

## ORIGINAL ARTICLE

# Quantification of the subjective labour load of a filmless radiology system by the contingent valuation method: a pilot study

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**Received:** February 29, 2012

**Accepted:** June 25, 2012

**Published:** September 1, 2012

**DOI:** 10.5430/jha.v1n1p30

**URL:** <http://dx.doi.org/10.5430/jha.v1n1p30>

## Abstract

**Background:** A filmless radiology system, which implements a radiology information system and picture archiving and communication system, brings major changes in the work patterns of radiologists and radiological technologists. The purpose of this study was to prospectively quantify the subjective labour load of a filmless radiology system for radiologists and radiological technologists by the contingent valuation method (CVM) and to evaluate the economic labour value.

**Methods:** The questionnaire survey included 14 radiologists and 46 radiological technologists. There was a 75% effective response rate with a total of 45 respondents. The subjective labour load of a filmless radiology system was quantified by the CVM as willingness to accept (WTA). The double-bound dichotomous choice approach was employed for the questionnaire format for WTA. Logistic regression analysis was used to identify the factors affecting WTA.

**Results:** The median and mean WTA per month for radiologists were estimated to be 82,902 yen (\$829) and 46,808 yen (\$468), respectively. The median and mean WTA for radiological technologists were estimated to be 15,622 yen (\$156) and 16,784 yen (\$168), respectively. Logistic regression analysis showed promotional view (i.e., willingness to introduce computerization of medical information) as the only significant factor affecting WTA for radiological technologists ( $p < 0.05$ ).

**Conclusions:** The change from film-based- to filmless- radiology system would be acceptable providing that medical staff in the department of radiology think their labour changes would yield an increase of satisfaction equivalent to 1,430,000 (\$14,300) -1,880,000 yen (\$18,800).

## Key words

Filmless system, Labour load, Subjective value, CVM, WTA

# 1 Introduction

In recent years, filmless radiology systems have spread widely in Japan. A filmless radiology system using the Radiology Information System (RIS) and Picture Archiving and Communication System (PACS) offer unique improvements in operational efficiency, and bring a major change in the work patterns of radiologists and radiological technologists<sup>[1,2]</sup>. This change influences therefore the economic labour value. It is important that a change of the value of the department of radiology was evaluated subjectively considers an individual sense. However, quantifying the value of a filmless radiology system through a subjective evaluation is difficult because it is a non-market good.

One evaluation method for non-market goods is the contingent valuation method (CVM), which is a survey-based, hypothetical, and direct method, to determine monetary valuations. CVM evaluates the willingness to pay (WTP) and willingness to accept (WTA) in a hypothetical market to assess the economic value of public goods that are not transacted in an actual marketplace<sup>[3]</sup>. This methodology, which is based on welfare economics, can be used to quantify all kinds of benefits, including intangible benefits related to psychological factors<sup>[4]</sup>. CVM has been applied to the medical field and a number of CVM studies have been published on health care evaluation<sup>[3-11]</sup>.

To our knowledge, no study has specifically addressed a filmless radiology system by quantitatively evaluating labour load using CVM. The primary purpose of this study was to prospectively quantify the subjective labour load of a filmless radiology system for radiologists and radiological technologists to evaluate the economic labour value.

## 2 Subjects and methods

### 2.1 Subjects

A questionnaire survey was performed targeting all radiologists (n=14) and radiological technologists (n=46) working for the department of radiology in the hospital. Survey respondents were guaranteed confidentiality, and those who consented to participate were informed of the study summary. In the department of radiology, A filmless radiology system has been completely applied since May 2004. The survey period ranged from July 10 to July 25, 2008 for radiologists and from November 12 to December 13, 2007 for radiological technologists.

### 2.2 Questionnaire

The questionnaire items included some individual attributes and WTA for the filmless radiology system. The individual attribute items were "age group" (20s/30s/40s/50s), "traditional clinical experience with a film-based radiology system" (none/<5 years/5-10 years/11-15 years/16-20 years/>20 years), "interest in digitization of medical imaging" (four grades: highly interested, somewhat interested, slightly less interested, least interested), "promotional view on the computerization of medical information" (four grades: highly promote, promote somewhat, promote slightly, promote least).

The subjective labour load of the filmless radiology system was quantified by the CVM using WTA. The scenario assumed there would be a change from a filmless radiology system to a film-based radiology system. The participants were showed the above scenario and present conditions of the filmless radiology system, and were asked if they thought that the labour load in the scenario increased. Those who answered that the labour load increased were then asked how much their individual WTA should be changed to in terms of salary per month. The double-bound dichotomous choice approach was employed for the questionnaire format of the WTA<sup>[3]</sup>. The dichotomous choice approach determines the probability that a representative consumer is willing to accept some nominated amount. As the nominated money amount is increased, the proportion of respondents willing to accept the amount is expected to increase. The participants were asked if they were willing to accept price X (radiologists, \$500; radiological technologists, \$100). They were then asked if they were willing to accept price Y (radiologists, \$300 or \$800; radiological technologists, \$50 or \$300). If the subjects

accepted the first bid of X, then they were subsequently given the lower price Y. However, if they rejected the first bid, then they were given a higher price. Assumed only The first bid was taken only one kind because of the small sample size. Prior to administration of the questionnaire, a small group, (including one radiologist and four radiological technologists) was set up. As a result, they provided valuable feedback on the questionnaire as a whole and determined the nominated amounts.

## 2.3 Data analysis

A random utility model was applied to estimated WTA and calculate representative median and mean WTA [6, 12]. The probability function that a respondent permitted the scenario was assumed to obey a logit model. The probability function was estimated by the most likelihood method. There is disagreement in the literature whether the median WTA or the mean WTA should be the representative value taken. The median WTA is relatively stable with regard to the functional form, whereas the mean is highly sensitive to assumptions about functional form [6, 12]. There are statistical advantages to using the median, but the mean is the strictly correct benefit measure [6, 12]. Therefore, both values were calculated and the user labour load was estimated. To calculate the median WTA, the probability was set at 0.5 and the function was solved for bid WTA. The integral of the logistic function with respect to bid from 0 to the maximum nominated amounts was calculated to estimate the mean WTA.

Logistic regression analysis was used to identify the factors affecting WTA. The list of parameters is shown in Table 1. All analyses were performed using R ver.2.7.1 (<http://www.r-project.org/>). A *p*-value less than 0.05 was considered significant. The exchange rate was assumed to be 100 yen for one US dollar as a rate in 2009.

**Table 1.** Definition and basic statistics of variables

Variable	Definition
Age	Respondent's age group in 10 years, 20,30,40,50
Film Imaging	Dummy=1, if respondent has experience with film-based radiology system, 0 otherwise
Information	The degree of interest for digitization of medical imaging, 1-4, 1=never, 4=very
	The degree of promotion view on the computerization of the medical information, 1-4, 1=never, 4=very

## 3 Results

### 3.1 Demographic characteristics

Sixty questionnaires were distributed, and 47 were returned. Two respondents were excluded because the WTA was not an individual WTA (n=1), and one respondent gave no answer for the dependent variables (n=1). This resulted in an effective response rate of 75.0% (45/60). Of the 35 remaining subjects, 12 were radiologists and 33 radiological technologists. The basic characteristics are summarized in Table 2.

**Table 2.** Demographic Characteristics of the radiologists (n=12) and radiologic technologists (n=33)

Characteristic	Measurement	Radiologists (%)	Radiologic technologists (%)
Age group	20s	1(8.3)	17(51.5)
	30s	7(58.3)	4(12.1)
	40s	4(33.3)	3(9.1)
	50s	0(0)	9(27.3)

(Table 2 continued on page 33)

**Table 2.** (Continued)

Characteristic	Measurement	Radiologists (%)	Radiologic technologists (%)
Traditional clinical experience with a film-based radiology system			
	Yes	11(91.7)	24(72.7)
	No	1(8.3)	9(27.3)
Interest in digitization of medical imaging			
	Never	0(0)	1(3.0)
	Not somewhat	0(0)	4(12.1)
	Somewhat	4(33.3)	17(51.5)
	Very	8(66.7)	11(33.3)
Promotional view on the computerization of medical information			
	Never	0(0)	0(0)
	Not somewhat	1(8.3)	2(6.1)
	Somewhat	1(8.3)	11(33.3)
	Very	10(83.3)	20(60.6)

### 3.2 WTA and associated factors

The median WTA and mean WTA for radiologists were estimated to be 82,902 yen (\$829) and 46,808 yen (\$468), respectively. The median WTA and mean WTA for radiological technologists were estimated to be 15,622 yen (\$156) and 16,784 yen (\$168), respectively.

Prior to the logistic regression analysis, an item (traditional clinical experience with a film-based radiology system for radiologists) was removed because only one person had no experience in using the traditional film-based radiology system. Logistic regression analysis showed that promotional view on the computerization of the medical information for radiological technologists was the only significant factor affecting WTA ( $P < 0.05$ ) (Table3).

**Table 3.** Results of logistic regression analysis

Variable	Radiologists		Radiologic technologists	
	Coefficient	Standard error	Coefficient	Standard error
$\alpha$	5.627	9.685	3.484	2.731
$\beta$	0.343	0.330	0.801*	0.200
AGE	-0.018	0.099	-0.018	0.034
FILM	-----	-----	0.857	0.861
IMAGING	0.100	1.311	-0.586	0.670
INFORMATION	-0.404	1.096	1.679*	0.831
Number	12		33	
Log Likelihood	-11.64403		-41.62203	

\*  $p < 0.05$

## 4 Discussion

In this study, the user labour load of a filmless radiology system by directly asking about WTA was assessed. The results indicate that the subjective labour load can be expressed quantitatively and compared with the other objective indices. Based on the 75% response rate, we can safely say that these results reflect the views of computerized medical imaging in the department of radiology. The labour load per month for radiologists and radiological technologists was estimated to range from 46,808 yen (\$ 468) to 82,902 yen (\$ 829) and from 15,622 yen (\$ 156) to 16,784 yen (\$ 168), respectively. The user receives value equivalent to these amounts of money using the filmless radiology system and feels that the convenience and usability are similar to those amounts of money compared to a traditional system.

A preliminary study of the user acceptance of PACS <sup>[2]</sup> suggests that radiologists have a comparatively better view of PACS than radiological technologists. This result is supported by our finding that the WTA for radiologists was approximately 2.8-5.3 times the WTA for radiological technologists, which shows that the radiologists prefer a filmless radiology system compared to radiological technologists. Several previous studies <sup>[2, 13]</sup> have performed subjective evaluations such as user acceptance of PACS or radiologist's satisfaction. However, evaluating these results economically reflecting individual sense of value is difficult. Estimating the economic labour value for the entire department of radiology using the subjective labour load by CVM indicates the ability to quantify the satisfaction and acceptance of the healthcare worker as a money unit.

The results showed that the change in the economic labour value obtained by introducing a filmless radiology system in the radiology department ranged from 1,430,000 (\$14,300) to 1,880,000 yen (\$18,800), on a monthly basis, and from approximately 17,160,000 (\$171,600) to 22,560,000 yen (\$ 225,600) annually. From these amounts, the filmless radiology system may reduce the labour load of seven to nine medical processors (approximately 200,000 yen (\$200) per month) including transportation and management of the film. Logistic regression analysis indicated that only promotional view on the computerization of the medical information for radiological technologists was a significant factor affecting WTA, and it followed that age group, traditional clinical experience with a film-based radiology system, and interest for digitization of medical imaging were not the salient predictors of WTA. This result implies that a higher promotional view of the computerization of medical information for radiological technologists is associated with higher WTA, and that a filmless radiology system is regarded as important.

Construct validity and reliability have been repeatedly confirmed in CVM studies <sup>[3-11]</sup>. The logic of construct validity is to determine whether the empirical data are consistent with the theoretical proposition. First, it was considered that the older respondents in this study had a higher WTA because of the difference in their sense of money. However, age group was not a positive predictor of WTA, which may have been due to the fact that younger respondents are very dependent on computerized work. Most young respondents have no experience in using a traditional film-based radiology system and use computers daily. In addition, it was predicted that respondents who promoted computerization of medical information had positive intentions and a higher WTA. Radiological technologists conformed to the proposition, but radiologists did not. The limitations of our study were the following: 1) the subjects were already familiar with a filmless radiology system, which might have biased the results; 2) biases commonly seen in CVM studies such as the first bid being not appropriate; the median WTA for radiologists might have exceeded the highest nominated money bid; 3) the number of participants was low because of the same scenario assumed.

## 5 Conclusion

The change from film-based- to filmless-radiology system would be acceptable providing that medical staff in the department of radiology think their labour changes would yield an increase of satisfaction equivalent to 1,430,000 (\$14,300) -1,880,000 yen (\$18,800).

## Acknowledgements

The authors would like to thank Professor Dr. Terae, Professor Dr. Shimizu, radiologic technologist Mr. Tsuji, for valuable advice and their assistance in collecting the questionnaire. Thanks to all the staff of the department of radiology for participating in the study.

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