

# Price Decomposition of Laser Treatment for Port-Wine Stain Using the Hedonic Pricing Model

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## Research

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# Abstract

**Background:** Port-wine stain (PWS) is a congenital capillary malformation associated with negative effects on the quality of life and psychological health of the patients. Pulsed dye laser (PDL) is the current treatment of choice for PWS, however there is little information on the factors determining the treatment price of PWS. We aim to explore the factors determining the treatment price of PWS.

**Methods:** Data were collected through telephone surveys and self-reported questionnaires from hospitals, chain clinics, and doctor's offices that offered PWS treatment from February 1 to March 30, 2021. Data were analyzed by descriptive statistics and multivariate analysis using a log-linear regression model.

**Results:** A total of 104 observations were gathered. The estimated base price of the treatment without any additional features is 98.34 USD. Treatment by dermatologists has an additional charge of 28.41 USD or 28.9%. Some private clinics offer a lower price of 28.7% (or 28.27 USD) by illegally having non-medical doctors perform the treatment. Treatment with 595-nm PDL and 585-nm PDL and 1064-nm Nd:YAG lasers have an additional charge of 34% (or 33.45 USD) and 38% (or 37.41 USD), respectively. The location and type of medical facility can also affect the price of the treatment.

**Conclusion:** Many factors determine the base price and shadow price of PWS treatment. By using Factors determining a higher cost of laser fee are non-government facilities, location within the capital city, and higher location cost like clinics in the shopping complexes. Lastly, the type of laser and medical personnel provider can also affect the price of the treatment.

## Key Points

Many factors determine the base price and shadow price of laser treatment for Port-wine Stain. By using Hedonic Pricing Model for evaluation, factors determining a higher cost of laser fee are non-government facilities, location within the capital city, and higher location cost like clinics in shopping centers. In addition, the type of laser and medical personnel provider can also affect the price of the treatment.

## Background

Port-wine stain (PWS) is a congenital capillary malformation with an incidence of 3–5 per 1000 newborns [1]. Initially, it presents as a flat, irregular lesion with red to purple color and it could progress into a thicker or more nodular appearance if not given treatment [2, 3]. This may lead to serious psychological consequences, thus affecting the patients' quality of life [4–6].

Over the past decade, pulsed dye laser (PDL) has been the treatment of choice for PWS [1, 4, 5] as it utilizes the theory of selective photothermolysis [7]. PDL with wavelengths of 585 to 595 nm are usually used, since there is a high absorption by hemoglobin and decreased absorption by melanin, thereby reducing epidermal injury [8]. Lasers with longer wavelength such as Alexandrite laser 755 nm and

neodymium:yttrium aluminium garnet (Nd:YAG) laser 1064 nm have been developed to target the oxy- and deoxyhemoglobin at a deeper level and to enhance the clearance of lesions [3].

Multiple PDL treatment sessions are needed to attain a near-complete clearance of the lesion [9]. However, the high cost and limited availability of PDL devices are considered factors in health policy issues. In the United States of America (USA), PDL treatment is charged at approximately 500 USD per session [6]. In Thailand, the Universal Health Coverage (UHC) does not include laser treatments since it is classified under cosmetic services.[9] Therefore, low-income PWS patients have limited access to proper treatment due to the high cost of PDL. Majority of the PDL devices in Thailand are available in government or private hospitals, chain clinics and in some doctor's office. The laser fee depends on the type of facility, location, type of PDL used as well as the wage of the medical personnel (general practitioners, dermatologists, or dermatologic surgeon). As a result, patients who are not aware of these hidden costs tend to pay more.

Objectives of this study include (i) to analyze the factors determining the treatment price of PWS (PDL fee); (ii) to analyze and determine the shadow price of PWS treatment based on different medical personnel (providers) and types of PDL; (iii) to evaluate the implicit government subsidy of PWS treatment in government hospitals; and (iv) to quantify the implicit value of network externality of the hospital/medical center locations.

## **Conceptual Framework**

In 1974, Rosen came up with the idea of describing the price determinants of heterogeneous quality products that have no standard unit [10]. A good example is the price of a house, the cost varies based on its characteristics (land price, number of bedrooms and bathrooms, living space and garage) and not on the number of units. A big or small house can only be quantified as one house. Hedonic pricing concept has been applied to study the pricing of heterogeneous quality products and services, including medical, house and hotel. In 1986, Custer did a study on the different attributes of medical services and physician wages using a hedonic pricing model, since it did not have a standardized quality of service [11]. Our study have a similar pricing determination, therefore, we utilized the hedonic pricing concept to determine the PWS treatment price according to its attributes.

Based on the expectancy theory, laser treatment operators with more experience and training would expect to earn more, thus, the physician wage of a specialist or dermatologists will be higher [12]. PDL have more operating features than non-pulsed dye vascular lasers, so the investment cost and service fee of this type of laser is expected to be higher. Government hospitals offer a lower service fee compared to private hospitals and clinics since it is owned and subsidized by the government. The location of the facility is another factor that could influence the service fee. People living within Bangkok have a higher cost of living, so the service fee is usually higher than those living outside Bangkok. Private clinics located in shopping centers would charge a higher service fee due to higher facility expenses. Lastly, in order to compete in the industry, many private clinics would offer discounted treatment packages (usually 10 treatment sessions with approximately 10% discount).

Using the hedonic pricing concept mentioned above, PWS treatment price can be determined by its characteristics as presented in this formula:

*Charge Price = f(Treatment Operator, Types of Laser, Types of Hospital/Healthcare Center, Location of the Hospital/Healthcare Center, Treatment Package)*

Where: *Charge Price* is the PWS treatment price; *Treatment Operator* is the specialty of the medical service provider (general practitioners, dermatologists, or non-medical doctor); *Types of Laser* is the type of laser used (non-PDL, 595-nm PDL, 585-nm PDL or 1064-nm Nd:YAG); *Types of Hospital/Healthcare Center* is the type of healthcare facility (Medical School, Government Hospital, Private Hospital, Chain Clinic, or Doctor's Office); *Location of the Hospital/Healthcare Center* is the location of the hospital/healthcare center (Within or Outside Bangkok, Located in a Hospital, Shopping Center, or Private Property); *Treatment Package* is the treatment package (usually 10 sessions per package).

## Methods

### Data Collection Process

This study collected data from hospitals, chain clinics, and doctor's offices that offer PWS treatment. Based on the infinite population proportion formula, a proportion of 95% of the population<sup>1</sup> with 95% confidence level and 4.2% margin of error, the sample size should be at least 104 observations.

Telephone survey and self-reported questionnaire, using online google form and postal delivery, were done last February 1 to March 30, 2021. The inclusion criteria are (i) hospitals or clinics that provide vascular-specific laser treatment (ii) facilities that used either 595 nm PDL (Vbeam®, Candela Corporation, Wayland, MA, USA) or 585 nm PDL/1064-nm Nd:YAG (Cynergy™, Cynosure Inc., Westford, MA, USA) (iii) provided the cost per session of the laser treatment on PWS with the size of 5x5 cm<sup>2</sup>. Exclusion criteria included hospitals or clinics that do not agree to provide information.

The data consisted of 104 observations, within (75%) and outside (25%) Bangkok, including 16 hospitals, 79 chain clinics, and 9 doctor's offices. Table 1 shows the sample categorized according to the type of facility and location.

### Data Analysis

Data were analyzed by descriptive statistics and multivariate analysis using log-linear regression model derived from the conceptual framework (Eq. 1). The log-linear hedonic pricing model<sup>2</sup> can be stated as:

$$\ln Charge_i = \beta_0 + \sum_{j=1}^2 \beta_{1j} Operator_{ji} + \sum_{j=1}^2 \beta_{2j} Laser_{ji} + \beta_3 Gov_i + \beta_4 Complex_i + \beta_5 BKK_i + \beta_6 Package_i + \varepsilon_i$$

Where:  $\ln Charge_i$  is the natural log of a 5x5 cm<sup>2</sup> laser treatment price of the hospital/healthcare center;  $Operator_{ij}$  is the dummy variable for types of operators, with a value of 1 if treated by dermatologists ( $j=1$ ) or treated by non-medical doctors ( $j=2$ ) or value of 0 if treated by general practitioners as the base case;  $Laser_{ij}$  is the dummy variable for the type of laser, with the value of 1 for 595-nm PDL ( $j=1$ ) or for 585-nm PDL and 1064-nm Nd:YAG lasers ( $j=2$ ) or value of 0 for non-pulsed dye vascular lasers as the base case;  $Gov_i$  is the dummy variable with a value of 1 for government hospital or value of 0 otherwise;  $Complex_j$  is the dummy variable for the location with a value of 1 for those located in shopping complex or value of 0 otherwise;  $BKK_j$  is the dummy variable for Bangkok with a value of 1 for those located within Bangkok or value of 0 otherwise; and  $Package_i$  is the dummy variable for the package with a value of 1 for the package (mostly 10 sessions per package) price with discount or value of 0 otherwise, and  $\varepsilon_i$  is stochastic disturbance term.

The model can be estimated using Ordinary Least Squares. The estimated coefficient  $\beta_j$  represents the shadow price of each aspects.

This study was approved by the ethics committee of the Siriraj Institutional Review Board. This was performed in accordance with the Helsinki Declaration of 1964.

<sup>1</sup>Ninety-five percent of hospitals and health care centers that offer PWS treatment had a price higher than 5,000 Thai Baht (THB) (or 167 USD) per 5x5 cm lesion size.

<sup>2</sup>The dependent variable (charged price) has a value range from 5,000 Thai Baht (THB) per 5x5 cm<sup>2</sup>, while the independent variables are mostly dummy variables with a value of 0 or 1. Linear regression might not be able to fully capture the exact relationship between the dependent and independent variables because of the huge differences in value. The log-linear model using logarithm of the charged price as the dependent variable would help reduce this problem, thus, the model would fully capture the relationship.

## Results

### Data Description

A total of 104 observations were gathered through telephone survey and self-reported questionnaire. Table 2 illustrates the descriptive statistics and bivariate analysis of the treatment price categorized according to the type of facility and location. The treatment price of different types of medical facility and location are significantly different.

### Estimated Results of Hedonic Pricing Model

Table 3 shows the estimated results of log-linear hedonic pricing model. Based on the significant overall F-test and R-squared of 0.5401, the estimated model can significantly explain the pricing of PWS treatment by 54%.

Based on the estimated results, the base price of the laser treatment on facial PWS at a size of 25 cm<sup>2</sup> without any additional features (treatment by general practitioners with non-pulsed dye vascular lasers) is 98.34 USD or 2,950 Thai Baht (THB).

#### Shadow Price of Medical Personnel

Treatment by dermatologists has an additional charge of 28.41 USD (852.22 THB) or 28.9% higher than base price. To make more profit out of the treatment by reducing labor cost, some private clinics offer a lower price of 28.7% (or 28.27 USD) by illegally having non-medical doctors perform the treatment which is against Thai medical council regulations.

#### Shadow Price of Pulsed Dye Vascular Lasers

Treatment with 595-nm PDL or 585-nm PDL and 1064-nm Nd:YAG lasers have an additional charge of 34% (or 33.45 USD) and 38% (or 37.41 USD), respectively, more than base price which is treated with non-pulsed dye vascular lasers.

#### Implicit Government Subsidy

Treatment done at a government hospital is expected to receive government subsidy of 63.4% (or 62.32 USD).

#### Implicit Value of Network Externality

The location and type of medical facility can also affect the price of the treatment. In Bangkok, the treatment will cost additional 27.8% (or 27.32 USD) more compared to other provinces, because of the higher cost of living and land price. Treatment at a private clinic located in shopping centers will have a higher price of 13.6% (or 13.34 USD).

#### Competitive Strategy

Under the competitive environment, several private clinics, mostly chain clinics, have offered 11.7% price reduction for the 10 sessions per package program.

## Discussion

In our study, the base price of the treatment without any additional features (treatment done by a general practitioner with non-pulsed dye vascular lasers) is 2,950 Baht or 98.34 USD. Treatment done by dermatologists has an additional charge of 852.22 Baht (28.41 USD) or 28.9%. To make more profit out of the treatment by reducing labor cost, some private clinics offer a lower price of 28.7% (or 28.27 USD) by illegally having non-medical doctors, such as therapists, technicians, and nurses, perform the treatment which reflects the decrease in shadow price of the medical personnel. In Thailand, only a

certified doctor is legally allowed to perform laser procedures [13]. Therefore, ethical and legal aspects should be emphasized.

Our study also showed that treatment with 595-nm PDL and 585-nm PDL and 1064-nm Nd:YAG lasers have an additional charge of 34% (or 33.45 USD) and 38% (or 37.41 USD), respectively, when compared to treatment with non-pulsed dye vascular lasers or intense pulsed light because they use consumable dyes to operate the machine and have smaller spot sizes that makes the procedure more time consuming [14].

The location and type of facility are considered important factors that could affect the price of treatment. Chain clinics has the most expensive base price or constant price of 111.17 USD for vascular-specific laser treatment followed by the doctor's office (108.37 USD) and private hospital (106.10 USD). With a high cost of living and land price, treatment done in Bangkok will cost 27.8% (or 27.32 USD) higher than in other provinces. Treatment at a clinic located in a shopping centers will have a higher price of 13.6% (or 13.34 USD) reflecting the infrastructures such as security systems and parking spaces. In addition to the competitive business environment, several private clinics, mostly chain clinics, offered at least 11.7% reduction for the 10 sessions treatment package.

The Implicit Government Subsidy is another factor that contributes to the reduction in the per session fee of PDL treatment for PWS patients. Treatment at a government hospital is expected to receive a government subsidy of 63.4% (or 62.32 USD) for labor and capital cost. In a previous study on unit cost of dermatologic procedures in Thai government hospital, the authors found that labor and capital cost of laser treatment is contributed to 59.58% of total cost [15], therefore, medical school (44.95 USD) and government hospitals (51.60 USD) had the lowest base price compared to the other facilities. The clinics located in shopping centers and private property also have a higher base price due to their rental fee as presented in Table 2.

Our results provided the factors determining the treatment price of PWS according to the different types of medical centers, locations, and facilities. Private hospitals or clinics located in the capital area of the country have a significant impact on the base price of the PDL per session. Secondly, the shadow price of PWS treatment based on different medical personnel and types of PDL were also important factors. Treatment with 595-nm PDL, 585-nm PDL and 1064-nm Nd:YAG lasers have the most expensive base price when compared to the non-pulsed dye vascular lasers, mainly due to the cost of the laser device. Treatment in government hospitals have lower prices due to the subsidy received from the government. A high cost of living and land price also impacts the factors that determine the treatment price.

The limitation of this study included small sample size. Majority of the sample for this study were medical centers located in Bangkok. Therefore, future studies with higher number of medical centers or facilities located outside Bangkok should be conducted to verify these findings.

## Conclusion

Many factors determine the base price and shadow price of PWS treatment. Factors determining a higher cost of laser fee are non-government facilities, location within the capital city, and higher location cost like clinics in shopping centers. Lastly, the type of laser and medical personnel provider can also affect the price of the treatment.

## **Abbreviations**

PWS : Port-wine stain

USD : United States Dollar

THB : Thai Baht

## **Declarations**

### **Funding:**

Not applicable

### **Competing interests:**

The authors declare that they have no competing interests.

### **Availability of data and materials:**

Not applicable

### **Code availability:**

Not applicable

### **Authors' contributions:**

JN, CY and TJ analyzed and interpreted the data. RW and TS were major contributors in writing the manuscript. All authors read and approved the final manuscript.

### **Ethics approval:**

Not applicable

### **Consent to participate:**

Not applicable

### **Consent for publication:**

Not applicable

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## Tables

Table 1  
Sample Categorized According to the Type of Facility and Location.

	<b>Bangkok</b>	<b>Other Provinces</b>	<b>Total</b>
Hospital	14	2	16
	87.5%	12.5%	100.0%
Chain Clinic	60	19	79
	75.9%	24.1%	100.0%
Doctor's Office	4	5	9
	44.4%	55.6%	100.0%
<b>Total</b>	<b>78</b>	<b>26</b>	<b>104</b>
	75.0%	25.0%	100.0%

Table 2  
Bivariate Analysis of Price Categorized According to the Type of Facility  
and Location.

<b>Average Price</b>			
	Obs.	Thai Baht	USD (30 Baht = 1 USD)
<b>Type</b>			
Medical School	6	1348.35	44.95
Government Hospital	2	1548.12	51.60
Private Hospital	8	3183.02	106.10
Chain Clinic	79	3335.01	111.17
Doctor's Office	9	3251.01	108.37
ANOVA F-test		5.66 ***	
<b>Location Area</b>			
Bangkok	78	3363.57	112.12
Other Provinces	26	2577.56	85.92
ANOVA F-test		5.10 ***	
<b>Located in</b>			
Hospital	19	2351.15	78.37
Shopping Center	58	3452.03	115.07
Private Property	27	3129.08	104.30
ANOVA F-test		2.14	
<b>Total</b>	<b>104</b>	<b>3167.07</b>	<b>105.57</b>
<b>Note:</b> * Significant at 0.1, ** Significant at .05, *** Significant at 0.01			

Table 3  
Estimated Results of Log-Linear Hedonic Pricing Model.

Variable	Log-Linear Model			
	Thai Baht		USD (30 Thai Baht = 1 USD)	% change from Base Price
Constance or base price (Treatment by general practitioners with non-pulsed dye vascular lasers)	2950.24	***	98.34	100.0%
Treatment by dermatologists (including dermatologic surgeon)	852.22	*	28.41	+ 28.9%
Treatment by non-medical doctors	-848.08	*	-28.27	-28.7%
Treatment with 595-nm PDL	1003.48	***	33.45	+ 34.0%
Treatment with 585-nm PDL and 1064-nm Nd:YAG laser	1122.41	*	37.41	+ 38.0%
Treatment in a government hospital	-1869.58	***	-62.32	-63.4%
Facility located in shopping center	400.12	*	13.34	+ 13.6%
Facility located in Bangkok	819.59	***	27.32	+ 27.8%
Pricing	-343.75	*	-11.46	-11.7%
Observations	104			
Overall F-test	23.826	***		
R-squared	0.5401			
Adj. R-squared	0.5014			
<b>Note:</b> * Significant at 0.1, ** Significant at .05, *** Significant at 0.01				

## Supplementary Files

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