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Quantitative Research on the Satisfaction of Shared Medical Equipment Under Sharing Economy

Huzhi Xue[1, a], Runtong Zhang [2, b]

[1]School of Economics and Management, Beijing Jiaotong University, Beijing, China.

[a] 20120619@bjtu.edu.cn , [b] rtzhang@bjtu.edu.cn

Abstract: Background: Shared medical equipment is one of the developments related to sharing economy, which can effectively reduce the excessive waste of medical resources. Different people have different expectations. In other words, people's responses influence the development. Therefore, identifying the expectations of different groups can provide guidance for the development of shared medical equipment. Methods: This study establishes a research model consisting of four personal characteristic indexes (identity, income, gender and age), four factors (financial affairs, sanitation, convenience and policies), and eight secondary indexes (rental price, diversified methods of payment, equipment disinfection, utility loss in transit, supporting services, scheduling efficiency, rights protection of damage and rights protection of medical malpractice). These data involved 337 effective Chinese participants and are analysed and tested through factor analysis, entropy method and nonparametric tests. Results: Factor analysis reclassifies eight secondary indexes and corrects four latent ones. There is no significant difference in the expectation of shared medical equipment among people of different ages, incomes and genders. Patients have the highest expectation (1.461). This is followed by personnel in medical industry, while ordinary people have the lowest expectation (1.448). People are most concerned about the disinfection degree of shared medical equipment, and least concerned about equipment scheduling efficiency. Conclusions: We propose a method to quantify the expectation of shared medical equipment. We also get the weight of each factor and determine the factor that people care more about. To maximize the benefits, different strategies are supposed to be introduced for different people according to their expectations.

Keywords: shared medical equipment, satisfaction survey, factor analysis, factor entropy method, nonparametric test

1. Introduction

Think of what we are sharing today-Commuters share bicycles, as they rent bicycles almost every day to go to work; travelers share rooms, as they rent rooms by online application like Airbnb. While sharing is almost as old as mankind, the sharing economy, intermediated by Internet and mobile technology, is a phenomenon of the 21st century. Sharing economy is based on peer-to-peer sharing of goods and services and as opposed to previous ownership-based economy it focus on the accessibility of a good or service instead of ownership[1]. In fact, driven by the peer-to-peer platforms and Information System (IS), its rise is changing the consumption behavior of millions of people around the globe[2]. Launched only 11 years, Uber Technologies, inc. is an app-based transportation service provider that operates in about 270 cities and more than 60 countries worldwide. Similar to Uber is the example of Airbnb taking on almost the same role but in the hospitality sector, with 100 million booking yearly and $30 billion worth of capital. In addition to these fields, one potential beneficiary sector of sharing economy is the healthcare industry.

Medical equipment, like ultrasound scanners, infusion pumps and navigation systems, are traditionally viewed as fixed assets that belong to a facility or even a specific hospital wing or operation room. In the U.S for example, the government alone spends $2.3 trillion dollars for healthcare1. According to GE Healthcare[3] studies, the hospitals use any given equipment only 42% of the time at most. Improving quality and controlling costs of medical systems are two key objectives in many countries[4]. MRI equipment is the equipment with high utilization rate in hospital, but the utilization rate is less than 70%[5], which indicates that the utilization rate of

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medical equipment is not that high. The idle energy for the facility is calculated very high. Purchasing expensive and advanced medical equipment often leads to the situation where hospitals feel under capacity. Moving onto patients, most patients do not need medical equipment all the time. For example, a patient will need a wheelchair after he breaks his leg, but after his injury is cured, he will no longer need the wheelchair. If he chooses to buy the wheelchair, there will be a waste of resource. In addition, under the background of Covid-19 pandemic, most people are isolated and cannot get the access to medical equipment. Shared medical equipment plays a vital role in Public Health Emergency of International Concern (PHEIC). For large scale medical equipment, on the one hand, it has considerable economic benefits. On the other hand, although it is an important embodiment of hospital medical level, its daily maintenance costs and operation costs are huge. However, forward-looking development modes are examining ways that can share equipment across the growing networks of facilities, instead of having those valuable assets sitting around underused.

2. Literature Review

The chapter is related to the literature on the rental of medical equipment. Toshiaki Noguchi et al[6] describe the whole process of endoscope and other inexpensive medical equipment rental system for medical organizations on a fee-paying basis. They find that it is possible to support medical examinations which are efficient and inexpensive. Sharp and Kreder7 compare the pros and cons of leasing and purchasing medical equipment to help make good business plan. Crampton and Reed[8] introduce current situation of medical equipment sharing industry including high rental fee and they also point how to drive benefits in this arena. Suwantarat, N. et al[9] demonstrate that hospitalized patients frequently have direct or indirect interactions with medical equipment that is shared among patients and they also introduce protocols to ensure routine cleaning of shared portable equipment which provides thoughts about the safety of medical equipment sharing system. Lari, Azam et al[10] investigate relevant statistical populations to obtain the factors influencing the decision-making of purchasing capital equipment in the Affiliated Hospital of Teheran Medical University. Lyu. et al[11] present novel cloud-based privacy-preserving solutions to support collaborative consumption applications for sharing economy. Andrew, S. et al[12] introduce a potential future state for health care, highlighting how concepts from the on-demand economy could shape health care to promote shared value across the healthcare system. It can be concluded that there is a lack of empirical researches on the expectations of shared medical equipment at present. Therefore, our research is of great significance.

Papers that are closest in spirit is Boateng, H. et al[13] who use factor analysis and collect data from self-administrated questionnaires to examine the factors that drive customers in Ghana to use Uber. Lee Zach et al[14]conduct a self-reported online survey among 295 Uber users in Hong Kong. They finally examine the effects of inhibiting, motivating, and technological factors on user’s intention to participate in the sharing economy. Saif Benjaafar et al[15] describe an equilibrium model of peer-to-peer product sharing, and collaborative consumption where individuals at different usage levels make decisions about whether or not to own a homogeneous product. Mittendorf, C[16] develops a questionnaire to investigate how social motives, financial motives, and trust influence the users’ intentions to request a booking on the online booking platform using factor analysis. Therefore, the method used in this study is reliable and effective.

3. Materials and Methods

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3.1 Analysis tool selection

To examine the complex relationships of the research model and individual effect on dependent variables, factor analysis[17] was used to test our model. FA can help verify the correspondence between factors and measurement items. Two reasons explaining why this study adopted FA method: 1) The measured variables are transformed into a few potential variables by dimension reduction[18]. 2) Factor analysis can quantify potential variables that are difficult to measure. We used SPSS version 26 to analyze the collected data and test our model. SPSS version 26 was selected because it has complete statistical models, achieving efficient and unbiased analysis and evaluating latent variable interactions[19]. We used Python 3 to calculate synthetical score of every sample because it can cope with highly complex models and provide a fast-processing speed.

3.2 Instrument Development

Current study in the research model measured variables by utilizing a five-point Likert scale ranging from strongly agree to strongly disagree which has been validated by published works. To establish reality and validity, we adopted 8-item scale in Table I[20] to measure people’s satisfaction with sharing medical equipment in different aspects. Moreover, we subdivided these eight secondary indices into four factors. Although other factors may be involved in, the following four primary indices and eight secondary indices should be the focus of this study.

3.3 Data collection and respondents’ profile

All subjects of this survey were Chinese individuals. According to their identities, we randomly selected personnel in the medical industry, patients, and ordinary people to ensure that we could get relatively comprehensive results. Since the survey would be investigated in China, participants were Chinese individuals and the content of the survey should be written into Chinese. We translated the survey instrument into Chinese before starting the survey process[21]. Similar to the translation process in previous works[22], for the consideration of cross-cultural adaption[23], we recruited native Chinese speakers with master’s degree or above who could speak English fluently and were proficient in scientific research translation to convert our scales into Chinese. Then we invited people with different identities to fill in the questionnaire and provide positive response to improve the scales. Finally, we performed a reverse-translation process that guaranteed the similarity of our scales to the original English version in the conceptually consistent section[24].

3.4 Participants

The investigation was conducted in January 2021. If response completion time is significantly below the average, the response is considered invalid. If the answer is incomplete or at least one answer is missed, the response is also considered invalid. Following these conditions, we received a total of 337 responses wherein 253 of them are considered valid. The validity rate was 75.07% (253/337). Table I represents the demographics of the sample. We found that 32.01% (81/253) of the participants were aged from 20 to 35 years old, and 54.98% (138/253) were female. 50.19% (127/253) of the participants were ordinary people and 36.36% earned less than 5,000 RMB per month. More than half of our sample was young, female, and low-income group. These characteristics were consistent with those of sharing equipment users in the sharing economy[25]. Therefore, the sample met our requirements.

Then we used chi-square test to investigate the acceptance and familiarity of shared medical equipment with different identities. Chi-square test shows no significant difference in the acceptance of shared medical equipment among people with different identities (=10.634, $p=0.223>0.05$). There are significant differences in the familiarity of shared medical equipment among people with different identities (=69.595, $p=0.00<0.05$). Personnel in medical industry (61.41%) are more familiar with shared medical equipment than patients (16.67%) and ordinary

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people (16.66%). People with different identities have significant differences in the ways to understand shared medical equipment (=77.952, p=0.00<0.05).

4. Results

4.1 Data reliability and validity

Before performing factor analysis, we need to consider the reliability and validity of the data. The reliability was calculated by Cronbach ’ s Alpha and validity was calculated by KMO and Bartlett ’ s Test[26]. Cronbach ’ s alpha is a measure of internal consistency, that is, how closely related a set of items are as a group. Cronbach ’ s alpha (needed to be greater than 0.9) in Table II show the reliability of scale in this study was excellent in internal consistency.

KMO test is used to check the correlation and partial correlation between variables and Bartlett’ s test is used to check whether variables are independent. KMO test (needed to be more than 0.80) and Bartlett ’ s test (Significance needed to be less than 0.05) in Table III show that the validity of scale in this study is acceptable.

4.2 Extract Principal Component and Common Factors

Table IV shows that four components explain 82.796% of the information in the scale (needed to be more than 80%) which is considered convincing. Then, analyzing the extraction rate of each factor, as shown in Table IV below: the information extraction rate of the eight original indices is more than 70%, which shows that the common factor formed by the factor analysis method can contain most of the information of the original index.

Table VI shows that factor 1 includes indice 8, 5, and 7. These projects mainly insist on compensation and services. Factor 2 includes indice 1 and 2. These projects mainly involve financial affairs. Factor 3 includes indice 3 and 4. These projects are mainly for safety concerns. Factor 4 includes indice 6. It mainly insists on equipment allocation. In addition, through the regression method, we also obtained the score of each factor.

4.3 Entropy method

Entropy method combines the information provided by entropy to determine the weight. The larger the entropy is, the more chaotic the data is, the less information it carries, the less utility value it has, and the smaller the weight it has[27]. As shown in Figure I, we use factor entropy method to weight the four factors.

Table VII shows that people are more concerned about the safety of shared medical equipment including equipment disinfection and utility loss in transit.

f_i is the score corresponding to each factor. F is each person’s expectation of shared medical equipment.

$$F = 0.2483 f_1 + 0.2306 f_2 + 0.2830 f_3 + 0.2381 f_4 \quad (1)$$

Based on these 253 samples, the expectation degree is quantified by the factor entropy method. Further descriptive statistical analysis of the expectation degree is carried out, as shown in Figure II: the expectation degree data distribution basically presents a right-skewed distribution, with an average of 1.475 and a standard deviation of 0.086. The average is greater than the median and mode. Taken together: this shows that residents' expectations for shared medical equipment have yet to be improved.

4.4 Nonparametric tests

As shown in Table VIII, because the quantitative expectation data presents a non-normal distribution, we use Kruskal-Wallis and Mann-Whitney tests to analyze whether the expectations of different populations have significant differences. Specifically, if the features are grouped and the

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number is 2 groups, the Mann-Whitney test is used for the study. If the number of groups exceeds 2 groups, the Kruskal-Wallis test is used for the study. The test results are shown in Table VIII below.

As shown in Table IX, there is no significant difference in the expectation of shared medical equipment between people of different genders (p=0.665>0.05) income groups (p=0.394>0.05) and people of different ages (p=0.337>0.05). There are significant differences in the expectations of people with different identities shared medical equipment (p=0.041<0.05). Patients have the highest expectations for medical equipment sharing, while ordinary people have the lowest expectations for medical equipment.

5. Conclusions

In our research model, we propose a method to quantify the expected value of shared medical equipment through factor analysis, specifically through eight secondary indicator matrices (rental price, diversified methods of payment, equipment disinfection, utility loss in transit, equipment supporting services, equipment scheduling efficiency, rights protection of equipment damage and rights protection of medical malpractice) are linearly transformed to quantify four unpredictable first-level indicators (finance, health, convenience and policy). Then, we use the entropy method to obtain the weight of each first-level indicator and weight it to obtain the expected value of the residents of shared medical equipment. At the same time, the weight can also reflect the degree of influence of the four aspects of finance, health, convenience, and policy on the degree of expectation. Finally, through non-parametric tests, it is found that people with different identities have different expectations for sharing medical equipment. These findings indicate that:

People with different identities have significant differences in the degree of and ways of understanding shared medical equipment, and the differences in the ways of understanding may be one of the reasons why the group's expectations are not high. In order to make the public understand, accept, and improve the overall level of shared medical equipment, it is necessary to adopt local conditions of promotion and publicity policies and equipment development plans for different groups of people, to enhance the public awareness and recognition of shared medical equipment.

According to Figure I, people have low overall expectations for shared medical equipment. Ordinary people’s understanding of shared medical equipment is far lower than that of doctors and patients, and various methods need to be adopted to help ordinary people improve their understanding of shared medical equipment.

In order to develop shared medical equipment to the maximum extent, health and safety should be most concerned. This is followed by indemnity and service, equipment allocation and financial affairs.

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Table 1. Descriptive Statistics of the scale

Index	Index number	Factors	M	SD
Rental Price	Index 1	Financial Affairs	2.28	1.191
Diversified methods of payment	Index 2		2.26	1.194
Equipment disinfection	Index 3	Sanitation	2.16	1.164
Utility loss in transit	Index 4		2.26	1.264
Equipment supporting services	Index 5	Convenience	2.18	1.200
Equipment scheduling efficiency	Index 6		2.36	1.127
Rights protection of equipment damage	Index 7	Policies	2.19	1.178
Rights protection of medical malpractice	Index 8		2.16	1.198

M: mean, SD: standard deviation

Table 2. Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.945	.945	8

Table 3. KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.932
Bartlett's Test of Sphericity	χ^2	1162.736
	df	28
	Sig.	.000

Table 4.Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
I_1	5.067	63.333	63.333	5.067	63.333	63.333
I_2	0.575	7.191	70.524	0.575	7.191	70.524
I_3	0.530	6.631	77.155	0.530	6.631	77.155
I_4	0.451	5.641	82.796	0.451	5.641	82.796
I_5	0.424	5.300	88.096			
I_6	0.363	4.542	92.637			
I_7	0.313	3.907	96.545			
I_8	0.276	3.455	100.000			

Table 5. Variance Explained

Index	Extraction
Rental price	0.788
Diversified methods of payment	0.834
Equipment disinfection	0.943
Utility loss in transit	0.745
Equipment supporting services	0.770
Equipment scheduling efficiency	0.983
Rights protection of equipment damage	0.798
Rights protection of medical malpractice	0.763

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Table 6. Rotated Component Matrix

	Factor 1	Factor 2	Factor 3	Factor 4
Index 8	0.779	0.194	0.255	0.297
Index 5	0.747	0.389	0.176	0.172
Index 7	0.713	0.327	0.336	0.189
Index 2	0.326	0.798	0.090	0.286
Index 1	0.270	0.759	0.350	0.125
Index 3	0.282	0.204	0.886	0.194
Index 4	0.443	0.486	0.523	0.198
Index 6	0.328	0.283	0.236	0.860

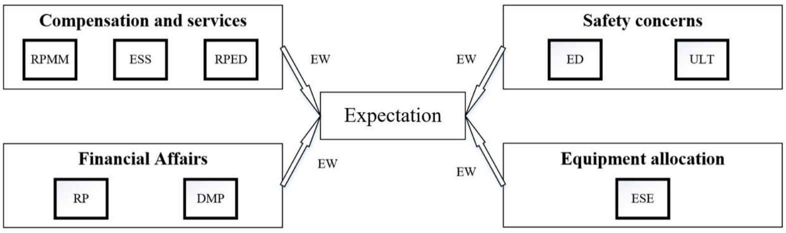

Figure1. Flowchart of expection quantification

We use abbreviation to indicate secondary index. For example: RP: Rental Price; EW: Entropy Weighting

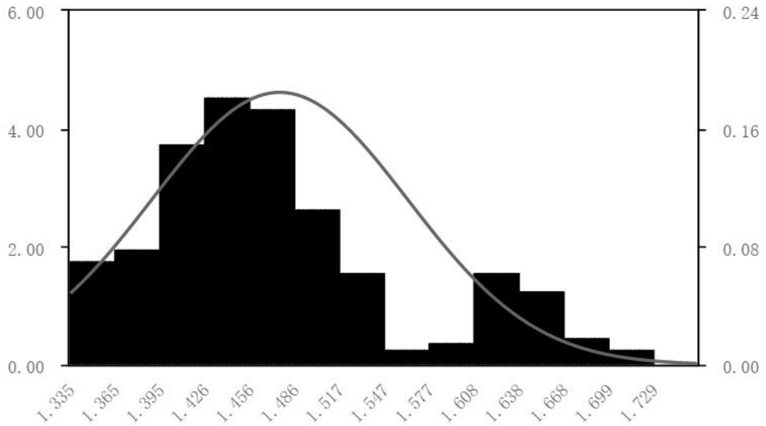

Figure2.Histogram of expected degree and normal fitting

Table 7. Information Entropy and Weight

Factor	Weight	Entropy
compensation and service	0.2483	0.998808
financial affairs	0.2306	0.998893
safety concern	0.2830	0.998642
equipment allocation	0.2381	0.998857

Table 8. Normality test analysis result

name	Sample size	Kolmogorov-Smirnov Test		Shapro-Wilk Test	
		D -Value	p-Value	W -Value	p-Value
Expectation	253	0.131	0.000**	0.909	0.000**
* p<0.05 ** p<0.01					

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Table 9.Comparison of differences in expectations of groups with different characteristics

characteristics	Kruskal-Wallis H-Value	Mann-Whitney Value	Mann-Whitney H-Value	p-Value
Gender	---	7684.000	-0.433	0.665
Age	4.551	---	---	0.337
Income	4.091	---	---	0.394
Identity	6.371	---	---	0.041*

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