# To be or Not to be: From Long-Term Economic Viewpoint to Decide Whether to Reimburse the Fee for Orthodontic Treatment by Government Insurance

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## ABSTRACT

The chewing habit in the modern life has caused the ratio of malocclusion to increase, especial for the young people with high degree of urban life style. The malocclusion will result the teeth clean more difficult, which in turn cause the cavity, endodontic, or even tooth extraction. Reviewing the claiming expenses for the dental diseases in Taiwan's National Health Insurance (NHI), the number of patients seeking dental care for the diseases since of malocclusions occupies over 50% of all treatments. Currently in Taiwan, the orthodontic treatment cannot be reimbursed by NHI, all the fees being paid by patients themselves. Obviously, not all families can afford the fee of the orthodontic treatment. According to the experience of dentists, the payments to cure the disease causing from malocclusion during the whole life can be cut down up to 90% if receiving orthodontic treatment in the earlier stage of the patients. The orthodontic treatment is a good preventive health care and can be considered as a solution of surging medical expenditure of NHI. This paper incorporates clinical results and the knowledge of orthodontics by an influence diagram, which uses influence diagram to model and evaluate the decision model. The purpose of this paper is to develop a decision analysis model based on the influence diagram and estimate the benefits if receiving orthodontic treatment. The results of the paper showed that 30% of the healthcare expenses for the populations who receive orthodontic treatment are less than the expenses for those who do not receive the treatment in a range of millions of dollar in a year. Therefore, if NHI provides reasonable benefit/reimbursement for orthodontic treatment services, not only the risk of people suffering from cavity, endodontic, tooth extraction, etc. can be reduced, but also the medical expenditure for the dental can be effectively reduced.

Keywords: influence diagram, healthcare economics, dental orthodontics, insurance claim.

## 1. INTRODUCTION

The chewing habit in modern society has caused the population a lot of probabilities of malocclusion. A malocclusion is seen as a deviation away from the ideal occlusion, ranging from mild to uncomfortable level (Duverger O, Ohara T, Shaffer JR, 2014). To cure malocclusion, orthodontics is an effective treatment for malocclusion, which re-aligns the teeth so as to improve the chewing function as well as the face appearance. The treatment utilizes (visible or invisible) bracelets to cure malocclusions and adjust the movement of maxillofacial bone in a slow way into a proper position. Orthodontics can adjust the dental arch and enhance facial appearance and aesthetic ailments but also significantly reduce the possibilities of cavity, periodontal disease, tooth decay, and dryness of oral mucosa. Nevertheless, the cure fee for

orthodontics is in general very high, and the cure process takes a long period. To accept the treatment involves social and economic matters. Not everyone can accept the treatment at will even if he/she suffers the malocclusion. In Taiwan until now, the orthodontic fee cannot be reimbursed. Whether to reimburse the fee related its effectiveness in economic and heathy concerns.

In each country, the expenses on the health insurance have increased yearly since the healthcare cost increases along with the extension of life expectancy and the advance of healthcare technology. How to constrain the growth of health insurance in an accepted speed is a crucial mission for the government and scholars in each country. Effective preventive health operations, like vaccine, and premature treatment, like the obesity treatment, are considered as a possible way that not only can reduce and/or delay the suffering of diseases but also reduce the healthcare cost simultaneously.

It is unknown that whether the philosophy, an ounce of prevention is worth a pound of cure, can be applied to the dental, especially on orthodontics. The academic reports mentioned that the earlier the malocclusion is treated, the less dental disorder or diseases the people suffer from. A successful orthodontic treatment can properly align the teeth, resulting into the effect that proper alignment can effectively lower the chances of oral diseases, like cavities and periodontal diseases (Murray Thomson W., 2014). For the severe periodontal disease (also known as gum disease), the teeth need to receive endodontic treatment or even been pulled away. Most patients come to the dental clinics for the treatments for cavities, dental calculus, and periodontal disease. But these diseases occur rarely in those people who receive well orthodontic treatment. The expenses for the dental diseases reimbursed by Bureau of National Health Insurance (NHI) in years 2016 and 2017 are shown in Table 1. Reviewing the claiming expenses for the dental diseases, like mouth cleaning (cleaning tartar) and operative dentistry (like periodontal treatment) and so, it is estimated that the number of patients seeking dental care for the diseases directly or indirectly from malocclusions occupies over 50% of all treatments. It can be expected that the payments can be effectively cut down if the patients receive orthodontic treatment in the early age.

Table 1. Expenses for dental outpatient in years 2016 and 2017 (National Healthcare instituion, Taiwan, 2019)

| Item/Year | 2016 | Ratio in 2016 | 2017 | Ratio in 2017 |
|---|---|---|---|---|
| Operative dentistry | 2,761,451,241 | 49.03% | 2,844,294,778 | 49.06% |
| Endodontic treatment | 640,353,738 | 13.94% | 512,282,990 | 13.92% |
| Mouth dental cleaning | 1,429,587,271 | 16.13% | 1,458,179,016 | 13.15% |
| Other treatments | 1,102,510,717 | 11.7% | 1,146,611,145 | 11.74% |
| Tooth extraction | 626,119,008 | 10.55% | 638,641,388 | 10.57% |
| Total | 6,560,021,975 | 100.00% | 6,600,009,317 | 100.00% |

The costs for orthodontic treatment are very high, especially for the family with financial difficulties. Extending health insurance for the treatment surely had a major positive impact on children and their families. Healthcare insurance in some European countries has covered the fee for orthodontics; they remove the economic barrier from 1992 (Moss, 1993). Most of European countries are rich enough to provide the health services to the public. In fact,

malocclusion did not hurt the survival of life immediately. Thus, But in some developed or not rich enough countries, like Taiwan, has not provided the service accessed in their national insurance. Though to provide the coverage for the orthodontics is definitely beneficial to the dental health, the evidence or estimation abut that whether the costs of precaution treatment can be compensated by the saving of later treatments should be answered. To be or not to be the countries to provide the coverage for the orthodontics in the economic viewpoint is the focus of the paper, which can be a reference for the insurance institution in deciding the above coverage of healthcare.

## 2. MATERIALA AND METHODS

There are a lot of methods in decision theory for cause-and-effect analysis, such as decision tree and influence diagram (Pearl, 2005; Manuel Luque, Thomas D. Nielsen, Finn Verner Jensen, 2016; Emanuel EJ, Ubel PA, Kessler JB, Meyer G, et.al, 2016). The influence diagram is the one that mainly uses graphs to represent the relationship between the cause and effect of a problem at first; and it uses the probability of the interrelationship among the cause and effect variables to calculate the final effectiveness value. The influence diagram is a directed acyclic graph, which consists of several nodes and arcs and has applied to help the decision in healthcare problems (Huang Chia-Hui, 2015). The influence diagram G, denoted as G=(N, A), where N is a set of all nodes in the graph and A is a set of arcs between nodes, has three types of nodes, namely, *V, C* and *D*, where *V* denotes the utility (or value) nodes, *C* the chance nodes, and *D* the decision nodes, respectively. In addition, there is a diamond node, which is objective to be maximized (or minimized) in decision process. The analyzing process upon the diagram is to maximize (or minimize) the value of the utility.

The paper surveyed the health-economic considerations and summary the investigated results in Figure 1, which is to evaluate a medical decision problem about whether to treat the patient's malocclusion. The diagram indicates that the direct and indirect costs since of malocclusion (represented by a diamond node, which acts as an effect node) will be influenced by the malocclusion status (denoted as oval node, which acts as a chance node) and whether to perform orthodontics (denoted as a square, which acts as decision node). The following is the decision process upon this diagram.
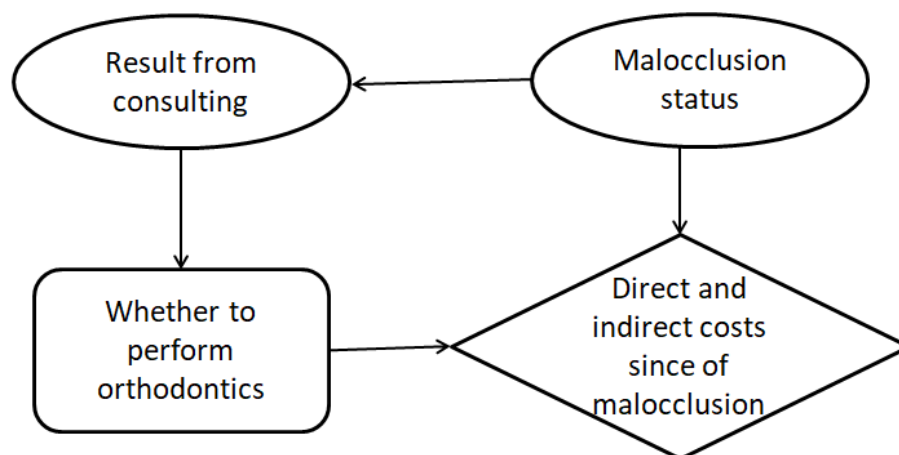


Figure 1. Influence diagram for evaluating the effects about whether covering the fee for orthodontics treatment

When a person suffers from malocclusion, he/she should consult a doctor before making a decision to perform the orthodontics. The influence diagram represents the result as a chance

node to denote the result will influence the decision. Clearly, with the influence diagram, the target problem can be described and delineated in a qualitative way. If the probability for each chance node, the decision maker can see the influence of decision easily (Díez FJ, Yebra M, Bermejo I, Palacios-Alonso MA, et.al, 2017).

This paper is to evaluate whether to cover the orthodontics by the national insurance in economic viewpoint. The key factor is the cost benefit related to the to-be or not-to-be decision. Methodologically, the first step is to discuss the chance node, malocclusion status. That is, we need to compute the probability $P(N1)$, shown in Figure 2(a), where $N1$ is the chance node that denotes the prevalence probability of malocclusion. According to report by Doğan AA, Sari E, Uskun E, Sağlam AM. (2010), there are 72.26% of 483 students required orthodontic treatments in an elementary school in Europe. In Taiwan, from Taiwan Association of Orthodontics (National healthcare institution, 2019), only 150 from 1000 people have no malocclusion problems according to the in the statistic. Clearly, the prevalence rate of the malocclusion is similar among different countries. Thus, the probability of chance node $N1$ can be seen as 85%, namely, $P(N1) = 85\%$.
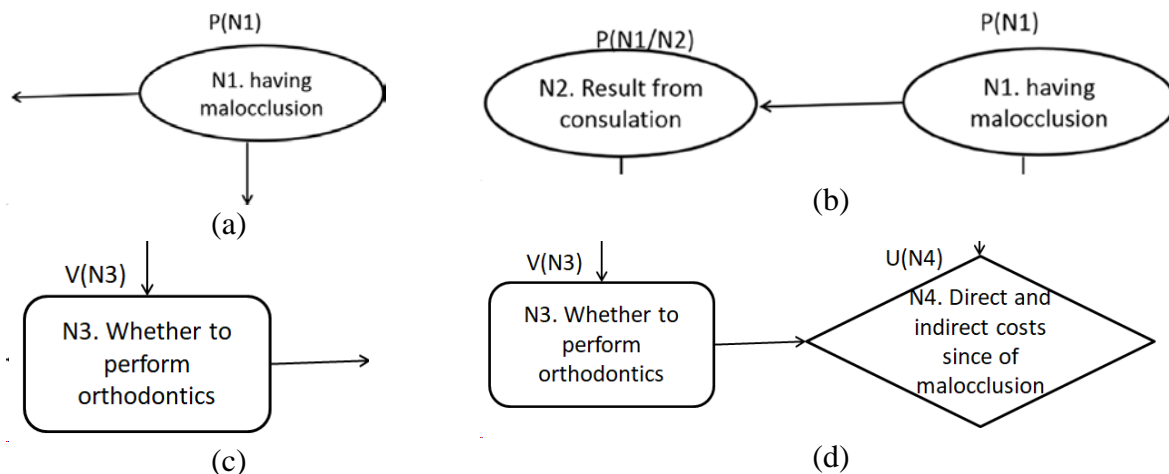


Figure 2. The separate focus (computing) on the influence diagram derived from that of Figure 1.

According to the statistic from the American Association of Orthodontics, there are around 80% of people will come to the dentists for consulting since of malocclusion problems; namely, the conditional probability of the chance node under the condition that patient has malocclusion status, is 80%, namely, $P(N1/N2) = 80\%$, where $N2$ is the chance node that a patient comes to dentists for consultation (Ku, L. C., Sharac, J., Bruen, B. K., Thomas, M., & Norris, L., 2013; Metcalf, S. S., Birenz, S. S., Kunzel, C., Wang, H., et.al., 2015). This probability, though up to 80% shown in Figure 2(b), sounds reasonable since each one has an intention to know his/her health status and its influence if having malocclusion.

After consulting the dentists, the patient may receive or not receive the treatment, or take a long time to consider the decision. The main influencing factors are the patient's age, socioeconomic status, awareness of the dental health and so on. According to the survey of this paper, only 20% of people in Taiwan will receive the orthodontics treatments. However, in Europe from 1992 (Moss, 1993), since the national insurance covers the fees for orthodontics, the economic barriers have been removed. A high need for orthodontic treatment was recorded in 74.0%. Clearly, in the developed countries, the orthodontics treatments are very popular, but in the developed and under-development countries, the ratio accepting orthodontics treatments will not be so high. The socioeconomic canonical greatly counts for whether to receive the orthodontic treatment. In the survey of this study, there are 24% of patient with malocclusion

will receive the treatment.

Also according to the survey of this study, the orthodontic treatment for a patient ranges from NT100,000 (or USD 3,300) to NT180,000 (or USD 54,000), or NT140,000 (USD 4,240) in average (which will be used as the cost standard of the decision node in Figure 1(c); namely, $V(N3) = $ NT140,000, where $V$ denotes the value of the action performed in the node). The costs are not affordable for each one. In Taiwan, orthodontists rated 51.4% of patients as having a severe malocclusion on aesthetic grounds, but only 33.6% of parents rated their child malocclusion as severe to receive the treatment. Parents rated their child-orthodontic-treatment's need less severely than that rated by the orthodontist mainly comes from the financial status of the families. In this study, we found the rate to receive the treatment is as low as to 24% after consulting for the dentists. According to the above discussion, we can summarize the cost for a population to cure the malocclusion in average under the condition that the treatment is not covered by the national insurance is:

(1)   $P(N1) \times P(N2/N1) \times V(N3)$
   $= 85\% \times 80\% \times 24\% \times 140{,}000$
   $= 22{,}840$

The cost, NT 2,284, in Formula (1) is relatively low. The main reason is the treatment fee is self-paid; not every person can afford the fee. Suppose the treatment is covered by the insurance, the study uses the statistical data in Europe instead; in detail, the ratio to receive the orthodontic treatment will be as high as to 74%. We can then summarize the cost for a population to cure the malocclusion in average under the condition that the treatment is covered by the national insurance is:

(2)   $P(N1) \times P(N2/N1) \times V(N3)$
   $= 85\% \times 80\% \times 74\% \times 140{,}000$
   $= 70{,}448$

Figure 2(c) shows that the value of the operation is influenced by objective result after consulting the dentists and objective results by the patient decision.

Formula (1) and (2) are the average direct costs of orthodontic treatment for a patient respectively under the two conditions that the expenses are reimbursed or not. The next is to compute the expected costs of orthodontic treatment for all the populations. According to Taiwan's government statistics (seen in Table 2), there are 1,024,184, 1,272,083, and 1,532,860 persons in the three age ranges, namely, ages 15-19, 20-24, and 25-29, respectively, or 3,829,127 persons with ages from 15 to 29. The populations in these three age ranges are the most possible ones to receive the orthodontic treatment. Assume the costs for orthodontic treatment for all the above populations are covered by the national insurance. The total costs for the treatment is shown in Formula (3):

**(3)**   All populations $\times$ average cost
   $= 3{,}829{,}127 \times 70{,}448$
   $= 2.697 \times 10^{11}$

Table 2. Populations from top 3 age groups who are the most possible ones receiving the orthodontics treatment

| Age 15 ～ 19 | | | | | |
|---|---|---|---|---|---|
| Total | 15 | 16 | 17 | 18 | 19 |
| 1,272,083 | 219,458 | 234,392 | 247,021 | 280,689 | 290,523 |
| Age 20 ～ 24 | | | | | |
| Total | 20 | 21 | 22 | 23 | 24 |
| 1,532,860 | 275,739 | 292,860 | 321,029 | 322,207 | 321,025 |

| Age 25　　～　　29 | | | | | |
|---|---|---|---|---|---|
| Total | 25 | 26 | 27 | 28 | 29 |
| 1,606,950 | 321,209 | 322,434 | 316,773 | 320,086 | 326,448 |

Note that the expenses in Formula 3 are paid only once for a person at most, and the age range of the populations spans 30 years, i.e., from 15-29). Since the person if having malocclusion will take only once treatment. Thus, the cost in formula (3) should be divided by 30 to get the annual costs in average for the treatment. That is, the costs in a year for the orthodontic treatment will be NT 8.9 billion, as follows:

(3') $2.697 \times 10^{11} / 30$

$= 8.9 \times 10^{10}$

The cost in formula (3') is still high for the insurance. We shall consider whether the costs can be compensated by the saving of the costs after the malocclusion is cured. The next step is to compute subsequent costs (or called indirect cost) caused by the diseases from malocclusion. From table 1, the claiming fee for the dental department in a year (in 2016) is NT6,560,021,975, which accounts for all the population, i.e., 23,593,794. That is, the average fee for the dental department is NT278 a person a year (= 6,560,021,975/23,593,794) regardless of the age. That is:

(4)　$6,560,021,975/23,593,794$

$= 278$

Since at least a quarter of dental expenses are directly or indirectly from the disease of malocclusions, the costs will be cut NT 69.5 a year if a person receives the orthodontic treatment. According to the report of Taiwan's government in 2018, the average life expectation is 80.4 years. If a person received the orthodontic treatment in age $k$, where $k$ is in the range from 15 to 30, the saving cost in dental department will be accumulated year by year until the end of his/her life. That is, the direct and indirect average costs saving since of the treatment in his/her lifespan is:

(5)　$278 \times 25\% \times (80 - k)$

$= 69.5 \times (80 - k)$, where $15 \leq k < 30$

We then use the populations shown in Table 2 in each age to count the total saving after receiving the orthodontic treatment until the end of the population's death. For example, the total saving for the populations if they receive the treatment at age 15 (i.e., k = 15) is:

(6)　$69.5 \times (80-15) \times 219,458$

$= 991,401,515,$

where the number, 219,458, is the population number with the age being 15.

Similarly, the total saving costs for the populations with age from 15 to 29 are as follows:

(7)　$69.5 \times (80-15) \times 219,458 + 69.5 \times (80-16) \times 234,392 +$

$69.5 \times (80-17) \times 247,021 + \ldots + 69.5 \times (80-29) \times 326,448$

$= 28,233,800,460$

$= 2.8 \times 10^{10}$

Comparing the two values in Formula (3') and (7), the value in formula (3') is three times or so larger than that in formula (7). If the insurance covers 30% of the orthodontics fee, it can be seen that the insurance payment for the treatment can be compensated by the total saving of the costs in the whole life of the populations.

Clearly, if the considerable expenses for orthodontic treatment can be included in the payment reimbursed by the national health insurance system, people will have more motivation to receive the treatment. If so, the precautious policy can lower the chance that people suffering the dental diseases before the diseases occur or become worse. Finally, NHI can reduce the costs for dental treatments which result from inappropriate cleaning caused by malocclusions.

It is a win-win policy for the country, since the government can avoid from paying too much for treating dental diseases caused by malocclusions and the patients have a better health quality simultaneously.

## 3. CONCLUSION

To efficiently and long-termly control the growth of medical expenditure, the government should provide a preventive medicine to effectively reduce the long-term costs of the healthcare (Anastasia S.A, 2014; Baio G, Dawid AP, 2015, Marta B., 2015). The medical profession has been noticed the orthodontic treatment in the early stage can not only reduce the costs of its related diseases occurring in the later stage and not only keep the better life quality. Orthodontic treatment can effectively reduce the public the probabilities of suffering from the dental diseases, providing a better dental hygiene condition. If the fees for the treatment can be reimbursed by NHI, the population will have higher intention to cure the malocclusion of teeth and then increase the dental health. To evaluate the problems mentioned above, this research applies the influence diagram of Bayesian Network in a long-term economic viewpoint. This paper provided a quantitatively evidence to support the speculation that if Taiwan's NHI provides reasonable reimbursement for the curing for malocclusion, the medical expenditure could be effectively reduced. From the research results, the government can have their own more detail data to assure the suggestion and review their decision about their reimbursement policy not only in orthodontic treatment but also other preventive treatments. This research has proved that the cost of dental outpatient services can be effectively reduced if the preventive medicine is provided.

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