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Perceived usefulness, benefits, and needs of patient-generated health data among older adults after lung cancer surgery

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A B S T R A C T

This study explored the usefulness, benefits, disadvantages, and implementation needs of patient-generated health data (PGHD) among older adults after lung cancer surgery. Using a cross-sectional descriptive design, a self-administered survey was completed by 220 patients aged ≥ 65 years, and semi-structured interviews were held with 20 of them. Survey analysis identified lung function, blood pressure, and heart rate as the most useful PGHD parameters. Higher perceived usefulness was associated with younger age (65−74 years), higher income and education, fewer than three years since surgery, and greater digital literacy. Wrist-worn devices were the preferred data-collection modality. Qualitative content analysis revealed three themes: (1) benefits of PGHD for patients, healthcare providers, and family members; (2) disadvantages related to devices and data; and (3) PGHD-related needs concerning content and delivery platforms. Together, the findings indicate that older postoperative lung cancer patients value real-time physiological and activity data but face usability and trust barriers. Designing secure, user-friendly PGHD systems and providing tailored education and technical support are essential to maximize their benefits in postoperative care for this population.

Introduction

Lung cancer is the most frequently diagnosed cancer worldwide, with an estimated 2.5 million new cases in 2022, accounting for 12.4 % of all cancer diagnoses.[1] It also remains the leading cause of cancer-related mortality, responsible for about 1.8 million deaths (18.7 %) in the same year.[1] Although lung cancer was considered rare a century ago, it has become one of the most prevalent cancers worldwide. Surgical resection remains the primary treatment option with curative potential for patients with non-small cell lung cancer (NSCLC) .[2]

The incidence of lung cancer increases with age. In the United States, over 75 % of new NSCLC cases are diagnosed in adults aged 65 and older.[3] Similarly, in South Korea, data from the National Cancer Information Center in 2021 showed that approximately 70.5 % of patients diagnosed with lung cancer were 65 years or older.[4] As the older population is expected to continue growing, the burden of lung cancer in this demographic is also likely to increase, emphasizing the need for effective health management strategies for older patients.

Older patients often have lower tolerance to treatment than younger patients. They are at a higher risk of complications owing to comorbidities and age-related decline in physical function, leading to unexpected readmissions and prolonged recovery time,[5,6] which can negatively impact their quality of life.[7] Poor health status and reduced quality of life in older cancer patients are associated with a higher family caregiver burden, as caregivers provide comprehensive support, ranging from basic daily activities to emotional, social, and financial assistance.[8] Given the interdependent nature of the quality of life between patients and their family caregivers, where a higher caregiver burden can, in turn, affect patient care outcomes,[9] strategies to support older adults' postoperative health management and reduce caregiver burden are essential.

The use of patient-generated health data (PGHD) may offer a promising avenue for improving the postoperative care of older patients with lung cancer. The Office of the National Coordinator for Health Information (ONC) defined PGHD as "health-related data, such as activity level, symptoms, biometric data, and medication effects, created and recorded by or from patients outside of the clinical setting, through mobile applications, wearable devices, registered

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medical devices, or surveys and questionnaires, to help address a health concern" .[10] This definition highlights the fact that the primary responsibility for capturing or recording these data lies with the patients, not the providers and that patients manage to share or distribute the data to relevant stakeholders.

Various stakeholders, including patients, healthcare providers, researchers, and governments, envision a future in which PGHD plays a crucial role in healthcare.[10-12] For instance, in the United Kingdom, PGHD is considered a key component in enhancing care quality and reducing healthcare costs.[12] Similarly, in the United States, the incorporation of PGHD into healthcare practices has been planned to provide a comprehensive and continuous view of patients' health.[10] The use of PGHD has the potential to enable continuous and long-term tracking of various health-related metrics, which can be seamlessly shared between patients and healthcare providers.[13] These data can enhance the information traditionally collected by healthcare systems, providing personalized baseline indicators. Consequently, PGHD allows both patients and healthcare providers to promptly detect changes in health status, leading to timely and appropriate interventions.

Recognizing the utility of PGHD in managing patient health, several studies have applied PGHD to monitor and manage the health of older patients with cancer. For example, research involving older cancer survivors has been conducted using wearable devices to monitor step counts[14, 15] as well as tablet-based applications and connected devices to track physical activity, vital signs, and patient-reported symptoms.[16] Nevertheless, most studies have emphasized technical feasibility and aggregated outcomes.[14-16] Evidence remains relatively limited regarding how specific patient attributes, such as narrower age subgroups within later life, digital literacy, or time elapsed since surgery, influence the perceived usefulness of different PGHD categories. Data are also scarce on the benefits, disadvantages, and unmet needs that older adults associate with generating and sharing PGHD after lung cancer surgery. Because postoperative management for this group carries a high risk of complications and prolonged recovery, clarifying these perspectives is crucial for designing PGHD systems that genuinely support recovery and quality of life.

To address these gaps, this study explored the perceptions and needs related to PGHD and examined factors associated with its perceived usefulness among older patients who had undergone lung cancer surgery. Using self-reported surveys and semi-structured interviews, this study aimed to provide a comprehensive understanding of how older patients post-lung cancer surgery view the usefulness of PGHD in health management while examining their attitudes toward wearable devices and the challenges associated with their use.

The findings can contribute to advancing the field by providing foundational insights for the development of more effective and user-friendly PGHD systems for post-lung cancer surgery in older adults. It is anticipated that this study can inform healthcare providers and policymakers about the specific needs and preferences of this patient group, potentially leading to improved health outcomes and enhanced quality of life through tailored PGHD solutions.

Material and methods

Study design and participants

A cross-sectional descriptive design was used, which included a self-reported survey of 220 patients, and semi-structured and audio-recorded individual interviews with 20 patients. Patients who completed the survey and agreed to participate were interviewed. This approach provides a deeper understanding of the perceptions of PGHD among older patients who have undergone lung cancer surgery. Quantitative and qualitative data were collected using self-report questionnaires and interviews, respectively.

Participants were recruited between December 2023 and May 2024 when they visited the outpatient pulmonology clinic at a tertiary hospital in Seoul, South Korea. Participants included in the study were individuals aged 65 or older who had undergone lung resection, including lobectomy, bilobectomy, segmentectomy, or wedge resection and were diagnosed with lung cancer based on pathological examination. Individuals were excluded if they had not yet passed four weeks post-lung resection surgery or if they had been diagnosed with cognitive impairments such as dementia.

Eligible patients were identified, in collaboration with outpatient nurses, through a review of their electronic medical records. The study objectives and procedures were thoroughly explained to the patients, and screening questions were asked to confirm their eligibility and willingness to participate. Patients were informed that their participation was entirely voluntary and that they could withdraw from the study at any time without any repercussions on their treatment at the hospital. Data were collected in a quiet place at an outpatient clinic in the hospital.

Among the 301 eligible patients who provided study information, 225 (74.8 %) provided written informed consent. After excluding five patients who dropped out before answering >50 % of the questionnaire items, survey data from 220 patients were analyzed. The minimum required sample size was calculated with G*Power 3.1.9.7 for a one-way ANOVA with three groups, the largest number of category levels anticipated among the planned between-group comparisons, such as annual household income, employment status, number of prescribed medications taken daily, and drinking status. Because a three-group ANOVA requires more participants than two-group t-tests under the same statistical parameters, this approach provided the most conservative assessment. Assuming a medium effect size ($f = 0.25$), $\alpha = 0.05$, and 90 % power, at least 207 participants were needed; the achieved survey sample of 220 therefore met this requirement. Of the 220 patients, 20 agreed to participate in subsequent interviews.

Ethical considerations

This study was approved by the Institutional Review Board of Yonsei University (4–2023–1145). The study protocol was neither prospectively registered nor published a priori.

Quantitative data collection

A 37-item questionnaire was employed to assess patients' perceived usefulness of PGHD, scored on a 5-point Likert scale (1 = "not at all useful" to 5 = "very useful"). First, 38 items were identified through a literature review[11,17] and a white paper published by the Office of the National Coordinator for Health IT (ONC) in the United States.[10] Second, three Ph.D. experts in nursing informatics and three Ph.D. experts in geriatric health evaluated the content relevance of the items. The item-level content validity index (I-CVI), which is calculated as the proportion of evaluators who selected "appropriate" or "very appropriate" for each item, is considered acceptable if it is 0.78 or higher.[18] Out of the 38 items, 36 items had an I-CVI of 0.83 or higher, while two items had an I-CVI of 0.67. The scale-level CVI (S-CVI), calculated as the average I-CVI across all items, was 0.96, exceeding the 0.90 acceptability criterion.[18] Based on expert feedback, one additional item was added, and two items with an I-CVI of 0.67 were removed. Thirty-seven items were divided into six categories through research team discussions: physiological parameters (seven items reflecting bodily functions and vital signs), environmental items (five items encompassing external conditions), metabolic and nutritional items (five items related to metabolic processes and nutritional intake), activity levels and sleep (six items covering physical activity and rest), physical and psychological conditions (eight items reflecting physical and mental health conditions), and social and communication activities (six items focusing on social interactions and electronic communication).

Patients' willingness to use wearable digital devices for PGHD was evaluated. Participants rated their willingness to use each of the following 10 types of digital devices on a 5-point Likert scale, from 1 = "not at all willing" to 5 = "very willing": glasses, wristwatch, necklace, ring, armband, shoes, clothes, belt, skin patch, and implantable sensor.

Participants' demographics and health-related information were collected. Demographics included age, sex, living arrangement, annual household income, educational level, and employment status. Health-related information included the cancer stage at diagnosis, the period since cancer surgery, reoperation status, number of prescribed medications taken daily, drinking status, and regular exercise. Additionally, patients' digital literacy levels were assessed using the Everyday Digital Literacy Questionnaire (EDLQ) .[19] The EDLQ consists of 22 items rated on a 5-point Likert scale (1 = "strongly disagree" to 5 = "strongly agree"). The total score of the 22 items was calculated according to the scoring guidelines, with higher scores indicating greater digital literacy. The content validity and construct validity of the EDLQ have been reported, with good internal consistency (Cronbach's α = 0.98).[19]

Qualitative data collection

To explore perceptions of PGHD among older patients after lung cancer surgery, a semi-structured interview guide with open-ended questions was developed (Table 1). The sample questions were supplemented with follow-up prompts such as "Can you provide an example?" and "Please tell me more." Individual interviews ranged from 7.67 to 39.93 min in length, with an average duration of 17.83 min (standard deviation = 7.25 min).

Data analysis

Quantitative data

Descriptive statistics such as mean, standard deviation (SD), frequency, and percentage were used. To evaluate differences in patients' PGHD perceptions based on their personal characteristics, independent-sample *t*-tests and one-way ANOVAs were performed. When the ANOVA results were significant, post-hoc comparisons were conducted using the least significant difference (LSD) method.

Qualitative data

Content analysis was performed using the approach recommended by Graneheim and Lundman (2004): (1) transcribe the interviews promptly after they are conducted, (2) read the text thoroughly to understand the overall context, (3) identify meaning units and initial codes, (4) group similar initial codes into categories, and (5) reveal the underlying content within the data.

The digital audio files of the interviews, labeled with participant ID numbers, were professionally transcribed verbatim immediately after each interview. Incidental identifiers such as the names of individuals or locations were removed from the transcripts as the recordings were checked for accuracy. The transcripts were read several times to gain a comprehensive understanding of the content, and specific words or sentences that appeared to capture essential ideas or concepts were highlighted. Following this, categories representing multiple key ideas were created through constant comparison. As more transcripts were reviewed, the categories were continuously refined and evolved. The identified categories were then compared and interpreted to organize them into domains and themes.

Credibility was established by conducting debriefings with research team members to explore potential categories and themes, and by adhering to the content analysis approach. Raw data, initial codes, and categories were retained for auditing purposes to ensure dependability. Transferability was achieved by providing detailed information on research procedures and patient characteristics. For confirmation, the results were supported by patient responses.

Table 1
Semi-structured interview guide.

- How do you think PGHD can be beneficial to you?
- How do you think PGHD can assist your healthcare providers in managing your health?
- How do you think PGHD can be helpful to your family?
- What are your expectations and concerns about using PGHD with healthcare providers or researchers?
- Based on the collected PGHD, what information would you like to receive from healthcare providers or researchers?
- Through which platform would you prefer to receive information related to PGHD?
- Have you ever used a wearable device before?
  - If yes, what did you like and dislike about using it?
  - If no, is there a particular reason why you haven't used one?

Results

Quantitative results

The average age of the participants was 71.7 years (SD = 5.1). The sex distribution was as follows: 50.5 % male and 49.5 % female. Most participants lived with others (87.7 %) and were previously employed but not currently employed (63.2 %). Approximately 56 % had at least a high school education. >80 % of the patients were diagnosed with stage 1 cancer (83.2 %) and had no reoperation (86.8 %). More than half of the patients had undergone cancer surgery less than three years ago (57.3 %).

Among the 37 PGHD items, lung function had the highest perceived usefulness (mean = 4.70, SD = 0.91), followed by blood pressure (mean = 4.52, SD = 1.13), heart rate (mean = 4.40, SD = 1.20), step count (mean = 4.40, SD = 1.24), and blood glucose level (mean = 4.36, SD = 1.33) (Table 2). The physiological parameters category had the highest overall score (mean = 4.38, SD = 0.95). The lowest perceived usefulness was for the number of home visitors (mean = 2.42, SD = 1.64), followed by social media use (mean = 2.90, SD = 1.73), and internet usage time (mean = 2.61, SD = 1.72). The category with the lowest average score was social and communication activities (mean = 2.98, SD = 1.25).

The most preferred wearable device was the wristwatch (mean = 3.64, SD = 1.74), whereas the least preferred device was the implantable sensor (mean = 1.38, SD = 1.05; Table 3).

Table 4 presents the differences in perceptions of PGHD according to the patients' personal characteristics. Patients aged 65−74 had significantly higher mean scores across all PGHD categories compared to those aged 75 and older. Patients living with others had significantly higher mean scores in the environmental items category than those living alone (t = 2.12, p = 0.04). Higher annual household income was associated with a higher perceived usefulness of PGHD, with significant differences observed in all categories except physiological parameters. Those with at least a high school education had significantly higher scores in all PGHD categories except physical and psychological condition, than those with a middle school education or less. The currently employed participants had significantly higher scores on social and communication activities than those who were previously or never employed (F = 5.06, p = 0.01). Patients who had undergone surgery less than three years ago had significantly higher

Table 2
Perceived usefulness of patient-generated health data (n = 220).

Category (Mean ± SD)	Data	Mean	SD
Physiological Parameters (4.38 ± 0.95)	Lung Function	4.70	0.91
	Blood Pressure	4.52	1.13
	Heart Rate	4.40	1.20
	Blood Glucose	4.36	1.33
	Body Temperature	4.25	1.35
	Oxygen Saturation	4.21	1.38
	Electrocardiogram (ECG)	4.20	1.41
Activity Levels and Sleep (4.15 ± 1.08)	Step Count	4.40	1.24
	Sleep Quality	4.27	1.38
	Physical Activity Level	4.25	1.33
	Sleep Duration	4.08	1.52
	Gait Information	4.06	1.47
	Sitting Time	3.84	1.52
Metabolic and Nutritional Items (3.87 ± 1.23)	Body Fat Percentage	4.07	1.44
	Daily Water Intake	3.94	1.51
	Body Weight	3.92	1.53
	Calorie Expenditure	3.87	1.50
	Meal Intake	3.57	1.64
Physical and Psychological Condition (3.78 ± 1.22)	Physical Symptoms	4.13	1.47
	Psychological Symptoms	3.99	1.56
	Medication Side Effects	3.91	1.61
	Electrodermal Activity (e.g., Stress level)	3.86	1.62
	Photos (Wounds, Skin Cancer)	3.80	1.65
	Medication Adherence	3.80	1.67
	Mood	3.71	1.63
	Inhaler Use	3.01	1.82
Environmental Items (3.64 ± 1.35)	Ambient Air Quality	4.18	1.46
	Ambient Temperature	3.75	1.65
	Ambient Noise	3.67	1.69
	Ambient Light	3.60	1.71
	Global Positioning System (GPS)/Location	3.00	1.76
Social and Communication Activities (2.98 ± 1.25)	Time Spent Outdoors	3.67	1.65
	Social Symptoms	3.18	1.78
	Electronic Communication Activities	3.10	1.77
	Social Media Use	2.90	1.73
	Internet Usage Time	2.61	1.72
	Number of Home Visitors	2.42	1.64

Note. SD, Standard Deviation.

scores in physiological parameters (t = 1.98, p = 0.049), environmental items (t = 2.06, p = 0.04), and physical and psychological condition (t = 2.16, p = 0.03) compared to those who had surgery three or more years ago. The metabolic and nutritional items category was perceived as more useful by patients who were not taking any prescribed medications daily than by those taking three or more medications (F = 3.78, p = 0.02). Patients' digital literacy levels were significantly related to the perceived usefulness of PGHD in all categories. Participants with higher digital literacy (a score above 75) scored significantly higher on all factors than those with lower digital literacy (a score of 74 or less).

Qualitative results

The average age of the 20 interviewed participants was 69.1 years (SD = 3.0), ranging from 65 to 77 years. There were an equal number of female and male participants (n = 10 each). Most participants lived with others (90 %, n = 18) and were previously employed but not currently (55 %, n = 11), whereas 40 % (n = 8) were currently employed. Sixteen participants (80 %) had at least a high school education. The majority of patients were diagnosed with stage 1 cancer (90 %, n = 18), and 60 % (n = 12) had undergone surgery more than three years ago.

The individual interviews revealed three major themes: (1) Perceived benefits of using PGHD, (2) Perceived disadvantages of using PGHD, and (3) Needs for using PGHD (Table 5).

Table 3
Wearable devices preference (n = 220).

Wearable devices	Mean	SD
Wristwatch	3.64	1.74
Shoes	3.40	1.80
Skin Patch	2.54	1.80
Belt	2.53	1.74
Glasses	2.40	1.76
Clothes	2.38	1.71
Ring	2.12	1.63
Necklace	2.08	1.57
Armband	2.00	1.53
Implantable Sensor	1.38	1.05

Note. SD, Standard Deviation.

Theme 1. Perceived benefits of using PGHD

Participants identified the benefits of using the PGHD, which were categorized into three domains: patient, healthcare provider, and family.

In the **patient** domain, self-monitoring of one's health status has been reported to be beneficial. Participants appreciated the ability to track their health metrics such as blood glucose levels and blood pressure. The use of PGHD was also seen as a helpful tool for enhancing healthcare, as it provided information that could assist in treatment plans. Participants also perceived that PGHD could serve as a motivator for adopting a healthier lifestyle as they could see the effects of their actions, such as exercise, on their health metrics.

In the **healthcare provider** domain, sharing information about health status has been reported to be beneficial. Participants noted that having accurate and comprehensive health data readily available would facilitate personalized care and informed clinical decision-making. They expected comprehensive data to allow healthcare providers to make better treatment adjustments and offer improved care.

In the **family** domain, patients reported family members' involvement in and commitment to healthcare as the benefits of using PGHD. Patient-generated health data can encourage family members to engage in shared health goals and behaviors, thereby fostering a supportive environment for a healthier lifestyle. The patients also noted that their use of PGHD would alert family members about their own healthcare. Participants believed that their collected data could encourage family members to adopt similar health-monitoring practices and become more cautious about their own health, such as reducing food intake and exercising more.

Theme 2. Perceived disadvantages of using PGHD

Participants reported the disadvantages using the PGHD, which were categorized into two main domains: device and data.

In the **device** domain, physical discomfort was an issue, particularly with wearable devices. A lack of knowledge and technical support were also reported as barriers, particularly for older participants who struggled with new technologies and lacked adequate support to use them effectively.

In the **data** domain, the patients noted threats to data security as a concern. Participants were worried about the potential for their health data to be leaked to unauthorized individuals. Concerns regarding the accuracy and trustworthiness of the PGHD have also been reported, with some participants questioning whether the data collected using these devices match the accuracy of traditional medical assessments. Patients also expressed that the control and burden of additional data inputs were disadvantages. Participants felt that the need for regular data input was burdensome and stressful, detracting from the convenience of using PGHD.

Table 4
Differences in perceptions on patient-generated health data by patients' personal characteristics (*N* = 220).

Variables (n, %)	Physiological Parameters		Environmental Items		Metabolic and Nutritional Items		Activity Levels and Sleep		Physical and Psychological Condition		Social and Communication Activities	
	Mean ± SD	**t/F (*p*)**	**Mean ± SD**	**t/F (*p*)**	**Mean ± SD**	**t/F (*p*)**	**Mean ± SD**	**t/F (*p*)**	**Mean ± SD**	**t/F (*p*)**	**Mean ± SD**	**t/F (*p*)**
Age in years (71.70 ± 5.14)												
65−74 (160, 72.7)	4.5 ± 0.9	2.53 (<**0.01**)	3.8 ± 1.3	2.61 (**0.01**)	4.1 ± 1.1	4.47 (<**0.01**)	4.3 ± 1.0	3.04 (<**0.01**)	3.9 ± 1.2	2.62 (<0.**01**)	3.1 ± 1.2	3.11 (<**0.01**)
≥75 (60, 27.3)	4.1 ± 1.1		3.2 ± 1.5		3.3 ± 1.3		3.8 ± 1.3		3.4 ± 1.3		2.6 ± 1.2	
Sex												
Male (111, 50.5)	4.4 ± 0.9	0.35 (0.73)	3.7 ± 1.4	0.55 (0.58)	3.8 ± 1.3	-1.30 (0.20)	4.2 ± 1.0	0.54 (0.59)	3.7 ± 1.2	-0.65 (0.52)	3.0 ± 1.3	0.67 (0.50)
Female (109, 49.5)	4.4 ± 1.0		3.6 ± 1.3		4.0 ± 1.2		4.1 ± 1.1		3.8 ± 1.2		2.9 ± 1.3	
Living arrangement												
Living with others (193, 87.7)	4.4 ± 0.9	0.91 (0.36)	3.7 ± 1.3	2.12 (**0.04**)	3.9 ± 1.2	0.43 (0.67)	4.2 ± 1.1	1.31 (0.19)	3.8 ± 1.2	1.01 (0.32)	3.0 ± 1.3	1.45 (0.15)
Living alone (27, 12.3)	4.2 ± 1.1		3.2 ± 1.5		3.8 ± 1.3		3.9 ± 1.3		3.6 ± 1.3		2.7 ± 1.2	
Annual household income (10 thousand won/year)												
<1000 (51, 23.6) a	4.2 ± 1.3	2.79 (0.06)	3.3 ± 1.5	**4.76 (0.01) *a* < *c***	3.7 ± 1.4	**4.42 (0.01) *a* < *c***	3.9 ± 1.2	**6.08 (<0.01) *a* < *b* < *c***	3.4 ± 1.4	**5.91 (<0.01) *a* < *b* < *c***	2.6 ± 1.2	**6.29 (<0.01) *a* < *b* < *c***
≥1000, <3000 (73, 33.8) b	4.3 ± 0.9		3.6 ± 1.4		3.7 ± 1.3		4.0 ± 1.1		3.7 ± 1.2		2.8 ± 1.2	
≥3000 (92, 42.6) c	4.5 ± 0.8		3.9 ± 1.2		4.2 ± 1.1		4.4 ± 0.9		4.1 ± 1.1		3.3 ± 1.2	
Educational level												
≤ Middle school (96, 43.6)	4.1 ± 1.1	-4.10 (<**0.01**)	3.4 ± 1.5	-2.64 (<0.**01**)	3.7 ± 1.3	-2.13 (**0.03**)	3.9 ± 1.3	-2.89 (<**0.01**)	3.6 ± 1.3	-1.88 (0.06)	2.6 ± 1.2	-4.43 (<**0.01**)
≥ High school (124, 56.4)	4.6 ± 0.7		3.9 ± 1.2		4.0 ± 1.2		4.3 ± 0.9		3.9 ± 1.1		3.3 ± 1.2	
Employment status												
Currently employed (62, 28.2) a	4.5 ± 0.7	1.52 (0.22)	3.9 ± 1.3	1.49 (0.23)	4.2 ± 1.0	2.89 (0.06)	4.4 ± 0.7	1.97 (0.14)	3.9 ± 1.1	0.76 (0.47)	3.4 ± 1.2	**5.06 (0.01) b,c < *a***
Previously employed but not currently (139, 63.2) b	4.3 ± 1.0		3.5 ± 1.4		3.7 ± 1.3		4.1 ± 1.2		3.8 ± 1.3		2.9 ± 1.3	
Never employed (19, 8.6) c	4.2 ± 1.1		3.7 ± 1.2		3.8 ± 1.3		4.0 ± 1.1		3.5 ± 1.3		2.4 ± 1.2	
Cancer stage at diagnosis												
1 (183, 83.2)	4.4 ± 0.9	0.51 (0.61)	3.6 ± 1.4	0.22 (0.83)	3.9 ± 1.2	1.28 (0.20)	4.2 ± 1.1	1.38 (0.17)	3.8 ± 1.2	1.16 (0.25)	3.0 ± 1.3	1.24 (0.22)
2 or 3 (37, 16.8)	4.3 ± 1.0		3.6 ± 1.2		3.6 ± 1.1		3.9 ± 1.0		3.6 ± 1.2		2.8 ± 1.2	
Period from cancer surgery in years												
<3 (126, 57.3)	4.5 ± 0.9	1.98 (**0.049**)	3.8 ± 1.3	2.06 (**0.04**)	4.0 ± 1.2	1.80 (0.07)	4.3 ± 1.1	1.53 (0.13)	3.9 ± 1.2	2.16 (**0.03**)	3.1 ± 1.3	1.53 (0.13)
≥ 3 (94, 42.7)	4.2 ± 1.0		3.4 ± 1.4		3.7 ± 1.3		4.0 ± 1.1		3.6 ± 1.3		2.8 ± 1.2	
Reoperation status												
No (191, 86.8)	4.4 ± 0.9	0.20 (0.84)	3.6 ± 1.3	-0.01 (0.99)	3.9 ± 1.2	-0.04 (0.97)	4.2 ± 1.1	-0.03 (0.98)	3.8 ± 1.2	0.92 (0.36)	3.0 ± 1.3	1.05 (0.29)
Yes (29, 13.2)	4.3 ± 1.1		3.6 ± 1.4		3.9 ± 1.2		4.2 ± 1.0		3.6 ± 1.3		2.8 ± 1.1	
Number of prescribed medications taken daily												
0 (40, 18.3 %) a	4.6 ± 0.6	1.71 (0.18)	4.0 ± 1.3	2.45 (0.09)	4.2 ± 1.0	**3.78 (0.02) *c* < *a***	4.5 ± 0.8	2.63 (0.08)	3.9 ± 1.2	0.33 (0.72)	3.1 ± 1.3	2.30 (0.10)
1−3 (100, 45.7 %) b	4.3 ± 1.0		3.6 ± 1.4		4.0 ± 1.2		4.1 ± 1.1		3.7 ± 1.2		3.1 ± 1.3	
≥ 3 (79, 35.9 %) c	4.4 ± 1.0		3.5 ± 1.4		3.6 ± 1.3		4.0 ± 1.2		3.8 ± 1.2		2.8 ± 1.2	
Drinking status												
Currently drinking (48, 21.8)	4.3 ± 0.8	0.10 (0.91)	3.5 ± 1.3	0.16 (0.85)	3.8 ± 1.2	0.25 (0.78)	4.2 ± 1.0	0.16 (0.85)	3.7 ± 1.3	0.23 (0.79)	3.1 ± 1.2	0.23 (0.80)
Former drinker (76, 34.5)	4.4 ± 1.0		3.7 ± 1.4		3.9 ± 1.3		4.1 ± 1.2		3.8 ± 1.3		3.0 ± 1.4	
Never drinker (96, 43.6)	4.5 ± 0.9		3.7 ± 1.3		3.9 ± 1.2		4.1 ± 1.0		3.8 ± 1.1		2.9 ± 1.2	
Regular exercise												
Yes (202, 91.8)	4.4 ± 0.9	0.13 (0.89)	3.7 ± 1.3	1.22 (0.22)	3.9 ± 1.2	0.91 (0.37)	4.2 ± 1.1	0.84 (0.40)	3.8 ± 1.2	0.20 (0.84)	3.0 ± 1.2	1.21 (0.23)
No (18, 8.2 %)	4.4 ± 1.1		3.3 ± 1.4		3.6 ± 1.3		3.9 ± 1.0		3.7 ± 1.1		2.6 ± 1.4	
Digital literacy												
≤ 74 (114, 51.8)	4.1 ± 1.1	-4.00 (<**0.01**)	3.4 ± 1.4	-3.32 (<**0.01**)	3.7 ± 1.4	-2.82 (<**0.01**)	3.8 ± 1.3	-5.40 (<**0.01**)	3.6 ± 1.3	-2.29 (**0.02**)	2.5 ± 1.2	-6.43 (<**0.01**)
> 75 (106, 48.2)	4.6 ± 0.6		3.9 ± 1.2		4.1 ± 1.0		4.5 ± 0.7		4.0 ± 1.1		3.5 ± 1.1	

Note. SD, Standard Deviation; When the findings of ANOVA models were significant, the least significant difference post hoc comparisons were conducted.

Table 5
Patients' perceptions on patient-generated health data: qualitative findings.

Themes	Domain	Categories	Example quotes
Perceived benefits of using PGHD	**Patient**	Self-monitoring for health status	"As I get older, it's good to be able to check my health, like monitoring my blood sugar levels. My fasting blood sugar is currently at 109. Something like that... I can also check my post-meal blood sugar levels." – Participant 3
		Help with health care	"Since I have hypertension and diabetes, it will definitely help in my treatment." – Participant 13
		Increased motivation and behavior change for healthy lifestyle	"[If PGHD is being collected] I could see the effects of my exercise to some extent, so I think it would be helpful to know if I need to increase my exercise or change the way I exercise." – Participant 4
	Healthcare provider	Sharing information for health status	"I do measure [my blood pressure] at home, but I often forget to record it. The next day, I check the blood pressure device to see the previous readings and write them down. If this information could be tracked and automatically stored, meaning the blood pressure is measured and recorded, I could easily show these records to the healthcare providers during my hospital visits." – Participant 8
		Personalized care and informed clinical decision-making	"I need to show this information [collected PGHD] to the healthcare providers. That way, I can receive prescriptions or treatments related to it."– Participant 7
	Family	Involvement and commitment to health care	"[My family] could join me for exercise or suggest not eating certain foods if I start to eat them mindlessly."– Participant 16 "[Based on the collected data] It would provide an opportunity for the discussions and for us to think about our health together." – Participant 20
		Providing alerts to their own health care	"My children, seeing my collected data, would realize how well I'm doing. It might encourage them to use similar devices and become more cautious about their own health, such as reducing food intake and exercising more." – Participant 11
Perceived disadvantages of using PGHD	**Device**	Physical discomfort in using wearable devices	"But, If I had to wear [watch] for 24 h, I think it would be uncomfortable."– Participant 15 "[I don't use the device] because it gets in the way while I am working."– Participant 10
		Lack of knowledge and technical support	"... New things are not as easy for me as they are for younger people. I can't really ask anyone how to use them, which makes it difficult. Also, when I use a device, it tends to break. When that happens, I end up putting it in a drawer at home and not using it anymore."– Participant 1
	Data	Threats to data security	"I'm afraid that [the collected data] might leak to other people besides me and the healthcare providers."– Participant 5
		Concerns regarding data accuracy and trustworthiness	"These days, there are a lot of health-related things on smartphones. But then I wonder, is it really the same as going to the hospital and having doctors check it?"– Participant 1
		Control and burden of additional data input	"[For collecting PGHD] I don't like it when someone keeps pressuring and bothering me. When they keep telling me to do something. ...So, it's fine if I can do it on my own, but it's irritating if they keep trying to control me."– Participant 3 "[For health management] it seems helpful, but there might be quite a lot of information I need to input..."– Participant 20
Needs for using PGHD	**Contents**	Advice and feedback on lifestyle	"Overall, It would be great to receive advice on checking health status, identifying any issues, suggesting areas for improvement, and possible future diseases." – Participant 6 ".... My lifestyle patterns, such as sleep and walking, might be off. If I receive coaching on how to improve these areas, it could be an opportunity for me to lead a healthier life."– Participant 20
		Judgment and alert of health threats	"[The PGHD results] show that there are some areas of concern regarding my current health status, indicating that I should visit a hospital."– Participant 1 "If there is a sudden significant change in my heart rate, it would be good to receive a message advising me to get it checked because it's different from the usual, suggesting that I should have a medical examination."– Participant 16
		Features for medication reminders	"I sometimes forget to take my diabetes medication and eat first, even though it's a pre-meal medication. Reminders to take my medication on time... [would be helpful]."– Participant 15
	Platform	Convenient format that is familiar and easy to use	"KakaoTalk is fine, and if there's an application, using that would be okay too. It's because I can see it immediately." – Participant 4 "KakaoTalk or text messages. Because I'm familiar with them." – Participant 16

Note. PGHD, patient-generated health data; KakaoTalk is an app that offers features such as one-on-one or group messaging, shopping, banking, and more.

Theme 3. Needs for using PGHD

Participants identified the needs to effectively use PGHD, which was categorized into two domains: contents and platform.

In the **contents** domain, there was a desire for advice and feedback on lifestyle improvements based on PGHD. Participants expressed the need for guidance on interpreting their PGHD, identifying issues, and improving their lifestyles. Participants also reported receiving timely alerts about potential health threats and reminders for medication adherence, which were crucial for effective health management.

When asked about their preferred **platform** for receiving information related to PGHD, participants reported that convenience and familiarity were essential. The participants noted a preference for platforms that could integrate with mobile applications they were already familiar with, such as messaging apps.

Discussion

The findings of this study add to the limited body of literature on perceptions of PGHD among older patients who have undergone lung cancer surgery, employing both self-reported surveys and individual interviews. This comprehensive approach provides valuable insights into how patients perceive the usefulness of PGHD in managing their health. These findings emphasize the potential of PGHD to enhance health management in post-surgery older adults, while also identifying areas that require attention to maximize its effectiveness and acceptance.

Among the various PGHD items, lung function, blood pressure, heart rate, and step count were perceived as the most useful. Lung function, blood pressure, and heart rate fall under the physiological parameters category which scored the highest. Step count falls under the activity levels and sleep category, which had the second-highest average score. Physiological signs such as lung function, blood pressure, and heart rate provide critical, real-time insights into patients' immediate health status,[20] which is important for managing conditions such as lung cancer. These findings suggest that patients value data that directly reflects their physiological status and can be used to make timely healthcare decisions. Additionally, the high perceived usefulness of step count indicates the importance that patients place on monitoring their physical activity, which is crucial for postoperative recovery and overall health maintenance among lung cancer patients.[21] A previous study on older cancer surgery patients found that lower post-surgery step counts were significantly associated with higher rates of post-discharge complications and hospital readmissions, highlighting the critical role of step-count monitoring for early issue detection and the need for effective tele-monitoring systems.[16]

Wrist-worn devices were identified as the most preferred type of wearable device for collecting PGHD because of their ease of use, comfort, and ability to monitor collected data continuously without disrupting daily activities.[22] This finding aligns with that of a previous study on older adult populations, where participants considered wrist-worn sensors to be the most practical and convenient, making them suitable for extended use.[23] Conversely, implantable sensors received the lowest preference scores, likely owing to concerns about invasiveness and discomfort, which is similar to the findings of a previous study reporting patients' reluctance to use implantable biomedical device.[24] These findings provide an important foundation for developing strategies to enhance the acceptance and effectiveness of PGHD systems in older patients.

A previous review identified users' unperceived usefulness as a major barrier to PGHD generation, whereas perceived usefulness and relevance were facilitators.[25] Therefore, to develop effective strategies to enhance PGHD use among older patients undergoing lung cancer surgery, it is crucial to thoroughly examine the factors associated with patient perceptions of PGHD. In the present study, patients aged 65−74 years demonstrated higher mean perceived usefulness scores across all PGHD categories than those aged 75 years or older. Younger patients may be more familiar with technology and digital health tools[26] and more confident in learning new processes,[27] which can enhance their perceptions of usefulness. A recent study reported that younger older adults are more likely to use information and communication technologies (ICTs) than those who are older.[26]

Patients with a higher income had higher mean scores for perceived usefulness across all PGHD categories except for physiological parameters. This may be because financial stability can provide better access to healthcare resources, technology, and support systems,[28] which can enhance their ability to use PGHD effectively. Patients with at least a high school education had higher mean scores for perceived usefulness in all categories except for physical and psychological conditions. Individuals with higher educational attainment may have greater health literacy, enabling them to better understand and utilize health-related information and services,[29] which can make PGHD more useful. Additionally, patients with higher digital literacy had higher mean scores of perceived usefulness across all PGHD categories. They may be able to navigate and interpret PGHD more effectively, indicating that technological comfort plays a crucial role in the perceived value of PGHD.

These findings suggest several strategies for enhancing the effectiveness and acceptance of PGHD systems. Tailoring PGHD collection systems to be more user-friendly and accessible for older adults, particularly those aged 75 years and older, could improve their engagement and perceived usefulness. This may include simpler interfaces, larger text, and better support resources.[27] Furthermore, making PGHD collection systems more affordable and providing targeted education and training to enhance health literacy and digital skills for individuals with lower income and education levels could bridge the gap in perceived usefulness. Enhancing digital literacy, specifically for older patients, through specialized training programs and ongoing technical support could further increase the perceived usefulness of PGHD.

In this study, patients anticipated that PGHD would help them monitor their health status and motivate them to adopt healthier behaviors. Additionally, patients expressed a desire for advice and feedback on lifestyle improvements, timely alerts about potential health threats, and features for medication reminders. Similarly, for PGHD to effectively motivate behavioral changes, active participation from users is required, meaning that they need to engage in data collection actively rather than passively.[25] However, the study participants also noted the control and burden of additional data input as a disadvantage. A previous systematic review indicated that passive technology focusing only on data collection can hinder user engagement and acceptance.[30] User engagement and interaction are critical factors in the acceptance of PGHD technologies,[30] and this could be particularly true for older adults who might find technology adoption more challenging. These findings indicate that to effectively utilize PGHD in the postoperative health management of older patients, it is important to develop PGHD types and data collection methods that reduce the burden on users while still motivating behavioral changes.

According to the findings of this study, patients expected PGHD to enable personalized care and informed clinical decision-making by providing accurate and comprehensive health data. Patient-generated health data have been perceived as a way to supplement information collected during clinical visits by capturing rich details about patients' daily activities, lifestyles, and environments.[17] Systems that capture PGHD can serve as effective tools for healthcare providers to gain a deeper understanding of their patients, thus strengthening the patient-provider relationship, improving patient safety, and enhancing access to patient-related information.[31] However, a recent review reported that the incorporation of PGHD into electronic records was very restricted, and decision-support capabilities were mostly elementary.[17]

Integrating PGHD into routine practice may require policies and guidelines that accommodate various data types and scenarios.[17] Establishing standards for data tracking methods and addressing privacy concerns are essential steps, particularly considering that threats to data security were among the concerns mentioned by our study participants. Additionally, concerns about data accuracy and trustworthiness were perceived as disadvantages of using PGHD in the present study, consistent with previous research that has identified these issues as barriers to PGHD adoption.[25] Similarly, consumer-grade personal devices, which are affordable for widespread use, have sometimes been reported to have issues with accuracy and precision.[32] To address these challenges, reliable and secure PGHD systems must be developed. These measures will ensure that PGHD can be effectively and securely integrated into clinical workflows, ultimately benefiting patients, healthcare providers, and families.

Study limitations and recommendations

This study contributes to the growing body of literature on PGHD and offers practical recommendations for improving the design and implementation of PGHD systems in healthcare settings. However, this study has some limitations. First, the patients were recruited from a single hospital, which limits the generalizability of the findings. Second, the survey was self-reported, which may have introduced response and social desirability biases, as participants might have answered the questionnaire in a manner that they believed would be viewed favorably by the research team. Third, the convenience sampling method resulted in a lack of diversity among the 20 interview participants, who were slightly younger, more educated, and more likely to be employed than the 220 survey participants. Future research should include a more diverse sample to gain a broader understanding of the perceptions of PGHD. Future studies should explore additional factors that may influence the adoption and effectiveness of PGHD.

Conclusion

This study provides valuable insights into the perceptions of PGHD among older patients who have undergone lung cancer surgery, highlighting the usefulness and challenges of PGHD in health management. The quantitative findings indicated that lung function, blood pressure, and heart rate were the most useful parameters for PGHD. Wrist-worn devices were identified as the preferred type of wearable device for collecting PGHD. Personal factors such as younger age, higher household income, higher education level, shorter time since surgery, and higher digital literacy were associated with a higher perceived usefulness of PGHD. The interview data revealed three main themes: perceived benefits of using PGHD, perceived disadvantages of using PGHD, and the need for using PGHD. The findings highlight the importance of considering patient demographics and digital literacy when designing such a system. User-friendly, secure, and supportive PGHD systems are essential to maximize their potential benefits in the healthcare management of older patients.

Declaration of conflicting interest

The authors declare that there are no conflicts of interest.

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Data availability

The data that support the findings of this study are available on request from the corresponding author upon reasonable request.

Ethical considerations

The study received approval from the Institutional Review Board of Yonsei University Health System in Seoul, South Korea (IRB no 4−2023−1145).

Declaration of competing interest

None.

CRediT authorship contribution statement

Hyeonmi Cho: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation. **Yesol Kim:** Writing – review & editing, Methodology, Formal analysis, Data curation, Conceptualization. **Byung Jo Park:** Writing – review & editing, Investigation, Conceptualization. **Mona Choi:** Writing – review & editing, Writing – original draft, Supervision, Resources, Methodology, Investigation, Formal analysis, Conceptualization.

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