand is that all the functions… should be most suitable for Thai people".

4.4.2 Improving Country-of-Origin Brand Perception

Of course, getting a standard certification such as ISO13485 (international certification for medical device manufacturing) is a given, and the crucial first step, and Thai brands have already received that certification. But by changing the way it is communicated to customers may increase trust. For example, leveraging the positive image of another Country-of-Origin or Region-of-Origin by tying it with the Thai brand. “The first Thai brand certified by European standards” or “Made in Thailand, trusted by dentists worldwide”. Many Korean brands, which is currently the country with the most CBCT brands and product lines in the world, already use this technique in their communication channels (such as the official websites) through subtle positioning of their country image with international standards. Moreover, they feature their foreign customer base in their customer testimonial videos and promotional pictures, therefore most of the content contains non-Asian (mostly Caucasian) people. As such, someone who may not be familiar with the brand may perceive it to be more “International”. It is still unclear whether or not representation and diversity in this case will increase relevancy towards the prospective Thai customers, but English-based content will be able to be reached and understood by most dentists worldwide. However, use cases and certification must be gathered concretely before claiming such qualities do avoid any disputes as the locally governing rules and regulations towards advertising medical devices are still strict. It is also advised to adhere to best industry practices in designing online channels such as the company website; including having coherency amongst different platforms (so they appear to be part of the same brand. This may be addressed through brand logos, slogans, mission and vision statements, main value propositions, and a collection of unifying brand assets; quality of graphics and promotional images; content and language (as having English versions of website available too are standard in all the brands sampled in this study); and transparency of product and service information.

4.4.3 Pricing Models

Pricing differentiation can be creating by utilizing subscription pricing or renting models. This shifts the focus from ownership towards a circular economy

where X-ray devices may not have to be owned but rented in a short to long term basis. This also creates top-of-mind brand with users because it isn't a one-off payment, brand keeps in touch with users and vice versa. Moreover, the responsibility of ensuring a product is of good quality and will provide longevity, is on the company rather than the customers, customers will be able to be assured that they will be taken care of.

4.4.4 Proposed Framework

The proposed framework for the guidelines that have been developed through this present research to influence customer adoption and loyalty towards brand based on multiple touchpoints throughout the customer journey is illustrated in **Figure 4.3**. The X-axis shows how the brand may increase the resilience towards the brand for a sustainable growth, while the Y-axis suggests how the brand can expand its customer base. The house analogy adopted in this figure was created to visually indicate that companies can choose the actionable stages it wishes to take (windows) whilst building their dental X-ray brand and growing their customer numbers whilst retaining customer loyalty. The foundations for this are the backstage operations that should be completed in order to ensure a stronger brand engineered to withstand growth.

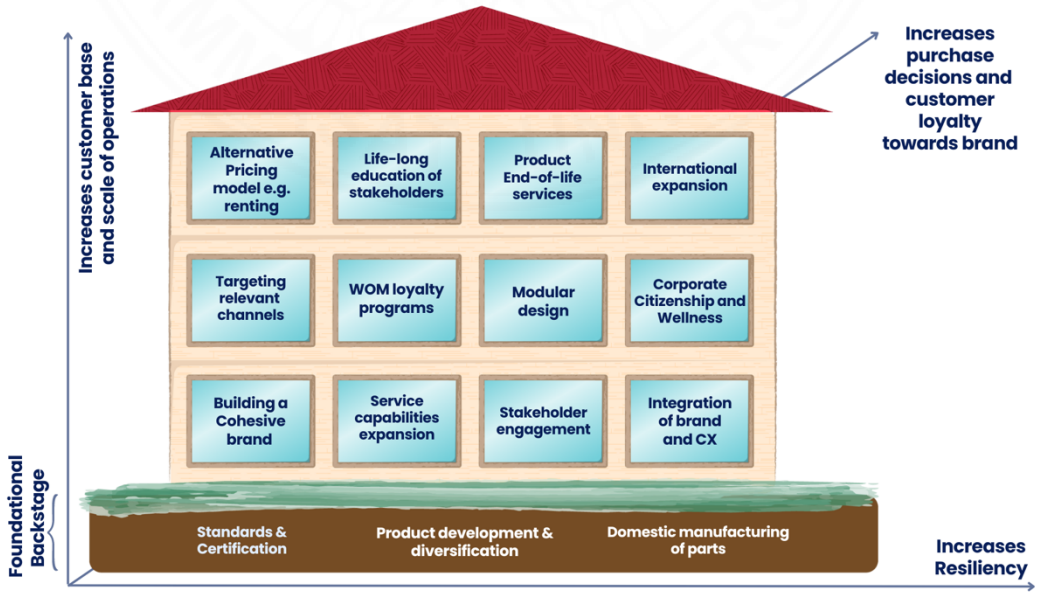

Figure 4.3 Proposed Framework for Developing Thai Dental X-ray Brands

To expand further on the framework at the foundational level, three things are suggested:

Obtaining **standards and certification:** (preferably internationally accredited ones) to start and establish trust in a Thai brand.

Product Development and Diversification: Of all the brands surveyed, the Thai brand had the smallest product portfolio. By developing new products and expanding the area of expertise, the brand will be able to create an ecosystem from their products, where multiple products in a single clinic will be from the same brand. This allows them to enter new markets, promote products and services that can be used together, and encourage multiple purchases through bundle sale promotions. The resiliency of the overall company increases as they are spreading the risk while still being able to grow the brand, and they will benefit from economy of scale as certain parts across different devices may be designed to be interchangeable. However, this is not economically viable in the earlier stages of development. The brand should focus about the products already launched, and how to provide outstanding service for their customers. Eventually, as the company grows it will then be advisable to expand and diversify its product lines.

Domestic manufacturing of parts: Currently, certain complex components are imported to be assembled into the X-ray machine. This is less economical in the long run, less resilient to external conditions, and reduces local companies and employees' capabilities to design and manufacture such components. Improved reliability in the supply of spare parts also improves service timeliness for maintenance and repairs.

As the foundation is being built, the "house" could then be laid out. The brand is advised to start from the axis of the graph (the bottom left window of **Figure 4.3**). **Figure 4.4** shows the directional growth plan for the brand. Though it is possible to build the "house" brand focusing on its "height" (scale) to grow customer base, in the long-term growth and longevity of the brand, the house should also be expanded on its "length" (resiliency). Overall, growing your brand both height-wise and length-wise will increase the trust in the brand, the heart of purchase decision and loyalty, leading to advocacy for the brand.

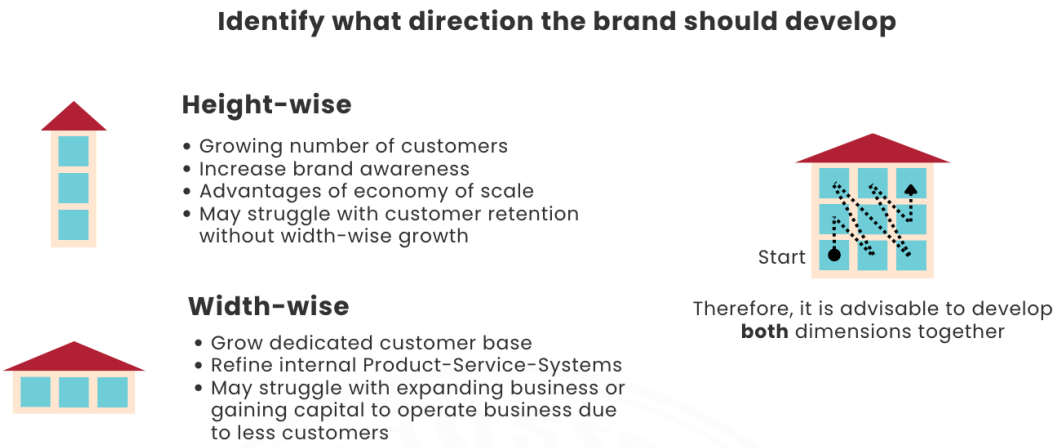

Figure 4.4 Brand Direction Strategies

It is recommended for the Thai dental X-ray brand to develop and grow the vertical and horizontal axis together. This strategy is arranged according to which actions should be completed first, and divided into 3 stages as follows:

Base-level Strategies:

1) Building a Cohesive Brand: As mentioned in the section 4.4.2 guideline to improve Thai COO brand image, achieving a set of cohesive branding assets, such as developing memorable product and service names, visual components (logos and brand themes and colours), memorable brand messages (what companies would like to communicate to customers and the associations they make towards the brand such as mission and vision statements, brand image (the way customers will perceive the brand), brand personality (characteristics which define the brand emotionally, etc.) throughout communication channels (website, social media, prints and brochures) is the pathway to ensuring that any promotional content is better associated with the brand and makes the brand more memorable to its potential customers.

2) Targeting Relevant Channels: Create content such as evidence-based promotions (where quantifiable characteristics such as statistics are used to promote products/services e.g. image quality resolutions), user testimonials (opinions from real customers), and product demos) which includes the brand assets, then launching them in relevant channels that dental personnel frequent (as mentioned in

section 4.2.7 of this work ‘Customer Journey and Touchpoints’) such as dental conferences, educational institutions, and online channels.

3) Service Capabilities Expansion: Once the first two strategies start to bring in more customers, service capabilities of the company (such as the number of employees, training, digitization, organization, database system, expansion of service centres) must also be increased to match the demands and ensure reliable and timeliness of service to handle the growing number of users.

Mid-level Strategies:

4) Alternative Pricing Models: Explore various pricing models such as renting (short and long-term) or subscription-based systems, which will be possible to start operating once the company has started to expand its capabilities from the base-level strategies.

5) WOM Loyalty Programs: At this point, there may be an increase in number of customers who are not yet regulars who were incentivized to try out the renting models. Therefore, loyalty programs (such as referral bonuses and memberships) must be put in action to retain the new customers.

6) Stakeholder Engagement: Incorporating various stakeholders (such as customers, R&D staff, service engineers, organizations that provide safety certifications) in the design and development process in order to gain appropriate and relevant feedback, and for the employees to gain empathy about each department and users, leading to a more human-centric approach in all the business operations.

7) Life-long Education: As already undertaken by some brands, there are courses and lectures held for their customers through collaborating with industry professionals. To go one step further, rather than courses that focus on X-ray dentistry only, there could be interdisciplinary courses on other relevant fields such as marketing for dental clinics, human resource. This shows that the brand is genuinely interested in the personal development of each client beyond business transaction. As many small private clinics are family owned or individually owned dentists, the brand could expand on its services to include consultation and education to encourage clients to thrive with them. For B2B businesses, if the client’s business is successful

and profitable, they will be more willing to invest in equipment and services to further grow their business.

Education also extends to the company employees and stakeholders in the supply chain, through workshops and activities that can foster leadership and collaboration, as well as personal skills development. A sustainable workforce means that employees can be productive and satisfied with the work they do and find meaning in the impact they have on society around them.

8) Modular Design: Any redesigns require flexible engineering methods that may be different from traditional machines in the market, setting the product technology apart from its competitors. By adopting modular design, it allows the machine components to be maintained or refurbished with greater ease throughout the product's lifecycle. It could even allow cutting-edge components to be added to the product instead of a completely new product being required, resulting in significant cost savings. This may be more feasible option for a company with more capital to develop, so it is recommended in the mid- to high-level strategies (though, if possible, could have benefits if achieved earlier). Currently only one brand of dental X-ray has adopted a certain level of modular design in its components, which allows customers the option to update and keep up with newer technology.

High-level Strategies:

9) Product End-of-life Services: As mentioned in the modular design section, these kinds of services could be benefitted from having a device that was designed with disassembly in mind. By offering end-of-life services, not only will the brand gain opportunities to further interact with its customers, do good, advertise any new products or services, obtain end-of-life product feedback, and persuade the customer to continue buying the product/service; but the disposed device may also be able to be reconditioned for a second or third use, and retain the materials from machine parts to recycle or reuse, closing the loop to become more sustainable. Moreover, this also discourages customers from seeking third-party disposal or refurbishing services, or contacting another brand to purchase new products, thereby retaining as many customers as possible.

10) Integration of Brand and Customer Experience (CX): In the earlier stages of strategy, it is mentioned that the brand assets should be integrated across the communication platforms. The next stage is to integrate it amongst all the interactions with customers, including the Product-System Services.

11) Corporate Citizenship and Wellness: The brand should engage in the wellbeing of the community around them, this can be through efforts that give back to society; such as financial initiatives like donating medical devices, skill-based volunteering to offer marginalised communities an opportunity to access dental services, investing in local workforce development in the field of dentistry and medicine through sponsorship in education and training, and implementing measures that encourage clinics to practice improved radiation safety such as correctly using protective equipment and taking X-ray dosage, and number of X-rays actually required, more into consideration. Similar to the section on life-long education, corporate citizenship can improve the positive brand image of the company, as when the community thrives, the company itself will be able to thrive as well.

12) International expansion: Once the brand has started to establish a loyal customer base in Thailand, the brand will be able to expand its services internationally. To gain experience, it may be possible to start with international communities in Thailand to understand more about the personality of each country's customer groups and seek to answer any pain points they are needing addressed. Though it may be tempting to expand manufacturing to another country due to cheaper labour costs, if it truly believes itself in being a Thai brand, continuing to expand and establish manufacturing locations within Thailand will further extend the Thai medical device ecosystem and develop the skill of its stakeholders. This will aid the process of fully transforming from OEM to OBM, being able to successfully manufacture, design, and brand their products.

CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The public healthcare system is a vital part of our everyday lives, and as the COVID-19 pandemic has shown, even the most complex and sophisticated of systems have their vulnerabilities that need to be addressed. It is also considered highly important to properly invest in this country and its medical infrastructure to help aid its prosperity and development. Therefore, effort must be taken to put in place measures to ensure that these systems are resilient enough to withstand both trends and uncertainties.

Ideally, Thailand should be able to meet its own medical needs, but the current situation is that majority of durable and complex medical devices are imported. Medical devices have an essential role in providing safe and quality healthcare to patients, yet this is an understudied and under investigated topic in existing Thai literature. The industry itself is also underdeveloped. The potential growth of the Thai medical device ecosystem can be attributed to 3 factors: a rise in NCDs, the aging population, and medical tourism. The dental industry was chosen as the target area of interest due to its intersection to these three factors, plus the fact that dental X-rays are essential to the provision of effective dental services, and that a very low proportion of dental X-ray devices used within Thailand are actually produced here. Huge potential for growth is indicated.

Whereas previous research conducted on Thai medical devices has mostly been on single-use medical devices such as gloves or surgical masks, or reagents such as test kits, research on the complex and durable medical devices category is still mostly lacking. Previous guidelines and roadmaps to encourage the development of the Thai medical device ecosystem such as Hamilton & Vatananan-Thesenvitz's 2017 study, have been published on the institutional perspective of laws and regulations which encouraged R&D and investment. COO branding perception of Thai brands were

previously conducted on consumer goods, mostly in the category of food and textiles. Lastly, the factors related to purchase decisions of medical devices were mainly conducted on the basis of hospital systems which required procurement systems and were often decided by non-users such as hospital managers and directors (Pornpasertphon, 2021).

Therefore, the contributions this thesis provides to the area of research undertaken are:

1) Showing that developing and improving the brand awareness, brand image, and purchasing behaviour of Thai dental care providers in favour of Thai manufacturers of dental X-ray devices is not as simple as developing a combination of logos, brand colours, brand message, and personalities. Much deeper thought and analysis are required. This is because dental X-ray device purchasers do not generally memorise these traditional "brand" aspects.

2) Revealing that the Thai dental X-ray device market is dominated by international brands. Some key players are Sirona, J Morita, and Vatech, which are from the USA, Japan, and South Korea, respectively. These brands adopt an international image with quality, service, and trust at its core, relying on word-of-mouth marketing from loyal customers and advocators to encourage new customers' purchase decisions.

3) Providing insights gained through analysing the collected data that developing trust towards Thai products will be critical in the development customer loyalty towards the brand, as dental X-ray devices are highly related to the safety of users and accuracy of X-ray images to aid diagnosis.

4) Development of human-centric branding guidelines based on real users which explore the possible actions that Thai dental X-ray brand(s) can take to address the issues identified and become a successful medical device brand that understands its clients, the marketplace, and opportunities for entrepreneurship and innovation. They are based on the findings that for B2B medical device businesses, it is rather the actions and experiences and how the brand interacts with its stakeholders, that are the identifiers for customer purchase decisions, satisfaction, engagement, and loyalty towards the brand. The benefits that devices can create over their rivals should also

be taken into account as a way forward, especially with the safety and wellness of users in mind.

For a dental X-ray brand to be recommended positively by a dentist, it is recognised that they might not necessarily even remember its name right away. It is due to the way the brand reaches out to clients, developing a lasting relationship and providing effective services and improved experiences in a timeliness manner that can count the most. This guideline offers a few memorable touch points for brands to keep in mind, throughout the lifecycle of the product, in the hopes of gaining importance in the user's minds and hearts and developing world-leading products and services. It is proposed that if brands adopt the recommendations and measures that have been developed in this work, Thailand's dental X-ray brands can successfully transition from OEM to OBM.

5.2 Limitations and Recommendations

Due to the small sample size compared to the size of the dental population within Thailand, it is recommended that further research is conducted on dental clinics in other provinces to gain a more comprehensive overview of Thai dentists and dental staff, which may be achieved using quota sampling of dental clinics in each region. Moreover, with regard to the length of interviews, many potential interview subjects were discouraged from participating in the interview due to the time-constraints of their jobs, and this may limit the participant's depth of answers. This issue needs to be addressed, if possible, in further research.

In particular, it is recommended that additional research be conducted on the backstage of X-ray device manufacturing and everyday usage (service engineers, mechanics, manufacturer, etc.), as well as further assessing and testing user needs to determine any adjustments needed to facilitate smooth and effective implementation, in order to further develop and refine the framework to positively differentiate between Thai brands and others, and help Thailand be a world leading producer of dental X-ray devices.

It is further proposed that this framework can be further developed and adapted to enable it to be applied to other areas of the Thai medical device industry wishing to transition from OEM to OBM.

REFERENCES

Books and Book Articles

Degeetern, M. (2009). *Changing perception: Hospital brand as a design strategy. Healthcare Design*, 9, 10-15.

Jones, P. H. (2013). *Design for Care: Innovating Healthcare Experience*. Van Duuren Media.

Lee, K., & Mathews, J. A. (2012). *South Korea and Taiwan*. In E. Amann & J. Cantwell (Eds.), *Innovative Firms in Emerging Market Countries* (pp. 223–246). Oxford University Press eBooks. https://doi.org/10.1093/acprof:oso/9780199646005.003.0006

Papanek, V. (2019). *Design for the Real World*. Thames & Hudson.

Articles

Aguwa, C. C., Monplaisir, L., Sylajakumari, P. A., & Muni, R. K. (2010). Integrated Fuzzy-Based Modular Architecture for Medical Device Design and Development. *Journal of Medical Devices, 4(3).* https://doi.org/10.1115/1.4002323

Barbero, S., Pereno, A., & Tamborrini, P. (2017). Systemic innovation in sustainable design of medical devices. *The Design Journal, 20(sup1)*, S2486–S2497. https://doi.org/10.1080/14606925.2017.1352763

Batra, R., Ramaswamy, V., Alden, D. L., Steenkamp, J. E., & Ramachander, S. (2000). Effects of Brand Local and Nonlocal Origin on Consumer Attitudes in Developing Countries. *Journal of Consumer Psychology, 9(2)*, 83–95. https://doi.org/10.1207/s15327663jcp0902_3

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3(2)*, 77–101. https://doi.org/10.1191/1478088706qp063oa

Bruner, G., & Pomazal, R., (1988). "Problem Recognition: The Crucial First Stage of The Consumer Decision Process". *Journal of Services Marketing, 2(3)*, pp. 43-53. https://doi.org/10.1108/eb024733

Ceschin, F., & Gaziulusoy, I. (2016). Evolution of design for sustainability: From product design to design for system innovations and transitions. *Design Studies, 47*, 118–163. https://doi.org/10.1016/j.destud.2016.09.002

Cherry, C. L., & Pidgeon, N. F. (2018). Why Is Ownership an Issue? Exploring Factors That Determine Public Acceptance of Product-Service Systems. *Sustainability, 10(7),* 2289. https://doi.org/10.3390/su10072289

Choi, A. J. (2022, December 4). The environmental impact of healthcare. *Pursuit.* https://pursuit.unimelb.edu.au/articles/the-environmental-impact-of-healthcare

Crowley, R. A. (2016). Climate Change and Health: A Position Paper of the American College of Physicians. *Annals of Internal Medicine, 164(9)*, 608. https://doi.org/10.7326/m15-2766

Gaêta-Araujo, H., Alzoubi, T., Vasconcelos, K. D. F., Orhan, K., Pauwels, R., Casselman, J. W., & Jacobs, R. (2020). Cone beam computed tomography in dentomaxillofacial radiology: a two-decade overview. *Dentomaxillofacial Radiology, 49(8)*, 20200145. https://doi.org/10.1259/dmfr.20200145

Guest, G., Bunce, A., & Johnson, L. (2006). How Many Interviews Are Enough?. *Field Methods, 18(1),* 59–82. https://doi.org/10.1177/1525822x05279903

Juntunen, M., Juntunen, J., & Juga, J. (2011). Corporate brand equity and loyalty in B2B markets: A study among logistics service purchasers. *Journal of Brand Management, 18(4)*, 300-311.

Kane, G., Bakker, C., & Balkenende, A. R. (2017). Towards design strategies for circular medical products. *Resources Conservation and Recycling*, *135*, 38–47. https://doi.org/10.1016/j.resconrec.2017.07.030

Keller, K. L. (2001). Building customer-based brand equity: A blueprint for creating strong brands. *Marketing Science Institute.* http://thearf-org-unified-admin.s3.amazonaws.com/MSI/2020/06/MSI_Report_01-107.pdf

Kemp, E., Jillapalli, R. & Becerra, E. (2014). Healthcare branding: developing emotionally based consumer brand relationships. *Journal of Services Marketing, 28*, 126-137.

Kuhn, K. L., Alpert, F., & Pope, N. K. L. (2008). An application of Keller's brand equity model in a B2B context. *Qualitative Market Research: An International Journal, 11(1)*, 40–58. https://doi.org/10.1108/13522750810845540

Kumlin, M. (2020, June 29). Elderly patients with complex health problems in the care trajectory: a qualitative case study - BMC Health Services Research. *BioMed Central*. https://bmchealthservres.biomedcentral.com/articles/10.1186/s12913-020-05437-6

Ladha, Z. (2007). Marketing Strategy: Are consumers really influenced by brands when purchasing pharmaceutical products? *Journal of Medical Marketing, 7(2),* 146–151. https://doi.org/10.1057/palgrave.jmm.5050072

Leek, S., & Christodoulides, G. (2012). A framework of brand value in B2B markets: The contributing role of functional and emotional components. *Industrial Marketing Management, 41(1),* 106–114. https://doi.org/10.1016/j.indmarman.2011.11.009

Linton, O. W. (1995). Medical applications of X rays. *Beam Line*, *25*(2), 25-34. https://www.slac.stanford.edu/pubs/beamline/25/2/25-2-linton.pdf

Lorke, W. (2021, January 24). Recycling and Disposal of Medical Devices. *Johner Institute.* https://www.johner-institute.com/articles/product-development/and-more/recycling-and-disposal-of-medical-devices/

Lurie, A. G. (2019). Doses, Benefits, Safety, and Risks in Oral and Maxillofacial Diagnostic Imaging. *Health Physics*, *116*(2), 163–169. https://doi.org/10.1097/hp.0000000000001030

Mangano, F., Gandolfi, A., Luongo, G., & Logozzo, S. (2017). Intraoral scanners in dentistry: a review of the current literature. *BMC Oral Health, 17(1).* https://doi.org/10.1186/s12903-017-0442-x

Marquardt, A. J., Golicic, S. L., & Davis, D. F. (2011). B2B services branding in the logistics services industry. *Journal of Services Marketing.*

Nguyen, A. N., Nguyen, P. V., & Luong, T. D. B. (2015). Factors influencing loyalty of dentists towards dental product suppliers. *International Journal of Economic Research*, 0972–9380.

Peres, M. A., Macpherson, L. M. D., Weyant, R. J., Daly, B., Venturelli, R., Mathur, M. R., Listl, S., Celeste, R. K., Guarnizo-Herreño, C. C., Kearns, C., Benzian, H., Allison, P., & Watt, R. G. (2019). Oral diseases: a global public health challenge. *The Lancet, 394(10194)*, 249–260. https://doi.org/10.1016/s0140-6736(19)31146-8

Pisitsankkhakarn, R., & Vassanadumrongdee, S. (2020). Enhancing purchase intention in circular economy: An empirical evidence of remanufactured automotive product in Thailand. *Resources, Conservation and Recycling, 156*, 104702. https://doi.org/10.1016/j.resconrec.2020.104702

Plant, A. V., Harrison, D. J., Griffiths, B. J., & Lam, B. (2010). Design standards for product end-of-life processing. *International Journal of Sustainable Engineering, 3(3)*, 159–169. https://doi.org/10.1080/19397031003686918

Ricci, P. M., Boldini, M., Bonfante, E., Sambugaro, E., Vecchini, E., Schenal, G., Magnan, B., & Montemezzi, S. (2019). Cone-beam computed tomography compared to X-ray in diagnosis of extremities bone fractures: A study of 198 cases. *European Journal of Radiology Open, 6*, 119–121. https://doi.org/10.1016/j.ejro.2019.01.009

Salama, K. F., AlObireed, A., AlBagawi, M., AlSufayan, Y., & AlSerheed, M. (2016). Assessment of occupational radiation exposure among medical staff in health-care facilities in the Eastern Province, Kingdom of Saudi Arabia. *Indian journal of occupational and environmental medicine, 20(1)*, 21–25. https://doi.org/10.4103/0019-5278.183832

Seyedghorban, Z., Matanda, M. J., & LaPlaca, P. (2016). Advancing theory and knowledge in the business-to-business branding literature. *Journal of Business Research, 69(8)*, 2664–2677. https://doi.org/10.1016/j.jbusres.2015.11.002

Sharma, R., Stano, M., & Gehring, R. (2008). Short-term fluctuations in hospital demand: implications for admission, discharge, and discriminatory behavior. *The RAND Journal of Economics, 39(2),* 586–606. https://doi.org/10.1111/j.0741-6261.2008.00029.x

Srivastva, K. P. (2019). A study to assess knowledge and awareness of dental surgeons towards radiation hazards. *IDA Lud J –le Dent 2019, 3(1),* 6-10.

Speece, M., & Pinkaeo, K. (2002). Service Expectations and Consumer Ethnocentrism.

Australasian Marketing Journal, 10(3), 59–75. https://doi.org/10.1016/s1441-3582(02)70158-4

Venkatesh, E., & Venkatesh Elluru, S. (2017). Cone Beam Computed Tomography: Basics and Applications in Dentistry. *Journal of Istanbul University Faculty of Dentistry, 51(0).* https://doi.org/10.17096/jiufd.00289

Wolf, T., Cagetti, M. G., Fisher, J., Seeberger, G. K., & Campus, G. (2021). Non-communicable Diseases and Oral Health: An Overview. *Frontiers in Oral Health*, *2*. https://doi.org/10.3389/froh.2021.725460

Electronic Media

Acteon. (2023). Acteon Thailand. https://m.facebook.com/story.php?story_fbid=pfbid02T8eM4jUxaqkHJFbo1CrteGKtniZh6c4PKJH2919f8qWe2Cf2CcWDh9TrJ3kUVKHrl&id=583116272070179&mibextid=Nif5oz

American Cancer Society. (2022). https://www.cancer.org/healthy/cancer-causes/radiation-exposure/x-rays-gamma-rays/do-xrays-and-gamma-rays-cause-cancer.html

Bangkok Dental. (n.d.). *Dental Tourism*. https://www.bangkoksmiledental.com/dental-tourism.php

Bangkok Post. (2021). Medical Devices to Leverage Thailand'S Competitive Supply Chain. https://www.bangkokpost.com. https://www.bangkokpost.com/business/2164951/medical-devices-to-leverage-thailands-competitive-supply-chain

Board of Investment. (n.d.). *Opportunities in the Bio-Circular-Green (BCG) Economy and BOI Support Measures* [Slide show]. https://www.boi.go.th/upload/content/BOI-BCG_DSG%20Chokedee.pdf

DBD DataWarehouse. (n.d.). 32501 Manufacture of medical instruments and supplies (except dental instruments and supplies). https://datawarehouse.dbd.go.th/business/32501/

Deloitte. (2022). Global Health Care Sector Outlook.

https://www.deloitte.com/global/en/Industries/life-sciences-health-care/perspectives/global-health-care-sector-outlook.html

DentiiScan. (2023). Medical Imaging System. https://facebook.com/story.php?story_fbid=pfbid0o3S4sjJvkr3LWfxyQReqdnQ85VJy7dRNoZVZZWhRxTWAmV8EZ2AEHGBJK5DNQ27sl&id=100063886332669&mibextid=Nif5oz&_rdc=1&_rdr

Dentsply Sirona. (2023). Dentsply Sirona. https://facebook.com/story.php?story_fbid=pfbid02T8eM4jUxaqkHJFbo1CrteGKtniZh6c4PKJH2919f8qWe2Cf2CcWDh9TrJ3kUVKHrl&id=583116272070179&mibextid=Nif5oz&_rdc=1&_rdr

Dentium. (2022). Dentium Thailand. https://web.facebook.com/dentiumthai/posts/pfbid02hwumqo1vgC1Bj2rDZK4m2oSdyrG3HZJeZM4CS2EVaUPzZxjTihkyXLB8YS418qYRl?locale=th_TH

Eastern Economic Corridor (EEC) Office. (2019) https://www.eeco.or.th/en/medical-and-comprehensive-healthcare

Ellen MacArthur Foundation. (n.d.). *Circular economy introduction*. https://ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview

FutureMarketInsights. (2022, July). Thailand Medical Tourism Market Size, Share & Trends 2032. https://www.futuremarketinsights.com/reports/thailand-medical-tourism-market

Global Wellness Institute. (2022, January 27). Statistics & Facts. https://globalwellnessinstitute.org/press-room/statistics-and-facts/

Hip Creative. (2021, August 26). Implant Marketing - Unbeatable Dental Implant Marketing Strategies. HIP Creative. https://hip.agency/specialties/dental-implant-marketing.

HDXWILL. (n.d.). http://www.hdxwill.com/en/bbs/board.php?bo_table=sub0201

IntBizTH. (2022, November 25). What is an advertisement license? | Intelligence Business (Thailand) Co., Ltd. Intelligence Business (Thailand) Co., Ltd. https://intbizth.com/en/what-is-an-advertisement-license/

International Trade Administration. (n.d.). International Trade Administration | Trade.gov. https://www.trade.gov/country-commercial-guides/thailand-medical-equipment

Jantarakolica, K. (2015). Brand Building for Thailand Export Products through Country Image. In Proceeding of 16th ISBITM Conference, Bali, Indonesia.

Ken Research. (2022, April 21). Medical Device Market in Thailand, Medical Device Industry in Thailand. https://www.kenresearch.com/blog/2022/04/thailand-medical-devices-market-research-report/

Krungsri Research Center. (2021, September 27). Industry Outlook 2021-23: Medical Devices. Krungsri. https://www.krungsri.com/en/research/industry/industry-outlook/Other-Industries/Medical-Devices/IO/medical-devices-21

Komchadluek. (2022, December 15). BCG ดันไทยเป็น Medical Hub เพื่อความมั่นคงด้านสุขภาพ. Komchadluek. https://www.komchadluek.net/pr/538199

Marketing Oops. (2023, May 2). *ไม่ต้องซื้อ เช่าเอา! “แคนนอน” ลุยตลาดเช่า เปิดให้เช่ากล้อง-เลนส์-อุปกรณ์เสริม เริ่มต้นวันละ 200-300 บาท จากศูนย์บริการสำนักงานใหญ่ในไทยครั้งแรก*. Marketing Oops! https://www.marketingoops.com/news/biz-news/canon-camera-rental-service/

MarketsandMarkets. (2020, March). Dental Imaging Market by Product, Application & End-User. MarketsandMarkets. https://www.marketsandmarkets.com/Market-Reports/dental-imaging-market-109621591.html?gclid=CjwKCAjw586hBhBrEiwAQYEnHRwNYqR0JBTbYE5kaG2Eay9-KdFks61idweZFPLcuMZS90qzg0mRlxoCy2oQAvD_BwE

Morita (2023). Cone-beam computed tomography with low dose. https://www.morita.com/america/en/specialists/topics/cone-beam-computed-tomography-with-low-dose/8173/

Nation. (2021, August 11). We need more equipment, nurses, medics, says Nonthaburi field hospital doctor. *Nationthailand*. https://www.nationthailand.com/in-focus/40004513

National Institution of Health. (2022, June). *X-rays*. National Institute of Biomedical Imaging and Bioengineering. https://www.nibib.nih.gov/science-education/science-topics/x-rays

National Science and Technology Development Agency (NSTDA). (n.d.). https://www.bcg.in.th/eng/background/

Pocket Dentistry. (2015, January 12). 14: Cephalometric radiography. https://pocketdentistry.com/14-cephalometric-radiography/

PopulationPyramid.net (2023). Thailand. https://www.populationpyramid.net/thailand/1980/

Riversimple. (2022, October 25). *Subscription*. https://www.riversimple.com/subscription/

Other Media

Agrasuta, V. (2013). The Adoption of Green Dentistry among Dentists in Thailand [Master of Science Dissertation, University of Manchester]. ResearchGate. https://www.researchgate.net/profile/Voramon-Agrasuta/publication/281629128_The_Adoption_of_Green_Dentistry_among_Dentists_in_Thailand/links/55f0f6b208aef559dc46eb9d/The-Adoption-of-Green-Dentistry-among-Dentists-in-Thailand.pdf

Department of Older Persons. (2020). SITUATION OF THE THAI OLDER PERSONS 2020. https://www.dop.go.th/download/knowledge/th1663828576-1747_1.pdf

European Commission. (2016). Joint Report on Health Care and Long-Term Care Systems and Fiscal Sustainability. European Commission, Brussels.

European Commission. (2012). Cone Beam CT for Dental and Maxillofacial Radiology: Evidence-Based Guidelines. Radiation Protection No. 172. Directorate-General for Energy Directorate D — Nuclear Energy. Unit D4 — Radiation Protection, https://www.sedentexct.eu/files/radiation_protection_172.pdf

Goedkoop, M. J. (1999). Product Service systems, Ecological and Economic Basics. *ResearchGate*. https://www.researchgate.net/publication/293825611_Product_Service_systems_Ecological_and_Economic_Basics

Hamilton, J., & Vatananan-Thesenvitz, R. (2017). Building a Medical Product Development Industry in an Emerging Economy. 2017 Portland International

Conference on Management of Engineering and Technology (PICMET). https://doi.org/10.23919/picmet.2017.8125437

Infodent., (2020). Thailand's Performing Dental Market. Infodent. https://www.comunicadhoc.it/files/pressoffice/infodent/focus0420_2.pdf

Kasikorn Research Center. (2019, November 11). KASIKORN RESEARCH CENTER. https://www.kasikornresearch.com/en/analysis/k-econ/business/Pages/z3053.aspx

Kilgannon, D. (2012). An exploratory study of the use of brand strategy in the Irish medical technology sector [Master of Science Dissertation, Atlantic Technological University Sligo]. THEA Research. https://research.thea.ie/handle/20.500.12065/583

Mkhize, V. (2015). The branding of Private Health Care Services: Experiences of General Practitioners in Private Medical Practice [Master of Business Administration Dissertation, University of Kwazulu-natal]. UKZN DSpace https://ukzn-dspace.ukzn.ac.za/handle/10413/14697

National Economic and Social Development Council (NESDC). (2022). The Twelfth National Economic and Social Development Plan. https://www.nesdc.go.th/download/document/Yearend/2021/plan13.pdf

Thongvigitmanee, S. S., Kasemsarn, S., Sirisalee, P., Aootaphao, S., Rajruangrabin, J., Yampri, P., Srivongsa, T., Sa-Ing, V., & Thajchayapong, P. (2013). *DentiiScan: The first cone-beam CT scanner for dental and maxillofacial imaging developed in Thailand*. IEEE Nuclear Science Symposium Conference Record. https://doi.org/10.1109/nssmic.2013.6829132

Wikipedia. (2014, August 18). *Cephalometric radiograph*. https://commons.wikimedia.org/wiki/File:Cephalometric_radiograph.JPG

Wikipedia. (2015, January 4). *Axial, sagittal and coronal plane of CBCT and 3D reconstruction*. https://commons.wikimedia.org/wiki/File:CBCT_image_01.png

Wikipedia. (2021, February 17). *Dental Panorama X-ray*. https://commons.wikimedia.org/wiki/File:Dental_Panorama_X-ray.jpg

Wikipedia. (2023, March 23). *X-Mind Unity dental X-ray generator for Intraoral Imaging*. https://commons.wikimedia.org/wiki/File:X-Mind_Unity_dental_X-ray_generator_for_Intraoral_Imaging.jpg

World Health Organization. (2021). *PREVENTION AND CONTROL OF NONCOMMUNICABLE DISEASES IN THAILAND: The case for investment*. https://thailand.un.org/en/159788-prevention-and-control-noncommunicable-diseases-thailand-%E2%80%93-case-investment

ทรายขวัญ พรประเสริฐผล (2564). ปัจจัยที่มีผลต่อการตัดสินใจซื้อเครื่องมือแพทย์ของบุคลากรโรงพยาบาลเอกชนขนาดใหญ่ในเขต กทม. ช่วงการระบาดของโรคโควิด-19 [วิทยานิพนธ์บริหารธุรกิจมหาบัณฑิต, มหาวิทยาลัยธรรมศาสตร์]. คลังทรัพยากรสารสนเทศอิเล็กทรอนิกส์ของมหาวิทยาลัยธรรมศาสตร์. https://digital.library.tu.ac.th/tu_dc/frontend/Info/item/dc:240045

นวพล ว่องวัฒนาการ (2562). ปัญหาการกำกับดูแลเครื่องเอกซเรย์ทางการแพทย์ที่ไม่มีวัสดุกัมมันตรังสีเป็นส่วนประกอบและการจัดการเครื่องเอกซเรย์ที่ไม่ประสงค์ใช้งานของประเทศไทย [วิทยานิพนธ์นิติศาสตรมหาบัณฑิต, มหาวิทยาลัยธรรมศาสตร์]. คลังทรัพยากรสารสนเทศอิเล็กทรอนิกส์ ของมหาวิทยาลัยธรรมศาสตร์. https://digital.library.tu.ac.th/tu_dc/frontend/Info/item/dc:178453

APPENDICES

APPENDIX A

INTERVIEW QUESTIONS

1. Part 1: General

1.1) Please Introduce yourself (Name, Job position, years of experience, which dental institution you graduated from).
กรุณาแนะนำตัวเอง (ชื่อ ตำแหน่งงาน ประสบการณ์กี่ปี ศึกษาด้านทันตกรรมที่ไหน)

1.2) Within the clinic(s) you are associated with, how many dentists are currently employed/contracted?
ปัจจุบันมีทันตแพทย์ที่ทำงานอยู่ที่คลินิกนี้กี่คน

1.3) Approximately how many patients does the clinic treat per month?
โดยเฉลี่ยต่อเดือน มีผู้ป่วยมาใช้บริการที่คลินิกนี้กี่คน

2. Part 2: Pre-purchase

2.1) Could you please tell me about the brand(s) and type(s) of dental X-ray machine you have installed at your clinic.
ช่วยเล่าถึงยี่ห้อและประเภทเครื่องเอกซเรย์ที่มีที่คลินิกตอนนี้ เป็นอย่างไรบ้าง

2.2) Could you tell me about the reasons why you wanted to purchase a (new) X-ray machine for this clinic?
ช่วยเล่าถึงเหตุผลว่าทำไมคุณถึงอยากซื้อเครื่องเอกซเรย์เครื่องใหม่มาใช้ที่คลินิกนี้

2.3) Which channels did you use to find out information about the brand chosen to aid your purchase decision?
คุณใช้ช่องทางอะไรบ้างในการหาข้อมูลมาประกอบการตัดสินใจซื้อ

2.4) Were there also other stakeholders who are also involved in this process? (e.g. other dentists, assistants, patients)
มีบุคคลอื่นๆที่มาช่วยประเมินการตัดสินใจซื้อด้วยหรือไม่ (เช่นทันตแพทย์อื่น ผู้ช่วย ผู้ป่วย)

3. Part 3: Branding components

3.1) Between which brands did you consider and why?
สนใจซื้อแบรนด์ไหนบ้าง ทำไมถึงสนใจในยี่ห้อเหล่านี้

3.2) Do you think environmental impact, energy consumption, radiation dosage, and longevity were some of your concerns when evaluating the brands? How so?
คิดว่าผลกระทบต่อสิ่งแวดล้อม การใช้ไฟฟ้า ปริมาณรังสี และอายุการใช้งาน เป็นปัจจัยที่มีส่วนสนใจตอนคุณประเมินยี่ห้อต่างๆหรือไม่ อย่างไร
กรุณาเรียงสี่ปัจจัยนี้จากความสำคัญมากที่สุดไปสำคัญน้อยที่สุด (4-1)

3.3) What protective measures are put in place for patients and operators who come near the X-ray equipment? Do the X-ray device brand servicers help recommend these measures?
คุณมีการป้องกันผู้ที่เข้าใกล้เครื่องเอกซเรย์ (ผู้ป่วย เจ้าหน้าที่) จากรังสีอย่างไรบ้าง (เช่น ฉากกั้น ห้องตะกั่ว ผ้ากันเปื้อนกันตะกั่ว) ทางผู้ให้บริการแบรนด์เครื่องเอกซเรย์ได้ช่วยแนะนำเรื่องนี้หรือไม่

3.4) How does the level of certification gained for a product influence your purchase decisions?
คุณคิดว่าใบรับรองสินค้าหรือมาตราฐานมีผลกับการตัดสินใจอย่างไร

3.5) What do you think about a service that allows you to rent an X-Ray machine? Are there any potential benefits or concerns you would have as a professional user or a dental clinic owner?
คุณคิดอย่างไรกับบริการเช่าเครื่องเอกซเรย์ ในฐานะผู้ใช้งานทางการแพทย์หรือผู้ประกอบการคลินิกคุณเห็นประโยชน์หรือ/ข้อกังวลใดๆหรือไม่

3.6) What do you think about reconditioned 2nd-hand X-ray machines
คุณคิดอย่างไรกับการใช้เครื่องเอกซเรย์มือสองที่ถูกบำรุงกลับมาใช้ใหม่

3.7) Do you think the brand’s country of origin had an impact on your purchase decision? How so?
คิดว่าประเทศแหล่งกำเนิดของแบรนด์มีผลต่อการตัดสินใจของคุณไหม อย่างไร

3.8) What do you think of foreign brands who manufacture their medical devices in Thailand? Would you consider that brand Thai or foreign? Is this factor important to your decision making?
คุณคิดอย่างไรกับแบรนด์ต่างประเทศที่มาผลิตเครื่องมือแพทย์ในไทย กรณีนี้คุณถือว่าเป็นแบรนด์ไทยหรือแบรนด์นอก แล้วปัจจัยนี้สำคัญกับการตัดสินใจซื้อของคุณไหม

3.9) What do you think about Thai-produced dental X-ray machines? Would you consider purchasing them?
คุณคิดอย่างไรกับเครื่องเอกซเรย์ยี่ห้อไทย ที่ผลิตในไทย เคยเป็นตัวเลือกที่คิดจะซื้อไหม

4. Part 4: Purchase & Post-Purchase

4.1) In the end, which brand did you end up purchasing? And what was the major factor that made you decide?
สุดท้ายคุณได้ตัดสินใจซื้อแบรนด์ไหน แล้วอะไรเป็นปัจจัยหลักที่ทำให้ตัดสินใจเลือกได้

4.2) Could you tell me the steps involved in purchasing the device from your experience.
จากประสบการณ์ที่เคยซื้อเครื่อง คุณมีขั้นตอนในการซื้ออย่างไรบ้าง

4.3) What was the most memorable aspect about the brand?
เมื่อพูดถึงแบรนด์นั้นๆ อะไรคือสิ่งที่น่าจดจำที่สุด

4.4) How was your experience after purchasing from that brand? [How are they for servicing your equipment and dealing malfunctions?].
หลังซื้อแล้วมีประสบการณ์ที่ได้รับจากบริษัทนั้นอย่างไรบ้าง มีบริการการบำรุงซ่อมแซมอย่างไรบ้าง

4.5) As far as you are aware, do your clinic's stakeholders (e.g. other dentists, assistants, patients) hold the same opinions?
ผู้เกี่ยวข้องกับคลินิก เช่นทันตแพทย์คนอื่นๆ ผู้ช่วย ผู้ป่วย มีความคิดเห็นเหมือนกันไหม

4.6) Would you repurchase from this brand again? Why?
คุณคิดว่าจะซื้อสินค้าจากยี่ห้อนี้อีกหรือไม่ ทำไม

5. Part 5: Hypotheticals

5.1) Hypothetical: If you were selected to be a consultant for a Thai X-ray brand to improve its level of recognition and sales, what would you recommend to that company?
ถ้าสมมุติวันหนึ่งบริษัทเครื่องเอกซเรย์ยี่ห้อไทยเชิญคุณหมอไปเป็นที่ปรึกษา ให้ช่วยพัฒนาแบรนด์ไทยให้คนรู้จักและซื้อใช้งานมากขึ้น คุณหมอจะแนะนำบริษัทอย่างไรบ้าง

5.2) Hypothetical: If you were selected to be on a national committee to boost the market position of Thai X-ray brands what measures would you recommend to help achieve their success?
ถ้าสมมุติวันหนึ่งภาครัฐมีการจัดตั้งคณะกรรมการระดับชาติมาพัฒนาเครื่องมือแพทย์สัญชาติไทย แล้วเชิญคุณหมอไป คิดว่าคุณหมออยากแนะนำอะไรเพื่อพัฒนาภาพลักษณ์แบรนด์ไทยในตลาดสากล

Thank you for the insights you have provided. They are gratefully appreciated and will be useful in developing a thesis on the development of Thai X-ray device brands.
ขอบพระคุณสำหรับข้อมูลและคำแนะนำต่างๆ ข้อมูลจะมีประโยชน์กับการใช้ทำวิทยานิพนธ์เกี่ยวกับการพัฒนาแบรนด์เครื่องเอกซเรย์ของไทย

APPENDIX B

BREAKDOWN OF THEMATIC ANALYSIS

Themes		Sub-Themes	Code	Other Keywords and Context
Trust	C1	Company's experience	C1.1 Reputation and Years of experience	Operational years, Old player in the market, widely known in the field, Lack of trust in newcomers
			C2.2 Relationships and Connections	Head of faculty is close to a certain brand
	C2	Familiarity	C2.1 Word-of-mouth	Friends, Colleagues, University, Seniors, Other Dentists
			C2.2 Previous Experience	Used it before at my university, at another clinic, Seen online
			C2.3 Demo/Trial	"If I could demo the product for a period before buying I would consider it more"
	C3	Standards and Certification	C3.1 International Certification	Product Grading, Standards
			C3.2 Technology "up-to-date"	Technology, Innovation, Up-to-Date
			C3.3 Safety	Radiation Dosage, "I'm not that concerned about radiation safety because there's an organisation that comes check the radiation levels already."
Service and Maintenance	C4	Timeliness	C4.1 Lead time	Availability of technicians, how long they take to come in (to the clinic)
			C4.2 Preventative Maintenance (PM)	Scheduling, "Sometimes [the brand] they've forgotten the schedule", 3-6 months

			C4.3 Spare part inventory management	“Even if the technician can come, they don’t have the parts to fix it.”
	C5	Staff quality	C5.1 Technician skills	“Not everyone can fix X-ray machines”, fixing, In-house technicians, Recalibration, reliability, problem-solving, “It’s really easy to fix so it’s convenient”
			C5.2 External Dealers	Middlemen, Sells multiple brands, Provide guarantees, Provides payment options, Financing.
			C5.3 Customer Service	Call operators always pick up the phone, Constant updates with new product lines and promotions
			C5.4 Service continuity	“With COVID-19, all brands laid off employees or downsized or increased turnover, so new staff doesn’t know the detail about the specific issues with this machine so I have to explain again each time about what happened last time they came to fix.”
	C6	Consultation Service	C6.1 Clinic room planning	Electricity, Stabiliser, Size of room, X-Ray swing circumference
			C6.2 Radiation safety	Lead wall, Wall thickness, Have to get certification to open clinic with X-ray equipment, Contact the Dept. of Medical Science for certification
Price	C7	Payment Terms	C7.1 Instalments	Paying in instalments, then owns device in the end
			C7.2 Renting	Renting helps with cash flow of clinic, reduced fix cost
			C7.3 2nd Hand	Second-hand devices, for people with less budget

		Operating Cost	C7.4 Electricity consumption	“If the electricity usage could be reduced, it reduces the operating cost, X-ray scans uses a lot of electricity so it may disrupt the other electrical equipment.”
		Price	C7.5 Value for price	Would invest in a higher price if service/quality outweighs.
	C8	Promotions	Freebies	Free items with purchase, lead aprons, lead screen
Functionality	C9	Image quality	C9.1 Determines quality from sharpness of scans	Sharpness is usually dependent on the price, “How sharp you need the scans depend on what kind of treatment you are providing”
			C9.2 Software for image reconstruction	Can improve image quality without upgrading hardware, Dentists interact with software the most
			C9.3 Reduction of human error	Patient positioning error for scans sometimes increase blurriness, “blurred images mean you have to take another scan of the patient.”
	C10	Reliability	C10.1 Longevity	Wants to buy and forget about it, use it for a long time and not worry
			C10.2 Ease-of-fixing	Prefer to fix than replace, want in-house technician can fix
	C11	Ease of use	C11.1 Product Tutorial	The brand has to properly recommend and train users at the clinic
			C11.2 User-friendliness	Dental helpers usually scan the patients, wants the acquisition software to be easy to use, wants to click the least amount. Dentists interact with display SW the most (after scan)

Branding	C12	Country-of-Origin	C12.1 Only remembers COO	“I don’t remember the name, but it’s from _country_”
			C12.2 Factors COO when deciding purchase	Finds foreign brands to be more “trustworthy”, Associates COO with diff. product grades so would choose one that fits the target market. “Thai brands have to prove their quality but have lower price for me to consider”. “I would want to support Thai brands if I can. Why? because I’m Thai.”
			C12.3 Doesn’t factor COO	“I don’t care at all about the country, if the price and function is there I’ll buy it.”
			C12.4 Thinks Thai brands are more suitable for Thai users	“A Thai brand’s functions, height, size, should be more suitable for Thai people’s ergonomics, right? Or like the force needed to pull the machine arm for example, well it’s developed to be used by Asians.”
	C13	Name	Previous brand name	“I can’t remember the name” “It used to be called _Old brand name_”
	C14	Brand Awareness		“It’s a well-known brand” “I saw it in advertisements”

BIOGRAPHY

Name	Naphat Jittavisutthikul
Date of Birth	5 April, 2003
Educational Attainment	2021: Bachelor of Science (Design, Business and Technology Management).
Scholarships (if any)	2022-2023: Academic Scholarship from Design, Business and Technology Management, Faculty of Architecture and Planning.

Publications (if any)

Jittavisutthikul, N., Jamieson, I. A., Thienthaworn, A., & Lam, B. (2023). Investigating Strategies to Develop and Retain Thai Healthcare Providers' Brand Loyalty to Thai Dental X-Ray Devices. 14th Built Environment Research Associates Conference, 21st June 2023, Thammasat University.

Work Experiences (if any)	2022-2023: Research Assistant, National Science and Technology Development Agency (NSTDA), Thailand.