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Original Article

Factors for reducing monetary loss due to presenteeism using a tailored healthcare web-application among office workers with chronic neck pain: a single-arm pre-post comparison study

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Abstract

Objectives: This study aimed to examine the factors for reducing monetary loss due to presenteeism by using a tailored healthcare web-application among office workers with chronic neck pain. **Methods:** The study was single-arm pre-post comparison study using secondary data of 130 Japanese office workers with chronic neck pain who used a tailored healthcare web-application (web-app) over 12 weeks. This data was obtained from BackTech Inc. (Kyoto, Japan), which manages the healthcare web-app. The primary outcome measure was the monetary loss due to presenteeism based on the quality and quantity method. Secondary outcome measures were intensity of physical symptoms measured by the Visual Analog Scale, frequency of web-app use obtained from the database, and the risk of depression score assessed by the Depression and Suicide Screen. **Results:** Eighty-six participants were included in the complete-case analysis. Monetary loss due to presenteeism and the risk of depression reduced, while physical symptoms improved significantly ($p < 0.01$) after using the web-app. After covariate adjustment, decrease in neck pain intensity ($\beta = 0.25$, confidence interval = 2.34 to 32.66) and high frequency of web-app use ($\beta = -0.24$, confidence interval = -10.29 to -0.63) were significantly associated with a reduction in monetary loss due to presenteeism. **Conclusion:** Neck pain intensity and frequency of web-app use may be important factors for reducing monetary loss due to presenteeism among office workers with chronic neck pain who used a tailored health care web-app.

Keywords: chronic pain, monetary loss, neck pain, telemedicine

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Introduction

The term “presenteeism” generally refers to the loss of productivity faced by workers who are on the job despite their illness or other medical conditions¹. Since the

2010s, presenteeism has become an urgent global issue, particularly in developed countries, since the working-age population has been decreasing remarkably in these regions². Previous studies have shown that neck pain is the primary cause of presenteeism³.

Neck pain is a serious issue, especially among office workers who are usually restricted to a sedentary work position^{4,5}. It has been suggested that almost 17% of healthy office workers experience new-onset neck pain that develops into chronic pain lasting at least 3 months

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within a year⁶). The risk factors of chronic neck pain include physical and psychosocial aspects⁷ that interact with each other^{8–10}. In addition, chronic neck pain often accompanies comorbid physical symptoms, such as low back pain, headache, asthenopia, and so on¹¹. Therefore, it is essential to approach neck pain along with the related psychosocial aspects and comorbid symptoms to solve problems associated with chronic neck pain¹².

Web-based intervention is expected to be an effective way to cope with chronic neck pain and related issues^{13,14}. Web-based interventions have the following benefits compared to conventional methods. First, the users do not need to be present at a specific location, and the intervention can be delivered at any place as long as the users have access to the internet through their digital device. Second, as opposed to conventional methods, users can receive web-based interventions at any time they want without setting up an appointment with the intervention providers.

In the last decade, some studies have explored the use of tailored, web-based interventions for people with low back pain or psychological problems, but very few studies have focused on people with chronic neck pain, and even fewer studies have examined the effectiveness of web-based interventions on presenteeism due to chronic neck pain or monetary loss due to presenteeism^{13,15}. In addition, the relationship between the outcomes of physical symptoms and specific variables related to web-based interventions, such as frequency of use, is not clear. Therefore, it is unknown whether healthcare web applications (web-apps) are effective regarding presenteeism or monetary loss due to presenteeism among people with chronic neck pain.

Hence, the purpose of this study was to investigate the changes in chronic neck pain and whether the use of the web-app is a factor in reducing monetary loss due to presenteeism, especially among office workers with chronic neck pain. We hypothesized that: (1) a reduction in neck pain intensity is associated with a reduction in monetary loss due to presenteeism, and (2) frequent use of healthcare web-app is associated with a reduction in monetary loss due to presenteeism.

Subjects and Methods

This single-arm pre-post comparison study was conducted using secondary data collected by BackTech Inc. (Kyoto, Japan), which manages the healthcare web-app called “Pocket-Therapist.” The current study used anonymized data, so the individuals did not need to be identified. The calculated sample size was assuming that the outcome was a change in cost (in United States dollars [USD]) due to presenteeism between before and after the use of web-app, α error=0.05, β error=0.20, Cohen’s d =0.50, and the corresponding t -test. As a result, the required sample size was at least 34. This study was

approved by the Medical Ethics Committee of Kyoto University (approval number: R2145).

Study populations and procedures

We identified 281 office workers with self-reported chronic neck pain lasting at least 3 months who had used the tailored healthcare web-app from January 2019 to December 2019. Of these, 130 people who had used the web-app for more than 12 weeks were included in this study. The period of 12 weeks was set by referring to the previous study¹⁶. These workers work for Japanese companies and usually have desk-based jobs. Users of the web-app were recruited through the Intranet flyers, and e-mails from the company’s health management department. To start using the application, workers themselves proceeded to the registration form on each media. Workers did not have to pay for the use of this web-app themselves, as it was paid for by the company where they worked. Participants agreed to a privacy policy at the start of their use of the app, which stated that the data gathered in the web-app might be used secondarily for future research. Individuals were eligible for participation if they met the following criteria: (1) were aged 18 to 65 years and (2) had persistent pain in the neck region for more than 3 months when starting the use of the web-app¹⁷. Participants were excluded if their questionnaires were incomplete.

Web application

Pocket-Therapist is a web-based application that can be used with any web-connected device (e.g., smartphone, personal computer, or tablet). This web-app connects workers having musculoskeletal symptoms with healthcare professionals, such as physical therapists and occupational therapists. The therapists registered on this web-app pass a rigorous interview process and are trained by BackTech Inc. Even after registration, the quality of support is checked by an operational manual that consolidates the latest data from meta-analyses and other publications.

Support contents

The therapists provide appropriate support to the users via chats, mainly in the following areas:

(1) Exercise and stretching exercises: therapists teach yoga-based exercises and stretches proven to be useful for chronic neck pain, depending on the users’ symptoms¹⁸.

(2) Cognitive-behavioral intervention: cognitive-behavioral interventions are psychological interventions for alleviating distress¹⁹. The therapists assess the users’ risk of depression and catastrophic thoughts about pain through chats and questionnaires and provide interventions for modifying thought patterns and behaviors.

(3) Workplace adjustments: the therapists provide advice on the placement of computer screens, the height of desks and chairs, optimal intensity of lighting, and so on.

Methods of support

Support is provided through a chat-based exchange. Therapists can send not only chats but also images and video files to explain the treatment process. The recommended frequency of chatting, based on the manual, was at least once a week, but the specific frequency varied from user to user. If the users had other physical complaints besides neck pain, the therapists provided interventions with high priority for the most urgent complaint, in consultation with the users.

Measurements

The following five data points were collected from each participant before and after the use of the web-app.

(1) Demographic data: data on age, sex, height, and weight were extracted through the questionnaires. Body mass index (BMI) was calculated by dividing the weight in kilograms by the squared height in meters.

(2) Monetary loss due to presenteeism: we estimated monetary loss due to presenteeism using the quality and quantity method using the following steps based on previous studies^{3,20,21}. We asked the participants the following questions: first, the symptoms that primarily affected their working performance — the options were low back pain, headache, asthenopia, others, and none in addition to neck pain; second, how many days they had experienced the symptom during the last month; and third, how much the symptom affected their working performance in terms of quality and quantity in comparison to when they were symptom-free. The degree of change in quality and quantity was scored from 0 to 10, with 0 indicating the worst quality or quantity and 10 indicating the best. Finally, we converted their answers into monetary value per person/per month to determine the monetary loss due to presenteeism as follows, with reference to the equation derived equation used in the previous study³. Monetary loss was converted from Japanese yen (JPY) to USD employing the average pay and exchange rate between the JPY and USD in 2018. In 2018, the average pay per person per hour in Japanese large manufacturing companies was JPY 3,484 (USD 31.55 in 2018, since 1 USD = JPY 110.42 on average)^{22,23}.

(3) Physical symptoms intensity: the intensity of physical symptoms (neck pain, low back pain, headache, and asthenopia) was measured using a Visual Analog Scale (VAS). The participants recorded their symptom level by selecting a value from 0 to 100 for each slider question, where 0 denoted no pain, and 100 was the harshest pain²⁴.

(4) Total number of chat messages: as an indicator of the frequency of web-app usage, the number of chat messages (the sum of the number of chats of both the user and therapist) was obtained from the web-app database.

(5) Risk of depression: the risk of depression was assessed using the Depression and Suicide Screen (DSS) questionnaire²⁵. This questionnaire consists of five

closed-ended questions (options of “yes” and “no”). The results are scored on a scale of 0 to 5, with high scores indicating a high risk of depression.

Statistical analysis

The values are presented as mean ± standard deviation (SD) for continuous variables and percentages for nominal or ordinal variables. To understand trends in the variables, the Wilcoxon signed-rank test was used to determine the differences in variables before and after using the web-app. To verify our hypothesis, unadjusted and adjusted regression analyses were used based on the following two models.

Model 1

Changes in the monetary loss due to presenteeism before and after web-app use was a dependent variable and changes in the neck pain intensity before and after web-app use were independent variables. For unadjusted regression analysis, we used only the above two variables. For adjusted regression analysis, adjustment variables were age, sex, body mass index, and risk of depression score before web-app use. Age, sex, body mass index, duration of web-app use and risk of depression were chosen as adjustment variables because previous studies have suggested associations between presenteeism or neck pain^{16,26,27}.

The reason why changes in other physical symptoms (low-back pain, headache, and asthenopia) were not added as independent variables in model 1 was that they were significantly correlated with changes in neck pain (Supplemental Table 1), which may have caused multicollinearity.

Model 2

Changes in the monetary loss due to presenteeism were the dependent variable, and the total number of chat messages was the independent variable. Similar to model 1, age, sex, body mass index, duration of web-app use and risk of depression score before web-app use were chosen as adjustment variables.

Participants who did not complete both before and after web-app use questionnaires correctly were excluded from the analysis. To check for possibility of selection bias, the demographic data of those selected and unselected participants were compared using Mann-Whitney’s *U*-test and chi-square tests. Data analyses were performed using JMP Pro 14.0 (SAS Institute, Cary, NC, USA). A *p*-value of <0.05 was considered statistically significant.

Patient and public involvement

Patients and public were not involved in the design or development of the study, since we used secondary data.

Results

In the present study, 130 workers were selected, of whom 86 were included in the complete-case analysis. Forty-four workers were excluded (Figure 1) because 42 (33.8%) did not answer the questionnaire at the post period, and 2 (1.5%) entered incorrect demographic data. On comparing the demographic data of the included and excluded workers, no statistically significant difference was found between the two groups.

Participants characteristics

The demographic characteristics of the study population are shown in Table 1. There were 35 (40.7%) women, the median age of the participants was 50 years, the

Proportion of productivity loss
= $1 - \text{Quantity}(0 - 10) * \text{Quality}(0 - 10)/100$

Monetary loss due to presenteeism
= USD31.55 * 8(working hour per day)
* (Proportion of productivity loss)
* (days with symptom during last month)

Fig. 1. Calculation for monetary loss due to presenteeism

Table 1. Participants' demographics (N=86)

	N (%) or mean ± SD
Gender, Women	36 (40.7%)
Age, years	48.2 ± 7.97
Body-mass index	23.03 ± 3.11
Duration of use, Days	102.12 ± 28.33
Amount of chat total messages	100.93 ± 70.60
Amount of chat therapist's messages	49.81 ± 25.10
Amount of chat user's messages	51.12 ± 50.71

SD, standard deviation.

median BMI of the participants was 22.7, the median duration of use of the web-app was 91 days, and the median number of total chat messages was 84.

Scores of each variable before and after web-app use

The scores of each variable before and after web-app use are shown in Table 2.

Before web-app use, the median monetary loss due to presenteeism was USD 1,413.44 and median neck pain intensity by VAS was 74.5. After web-app use, the median monetary loss was USD 772.34 and median neck pain intensity was 50.0.

The other measures, except demographic data and the number of chats, showed statistical differences after web-app use.

Regression analysis

To examine the factors for reducing monetary loss due to presenteeism, we conducted a regression analysis with the change in monetary loss due to presenteeism between before and after web-app use as the dependent variable (Table 3).

Model 1

The independent variable was the change in neck pain intensity before and after web-app use. Adjustment variables were age, sex, body mass index, and risk of depression score before web-app use. According to the adjusted regression analysis results, there was a significant relationship between the reduction in monetary loss due to presenteeism and a decrease in neck pain intensity ($\beta=0.25$; 95% confidence interval [CI], 2.34–32.66; $p=0.024$).

Model 2

The independent variable was the number of total chat messages as the indicator of the frequency of web-app use. Adjustment variables were the same as in model 1. According to the results of the unadjusted and adjusted regression analysis, there was a significant relationship between reduction of monetary loss due to presenteeism

Table 2. Scores of each variable before and after web-app use

	before web-app use mean ± SD	after web-app use mean ± SD	p-Value
Monetary loss, USD	1813.55 ± 1833.24	1284.22 ± 1469.97	<0.01**
Risk of depression score	1.57 ± 1.51	1.12 ± 1.42	<0.01**
Neck pain intensity	65.84 ± 17.16	47.36 ± 21.25	<0.01**
Low back pain intensity	33.80 ± 26.03	25.01 ± 21.97	<0.01**
Headache intensity	28.28 ± 25.85	21.10 ± 23.51	<0.01**
Asthenopia intensity	50.38 ± 24.14	39.49 ± 25.00	<0.01**

SD, standard deviation.

** $p < 0.01$

Table 3. Regression analysis for examining monetary loss due to presenteeism

Dependent = Δ Monetary loss due to presenteeism						
	Adjustment	β^\dagger	Estimate	adjusted R ²	95% CI	p-Value
Model 1						
ΔNeck pain intensity	unadjusted	0.20	14.42	0.03	-0.38 to 29.30	0.056
	adjusted	0.25	17.50	0.04	2.34 to 32.66	0.024*
Model 2						
Amount of chat total messages	unadjusted	-0.26	-5.86	0.06	-10.59 to -1.13	0.016*
	adjusted	-0.24	-5.46	0.04	-10.29 to -0.63	0.027*

CI, confidence interval.

Adjustment variables were age, sex, body-mass index, duration of use and risk of depression score before web-app use.

No significant correlations were found among the independent variables and covariates.

Amount of chat total messages was used as an indicator of frequency of web-app use.

[†] β , standardized regression coefficient.

* $p < 0.05$

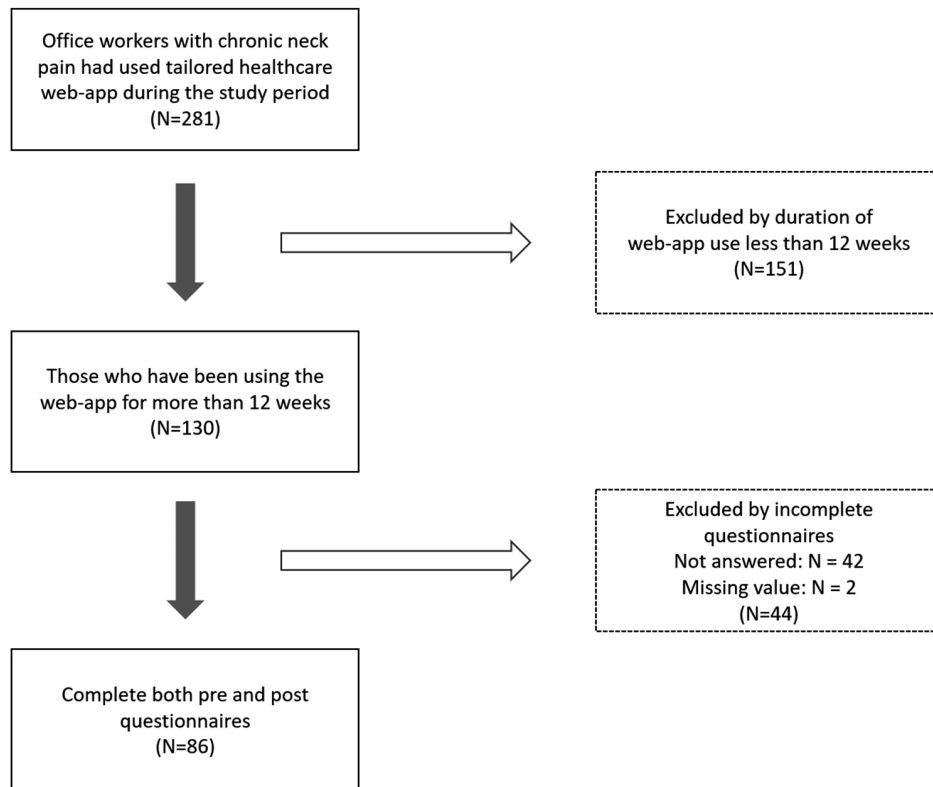


Fig. 2. Participants selection process

and high frequency of web-app use ($\beta = -0.24$; 95% CI, -10.29 to -0.63 ; $p = 0.027$).

Discussion

Key findings

This study found that the decrease in neck pain intensity and high frequency of web-app use had significant relationships with reducing monetary loss due to presenteeism among office workers with chronic neck pain who used a tailored healthcare web-app.

Pre-post comparison of measurements

The current study showed that the monetary loss due to presenteeism, as well as mental and physical symptoms, improved after using the web-app compared to before. Especially, the change in neck pain intensity was significant. In a previous study, the minimal clinically important difference of VAS for chronic neck pain is found to be -8 mm or 21.3%. In the present study, the improvement in neck pain intensity was about -18 mm (28%), which is a clinically meaningful improvement. In addition, since the quality and quantity method used in this study is a

symptom-specific presenteeism rating scale, it is likely that the amount of economic loss also decreased with the improvement in symptoms. Compared to previous studies²⁸⁾, the present study limited the target to office workers who mainly work at desks, so the ease of access to digital devices may be different. In addition, since the current study only included those who continued to use the web-app for over 12 weeks, the effect may have been greater.

Neck pain and monetary loss due to presenteeism

In previous studies, the monetary loss caused by presenteeism per person per year was approximately USD 3,055³⁾. On the other hand, in the current study, the monetary loss value due to presenteeism before web-app use was USD 1,413.44 per month (USD 16,961.28 per year), which is about 5.5 times larger than that in the previous study. This may be because previous studies have calculated presenteeism utilizing averages that include people without symptoms and did not consider the duration of neck pain. However, the current study was limited to people with chronic neck pain. Some studies have shown that neck pain is associated with presenteeism^{3,29)}. However, the relationship between changes in chronic neck pain and changes in presenteeism due to presenteeism overtime was not clear. The current study found that a decrease in pain intensity in office workers with chronic neck pain was associated with a significant reduction of monetary loss due to presenteeism.

This study did not include a comparison group, so it is not possible to conclude whether this reduction in neck pain was due to the use of the web-app. Future studies will need to compare neck pain changes and changes in monetary loss due to presenteeism with and without web-app intervention using randomized controlled designs.

Healthcare web-app use and monetary loss due to presenteeism

Web-apps are emerging as popular methods of interventions for people with chronic conditions physical and/or mental conditions^{30,31)}. These studies have shown the effects of web-based interventions on symptoms themselves, but reduction of monetary loss due to presenteeism has not yet been studied.

In this study, the more frequently the participants used the web-app, the more improvement in monetary loss due to presenteeism was shown. This suggests that the frequency of use could be an important indicator of effectiveness when conducting a web-app-based intervention for monetary loss due to presenteeism in persons with chronic neck pain. Previous research has pointed out the importance of making sustained behavioral changes by setting manageable goals in daily life in order to form healthy habits³²⁾. Frequent use of web-app may contribute to the formation of healthy habits by managing appropriate goals through chatting with a therapist. It is also

possible that the fact of being observed by the intervener through frequent use of the web-app may have triggered users to change their behavior (Hawthorne effect)³³⁾.

On the other hand, although the current study used the frequency of use as an indicator regarding the use of the web-app, past studies have found an association between the time spent using a smartphone and neck pain intensity³⁴⁾. Therefore, future studies should include not only the frequency of use, but also the effect of time spent using the web-app in terms of neck pain and monetary loss due to presenteeism.

To the best of our knowledge, this is the first study to reveal the factors for reducing monetary loss due to presenteeism among office workers who used a tailored healthcare web-app. This study suggests that changes in neck pain intensity and frequency of web-app use are important factors in this regard.

In the future research or development of web-based interventions, it may be important for therapists to provide feedback and coaching on goal setting via chat or other means to encourage more active use^{32,35)}. Besides, previous research has shown that during web-app intervention, users in pain are interested in forming a community with others experiencing the same distress, which may promote effective use³⁶⁾.

Limitations

This study included 86 participants out of 130 office workers who had chronic neck pain, meaning that almost 34% of the potential participants' data were not included in the statistical analytics. In addition, the number of users with chronic neck pain of the web-app in this study period was 281, but 151 stopped using it less than 12 weeks. Considering this background, the generalizability of this study may be limited. We compared the demographic data between participants who were included and excluded; as shown in Supplemental Table 2, statistical difference was not detected among the groups, so the risk of selection bias was presumably low. Second, this study focused only on the intensity of neck pain and the frequency of web-app use as factors that have an association with monetary loss. The intensity of back pain, headache, and asthenopia was obtained in addition to neck pain, but these variables could not be added to the adjustment variables due to the small number of subjects analyzed. Previous studies have found that presenteeism is associated with pain-related disability³⁷⁾, psychosocial factors³⁸⁾, and work-related factors³⁹⁾. In addition, in previous studies using web-based intervention, user engagement is also known to be a factor affecting outcomes⁴⁰⁾. Future research may need to include these indicators to clarify the relationship among monetary loss due to presenteeism, pain, and web-based intervention. Finally, because this study utilized secondary data, the content and amount of intervention provided by the web-app were not stan-

standardized in advance, and more rigorously designed prospective studies are needed to generalize the results.

Conclusion

In conclusion, our study suggests that improvement of neck pain intensity and frequency of web-app use are important factors concerning changes in monetary loss due to presenteeism in office workers with chronic neck pain.

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Author contributions

YO managed this study; NF collected the data; KS and TM analyzed the data; NM, NQ, YS, KM, MT checked sentence structure; TA was the director of this study.

Conflict of Interest

The co-author, Naoto Fukutani, is a board member of BackTech Inc. and owns more than 5% of the company's total shares. Naoto Fukutani was only involved in providing data on the results of the web-app users during 2019 and was not involved in any further process including subject selection and analysis. The other authors report no financial support or other benefits from commercial sources for the work reported in the manuscript, or any other financial interests that could create a potential conflict of interest.

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Supplemental Table 1. Spearman correlation coefficient (ρ) among changes in physical symptoms

	Δ Neck pain intensity	Δ Low-back pain intensity	Δ Headache intensity	Δ Asthenopia intensity
Δ Neck pain intensity	—			
Δ Low-back pain intensity	0.37**	—		
Δ Headache intensity	0.23*	0.10	—	
Δ Asthenopia intensity	0.48**	0.20	0.24*	—

* $p < 0.05$; ** $p < 0.01$

Supplemental Table 2. Baseline comparison with and without inclusion

	Group A	Group B	Group C	p -Value
Gender, Women	35 (40.7%)	13 (29.6%)	72 (47.7%)	0.09
Age, years	48.2 \pm 8.00	45.2 \pm 9.3	46.2 \pm 10.10	0.26
Body-mass index	22.96 \pm 3.16	23.20 \pm 3.15	22.43 \pm 4.24	0.44
Monetary loss, USD	1717.90 \pm 1736.55	1608.08 \pm 1451.83	1952.40 \pm 1595.65	0.35
Risk of depression score	1.64 \pm 1.53	1.51 \pm 1.41	1.74 \pm 1.65	0.73
Neck pain intensity	65.84 \pm 17.16	67.64 \pm 18.61	67.61 \pm 17.98	0.74
Low back pain intensity	33.80 \pm 26.03	40.00 \pm 27.06	34.15 \pm 25.98	0.41
Headache intensity	28.28 \pm 25.85	27.23 \pm 29.62	32.16 \pm 28.34	0.44
Asthenopia intensity	50.38 \pm 24.14	47.75 \pm 22.43	54.47 \pm 24.87	0.20

Group A, Included participants (N=86); Group B, Excluded by incomplete questionnaire (N=44); Group C, Excluded by less usage duration (N=151); To compare the three groups, Chi-square test for gender, and one-way ANOVA for other variables were used.