

# A Network Meta-Analysis on the Effects of Information Technology Application on Preoperative Anxiety of Patients

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## Abstract

*The application of information technology in health education plan in Taiwan had gone for a long time. This study was performed to synthesize existing research comparing the effects of information technology application versus traditional instruction in health education plan on patients' anxiety in Taiwan. In spite of claims regarding the potential benefits of using information technology in health education plan, research results comparing the effects of information technology application and traditional instruction in Taiwan were conflicting. Meta-analysis was a statistical process whereby the findings of several studies, focusing on a common problem or topic, are pooled in an effort to draw inferences as to the meaning of a collective body of research. The results of this study indicate that information technology application in health education plan had moderately effects on patients' anxiety over traditional health education plan in Taiwan. The results from this study suggest information technology application with health education is positive with patients' anxiety. This study compared the effects of traditional health education plan on preoperative anxiety of patients with the therapy of information technology application, music, and aromatherapy. It could find that the effects of music therapy were better than others, and information technology application was the second. So the effects of information technology application on preoperative anxiety of patients could be increased with the therapy of music.*

**Keywords:**health education plan, healthcare, patients' anxiety, network meta-analysis

## 1. INTRODUCTION

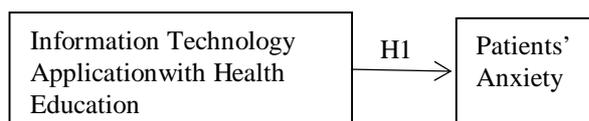
The application of information technology in healthcare in Taiwan had gone for a long time. The need to improve the health care system has led to the launch of a national initiative that stresses the use of health information technologies to enhance quality of care, support health care safety, and provide cost-effective health services for consumers, such as patients or individuals who receive medical care. While much of the discussion has focused on how health care organizations such as hospitals need to adopt health information technologies for patient safety, there is a growing recognition that such technologies can be used directly by consumers to acquire new forms of health care, such as telehomecare or eHealth. When used by patients, these technologies are referred to as consumer health information technologies [1]. Several definitions describing health information technologies can be found. Consumer health information technologies are defined as computer-based systems that

are designed to facilitate information access and exchange, enhance decision making, provide social and emotional support, and help behavior changes that promote health and well-being [2]. While the potential for using information technology application to improve health care has been acknowledged, these technologies are still not always accepted by patients for variety of reasons, including poor device usability, insufficient training on how to use the technology, lack of computer skills, and low self-efficacy [3, 4, 5]. This is a significant concern for patients and health care organizations; patients who reject information technology application would not benefit from them, and rejection means a loss of return on investment for health care organizations. This concern has been realized. Evidence shows that substantial numbers of potential users do not accept information technology application and this has led to technology implementation failure in several projects [5]. Therefore, studies that examine variables predicting patient information technology application acceptance are needed. It was important to define these approaches to ensure proper selection of appropriate studies. Information technology application, depending on their purposes, may be used by healthy individuals seeking out health information or by injured individuals for treatment or self-management. This latter group was the current population of interest because information technology application acceptance may directly affect their health and well-being. It could be referred to this group actively receiving medical care for an injury or illness as patients. Acceptance of technology has been defined in four primary ways: satisfaction with the technology, use or adoption of the technology, efficient or effective use of the technology, and intention or willingness to use the technology [6, 7, 8]. Therefore, our definition of information technology application acceptance is limited to those four conceptualizations. As described earlier, consumer health information technologies on which this article focuses are patient-oriented computer-based systems used to promote health, well-being, and safety, including telemedicine, e-health, and Web-based health technologies. In spite of claims regarding the potential benefits of information technology application in health education, research results comparing the effects of information technology application and traditional instruction in health education in Taiwan are conflicting. Chang [9], Li [10], Chao [11], Ming [12], Song [13], Shih [14], Chung [15], Chiu [16], Chang [17], Li [18], Lin [19], Chen [20], Yah [21], Chen [22], Lin [23], Yung

[24], Chang [25], and Liu [26] all reported significant gains for information technology application over traditional instruction in health education in patients' anxiety. However, Wu [27] had found no significant differences between information technology application and traditional instruction in health education in patients' anxiety. Meta-analysis was a statistical process whereby the findings of several studies, focusing on a common problem or topic, are pooled in an effort to draw inferences as to the meaning of a collective body of research [28]. Early meta-analysis studies were published prior to the microcomputer revolution, since 1970. In an effort to lend data to this debate, this study provides the meta-analysis verse traditional instruction in health education in patients' anxiety

## 2. MATERIALS AND METHODOLOGY

The research methodology implicated in this study was the meta-analytic approach which was similar to that suggested by Higgins, Thompson, Deeks, and Altman [29]. Their approach requires a reviewer to locate studies through objective and replicable searches, code the studies for salient features, describe outcomes on a common scale, and use statistical methods to relate study features to outcomes. This approach requires the reviewer to use objective procedures for locating studies, use quantitative techniques to describe study features and outcomes, and use statistical methods to summarize overall findings and explore relationships between study features and outcomes. The research framework of this study was as Figure 1. H1 is information technology application with health education is negative with patients' anxiety.



**Figure 1** Research framework of this study

### 2.1 Research Data

These studies considered for use in this meta-analysis came from Taiwan Theses and Dissertations Knowledge Value-Added System. 19 theses were located through this search procedure. They include 19 studies for patients' anxiety. Several criteria were established for inclusion of studies in the present analysis as:

1. The study had to compare the effects of information technology application and traditional instruction in health education plan on patients' anxiety.
2. The study had to provide quantitative results from both information technology application and traditional instruction in health education plan classes.
3. The study had to use Taiwan patients as subjects.
4. The study could be obtained with full-text.

Taiwan Theses and Dissertations Knowledge Value-Added System was the project entrusted to

Taiwanese National Central Library (NCL) by the Department of Higher Education of The Ministry of Education in Taiwan. As recalling to the past efforts of theses and dissertations related information gathering, NCL started editing and printing of Catalog of Theses and Dissertations in Taiwan in 1970. Taiwanese NCL has implemented the specific plan of theses and dissertations abstracts nationwide since 1994 by establishing abstracts files of theses and dissertations and launched web version of on-line search system which got very good feedback about positive value by various fields in 1987. In 1998, it also established theses and dissertations abstracts online system with the financial support by The Ministry of Education in Taiwan. Taiwanese NCL held the opening ceremony of National Theses and Dissertations Abstract File Building Plan which set up another new milestone on formal internet service of theses and dissertations. After 2000, Taiwanese NCL added functions of uploading of full text electronic theses and dissertations and online printing of authorization papers in addition to above mentioned National Theses and Dissertations Abstract File Building Plan. Thus Taiwanese NCL integrated the existing collaborative production and sharing of on-line database of National Theses and Dissertations information network [30].

### B. Data Analysis

Meta-analysis was originally created by Glass, McGaw, and Smith [31]. In relating it to existing analyses, it could be classified research analysis into primary analysis, secondary analysis, and meta-analysis. Primary analysis is the original analysis of raw data. Secondary analysis uses alternative analytical techniques to analyze the same data to answer the same research questions, or uses the same techniques to answer different questions from the same data. A meta-analysis encompasses results of studies that are already conducted. It did not use the term to refer to the analysis of a planned series of investigations. Purpose of a meta-analysis was not simply to summarize a whole body of literature with a single effect size or overall significance level. It also tried to determine how study features influence effect sizes. The effectiveness of information technology application in health education and training was determined by the overall effect of the treatment. Meta-analytic procedures were applied to calculate the size of this effect. As the meta-analysis progressed, and results unfolded, studies were grouped according to their common study features, and the various categories within the features were identified. Since a meta-analysis synthesizes the statistical results from many different studies, it is not necessary to define the independent variable in very specific terms. For this meta-analysis, it was sufficient to state the independent variable as the teaching method in technical education and training, which could be either computer-assisted instruction or traditional instruction. For the same reason, it was adequate to begin the meta-analysis by defining the dependent variable as student learning or achievement in learning resulting from technical education and training, as measured by some test or tests. Meta-analysis combines

statistical results with fixed effect or random effect. With fixed effect, meta-analysis assumes that the true effect size each study is trying to estimate is the same across all the studies. There will be differences in the estimates each study arrives at, but these are attributed to chance/random variations. The fixed effect ( $\theta_{IV}$ ) was combined into weighted average ( $W_i$ ) with inverse-variance method in this study. Pooled estimate is weighted average with inverse-variance method [32] as

$$\theta_{IV} = \frac{\sum_i^N W_i \theta_i}{\sum_i^N W_i} \quad (1)$$

weights are inverse of variance as

$$W_i = \frac{1}{SE(\theta_i)^2} \quad (2)$$

Standard error of pooled estimate with inverse-variance method as

$$SE(\theta_{IV}) = \frac{1}{\sqrt{\sum_i^N W_i}} \quad (3)$$

Heterogeneity (between-study variability) measured by

$$Q = \sum_i^N W_i (\theta_i - \theta_{IV})^2 \quad (4)$$

Advantages of inverse-variance method are maximizes precision of pooled estimate  $\theta_{IV}$ , and Most importantly it is applicable to a wide range of outcome types and study types. The disadvantage of inverse-variance method is poor results when event rates are low or studies are very small. With random effect, meta-analysis incorporates an estimate of the between study variation by relaxing the assumption of that there is one true effect. True effect sizes for each study are assumed to come from a distribution of answers that will vary from study to study. The right answer that one study is trying to estimate will be different from the right answer for another study. The pooled estimate from the meta-analysis is the mean of this distribution of right answers. The random effect pooled estimate is weighted average with DerSimonian & Laird method [33] as

$$\theta_{DL} = \frac{\sum_i W'_i \theta_i}{\sum_i W'_i} \quad (5)$$

Weights used for the pooled estimate are similar to the inverse-variance, but now incorporate a component for between-study variation:

$$W'_i = \frac{1}{SE(\theta_i)^2 + \tau^2} \quad (6)$$

DerSimonian & Laird method in random effect method, assumption that there is a single true answer that all studies are trying to estimate is relaxed. Now assume that each study has a different true answer that they are trying to estimate. Assume true effect sizes  $\theta_i$  have a normal

distribution with mean  $\Theta$  and variance  $\tau^2$ .  $\tau^2$  is the between-study variance. Between study variance as

$$\tau^2 = \frac{Q - (k - 1)}{\sum_i^N W_i - \left( \frac{\sum_i^N W_i^2}{\sum_i^N W_i} \right)} \quad (7)$$

Where:

$w_i$  are the weights from the fixed effect inverse-variance method  $Q$  is the heterogeneity test statistic from before (either from inverse-variance method or Mantel-Haenszel method)  $k$  is the number of studies  $\tau^2$  is set to zero if  $Q < k-1$  Ensures the test statistic  $Q$  has nice distributional properties, so that p-values can be derived from standard tables. Look up  $Q$  in tables of the chi-squared distribution on  $k-1$  degrees of freedom. The null hypothesis is that the true effect size is the same for all studies. A statistically significant result means that there is strong evidence against there being one common effect size, so we take it that there is heterogeneity. When there is little heterogeneity, so  $Q$  is smaller than  $k-1$ ,  $\tau^2=0$  and the weights are the same as the inverse variance method. When  $\tau^2 > 0$  the weights are smaller and more similar to each other than in a fixed effect model. Because the weights are smaller, the sum of weights will be smaller, and so the SE will be bigger, and p-values less significant. Small studies will have relatively greater influence. Advantages of DerSimonian & Laird method are as widely applicable as the inverse-variance fixed effect model, and incorporate heterogeneity into the model. Disadvantages of DerSimonian & Laird method are as placing more weight on smaller studies may be dangerous if smaller studies less reliable or more prone to bias, and Danger of pretending you don't have to worry about heterogeneity anymore. Network meta-analysis is a generalization of pairwise meta-analysis that compares all pairs of treatments within a number of treatments for the same condition. The graph-theoretical method for analysis of network meta-analyses uses graph-theoretical methods that were originally developed in electrical network theory. It has been found to be equivalent to the frequenters approach to network meta-analysis [34]. Proportion of total variability attributed to between-study heterogeneity ( $I^2$ ). Quantifies amount of heterogeneity as

$$I^2 = \frac{Q - (k - 1)}{Q} \times 100 \% \quad (8)$$

$k$  = number of studies ( $k-1$  = degrees of freedom)

$I^2$  is set to zero if  $Q < k-1$

Meta-analysis combines the results of a number of studies. The meta-analysis would be applied with R 3.1.1 computer software in this study.

### 2.3 Outcome Measures

The outcomes of health education measured in these 19 theses were patients' anxiety, as indicated on researcher-developed achievement tests at the end of the program. A meta-analysis was performed to synthesize existing

research comparing the effects of information technology application and traditional instruction on students' learning achievement in Taiwan. For statistical analysis, outcomes from a variety of different studies with a variety of different instruments had to be expressed on a common scale. The transformation used for this purpose was the one recommended by Higgins, Thompson, Deeks, and Altman [29]. For reduce measurements to a common scale, each outcome was coded as a standardized mean difference (SMD) that was information technology application group's learning outcome (treatment group) minus traditional instruction group's the learning outcome (control group). First suppose that the objective of a study is to compare two groups, such as Treated (referenced as t) and Control (referenced as c), in terms of their means. Let  $\mu_T$  and  $\mu_C$  be the true (population) means of the two groups. The population mean difference is defined as

$$MD_i = m_{ti} - m_{ci} \quad (9)$$

and the standardized mean difference

$$SE(MD_i) = \sqrt{\frac{SD_{ti}^2}{n_{ti}} + \frac{SD_{ci}^2}{n_{ci}}} \quad (10)$$

which is usually used as the effect size as weighted mean difference (WMD). This study applied the effect size as standardized mean difference (SMD) with Hedges' g. Hedges' g is an extension of Cohen's d [34]. It applied with a small adjustment to give better estimates with smaller sample size. If  $N_i$  is large then adjustment is relatively small and there is little difference between the two methods. The effect size (mean difference) of Hedges' g [34] as

$$g_i = \frac{m_{ti} - m_{ci}}{S_i} \times \left(1 - \frac{3}{4N_i - 9}\right) \quad (11)$$

standard error Hedges' g as

$$SE(g_i) = \sqrt{\frac{N_i}{n_{ti}n_{ci}} + \frac{g_i^2}{2(N_i - 3.94)}} \quad (12)$$

### 2.4 Coder Reliability

For get more reliable outcomes from coding, three research assistants coded these studies (theses). Each of the three research assistants coded one third of the studies independently. In addition, the different codes on each of the studies between research assistants were discussed. The final agreement had to be met after discussion.

## 3. RESULTS

These studies considered for application in meta-analysis got from Taiwan Theses and Dissertations Knowledge Value-Added System, and 19 theses were obtained through this search method. The summarize of these 19 theses in this study was as Table 1. They all were published after 1999. Most of them with the sample size between 51 and 100 (68.42%).

Table 1: Summarize of these 19 Theses in this Study

Variables	N	%
Year of publication	1	5.26
	2003	15.79
	2004	10.53
	2006	5.26
	2007	5.26
	2008	26.32
	2009	5.26
	2011	15.79
	2012	5.26
	2013	5.26
Size	1-50	15.79
	51-100	68.42
	101-150	10.53
	151-	5.26
Total	19	100.00

### 3.1 The Effects of Information Technology Application on the Anxiety of Patients

19 theses with the effect of information technology application versus traditional instruction in patients' anxiety in Taiwan were in this study. They were Chang [9], Li [10], Chao [11], Ming [12], Song [13], Shih [14], Chung [15], Chiu [16], Chang [17], Li [18], Lin [19], Chen [20], Yah [21], Chen [22], Lin [23], Yung [24], Chang [25], Liu [26], and Wu [27]. The number of comparisons and the study-weighted SMD with fixed effects analysis were reported and the SMD for these 19 theses were presented as a forest plot in Figure 2. In these 19 theses included in this study, the study-weighted SMD of all of them were positive and favored the information technology application group. The range of the SMD was from -4.45 to .10 with Equation 11. The overall grand mean for all 19 study weighted-SMDs was -.66 ( $p < .01$ ) with Equation 1 for fixed effect model and -.69 with Equation 5 for random effect model, suggesting that the effects of preoperative anxiety of patients of information technology application group was better than traditional instruction group. For the heterogeneity of these 17 studies,  $Q$  was 114.78 ( $p$ -value  $< .01$ ) with Equation 4, and  $I^2$  of 0.84 reflects the great heterogeneity across studies with Equation 8. The  $\tau^2$  is .30 with Equation 7. The funnel plot

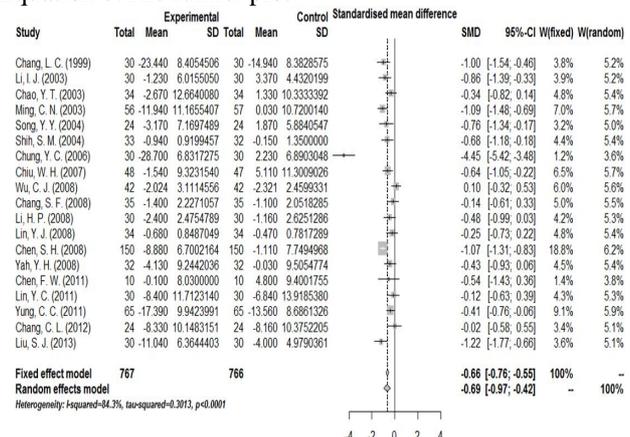


Figure 2 The forest plot of these 19 theses of patients' anxiety in this study

with random effect model of this study was as Figure 3. Based on the result, information technology application with health education is negative with patients' anxiety

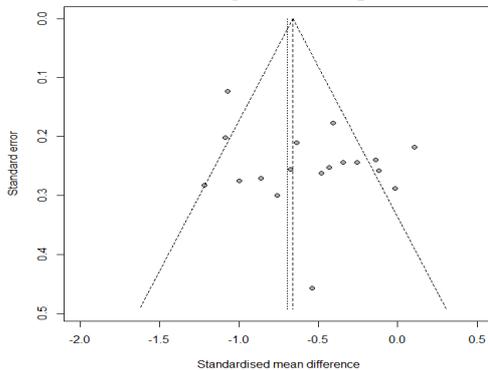


Figure 3 The funnel plot of this study

### 3.2 The Effects of Other Therapy on the Anxiety of Patients

This study compared the effects of information technology application on preoperative anxiety of patients with the therapy of aromatherapy, music by network meta-analysis. The network of the comparisons for the network meta-analysis was as Figure 4. There were 30 studies that discussion the effects of new therapy on preoperative anxiety of patients. 19 studies compare information technology application with tradition health education plan. 10 studies compare the therapy of music with tradition health education plan, and they included You [35], Liu [36], Peng [37], Wu [38], Chen [39], Ni [40], Hsiao [41], Su [42], Wang [43], and Hu [44]. 1 study compared the therapy of aromatherapy with tradition health education plan, and it is Wang's study [45]. The result of network meta-analysis that base on tradition health education plan was as Figure 5. The  $\tau^2$  is 10.31, the I<sup>2</sup> is 52.70%, and Q is 57.04 (p-value<0.01). It could find that the effects of music therapy was better than others(SMD=-5.42), and information technology application (computer) was the second (SMD=-4.10).

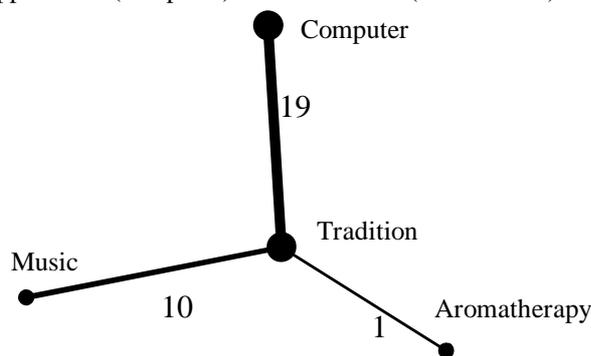


Figure 4 Network of the comparisons for the network meta-analysis

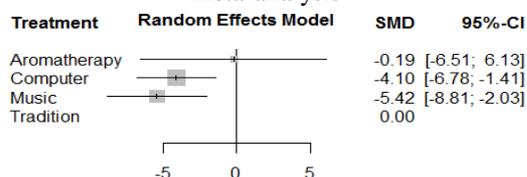


Figure 5 The network meta-analysis forest plot of the therapy of computer, aromatherapy, music, and tradition

## 4. DISCUSSION AND CONCLUSION

The results of this study indicate that information technology application in health education plan had moderately effects on patients' anxiety over traditional health education plan in Taiwan. The results from this study suggest information technology application on health education is positive with patients' anxiety. This study compared the effects of traditional health education plan on preoperative anxiety of patients with the therapy of information technology application, music, and aromatherapy. It could find that the effects of music therapy were better than others, and information technology application was the second. So the effects of information technology application on preoperative anxiety of patients could be increased with the therapy of music. Although traditional health education plan that provided by nurse make some patients feel not comfortable than information technology health education plan that provided by computer. But information technology was a good tool for reduce patients' anxiety.

### ACKNOWLEDGEMENTS

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