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Failure mode and effects analysis of telehealth service of minority elderly for sustainable digital transformation

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ABSTRACT

Background: Telehealth services are time- and cost-saving solutions for disease management for older adults. Minority older individuals with multiple risk factors have an increasing demand for telehealth services. There are insufficient data on patient safety in telehealth services. This study aimed to enhance the quality of telehealth services by reducing errors and creating a safe user environment for low-income older adults. Failure mode and effects analysis tool (FMEA) was adopted to manage potential risks for sustainable digital transformation.
Method: An eight-member multidisciplinary team conducted telehealth FMEA to determine risk priority numbers (RPNs). The process included identifying the potential cause and effect failure mode of each step; measuring severity, probability, and detectability scores for RPNs; and generating strategies to decrease potential failures.
Results: This study identified 24 risk factors and 34 causes in four major phases with a mean RPN of 90.7: preparation to measure biosignals, measurement of biosignals following instructions from a personal device, confirmation of measurement results, and intervention based on disease or condition type. Risk prioritization revealed four high failure modes and a total RPN of 362.7. Based on fundamental causes, risks were categorized as oblivescence, economic issues, and technology literacy.
Conclusions: To correct these failure modes, stabilization of the platform, adding to the providers' manpower, and support for government policies are recommended. FMEA identifies and evaluates the potential risks of telehealth services. The selected priorities reduce the clinical risks of low-income elders who use telehealth services by weighting clinical actions.

1. Introduction

In 2021, the United Nations announced the Sustainable Development Goal to ensure healthy lives and promote well-being for people of all ages. This can be achieved through telehealth services. Even though minority older adults have many risk factors, it is difficult to find an analysis of the patient safety aspects of telehealth services. The first step in this study was to identify the failure modes followed by the telehealth process using the failure mode and effects analysis (FMEA) method to manage risk factors. This study describes patient safety issues of telehealth for minority older adults.

Owing to the coronavirus disease 2019 (COVID-19) pandemic, the world has moved beyond primary interventions and must include health strategies to stop the spread of the virus. Therefore, a social support system is necessary to connect medical systems to people's physical, psychological, and social lives [1]. Telemedicine can serve as an essential aspect of medical care across all populations in this situation by saving time and cost. It is especially important to manage the health of older adults [2]. Despite the convenience of telehealth, problems arise when patients use unfamiliar equipment and protocols to access telehealth services [3] because telehealth devices are particularly reliant on information technology (IT), which older adults are not familiar with. Other technical errors and adverse events may also constitute the disadvantages of [4].

Low-income older adults can have greater difficulties in using telehealth because of relatively low levels of health conditions, economic problems, and no one to help them use the device [5]. It is connected to their higher rates of hospitalizations or emergency department visits than those of the usual care group [6]. Therefore, to protect these minority older adults, many countries have increased concerns about the pandemic. To prepare for future pandemics, it is necessary to have solutions and concerns to detect and solve the problems that may occur

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before providing telemedicine services for minority older adults.

The knowledge of these telehealth risks for minority older adults is limited. The only previous study on middle-aged and older adults using the FMEA method reported the usage of Internet drug-purchasing services partially with systematic human error reduction and prediction approaches, and not telehealth. According to a review of telehealth, to determine whether these issues are problematic, it is necessary to understand the real experiences of those who provide telehealth services [7]. The studies focus on factors derived from indirect evidence and outcomes rather than direct evidence related to patient safety [8]. It is difficult to find information concerning the role of healthcare professionals at each stage of telehealth service provision [7]. As few experimental studies exist, more careful consideration is necessary for telehealth among older adults.

Basic biomonitoring, a frequently used telehealth service, is fundamental to understanding patient conditions [9]. Thus, in this study, the expert team aimed to identify the risk factors of telehealth services, including biomonitoring using FMEA. The FMEA method, as a measure to improve patient safety, is a powerful tool that facilitates the prevention of future errors based on past events. This enabled us to prioritize potential failure modes and modify processes to resolve potential problems [10]. Another tool for patient safety, root cause analysis (RCA), differs by identifying errors in events that have already occurred [11].

This study makes a novel contribution to the literature by analyzing aspects of patient safety related to telehealth services for minority older adults using RPNs. The study results will be useful not only for risk prevention and performance with system improvements but also for establishing coherent guidelines for service providers [12].

This study aimed to identify potential problems prior to an event using the FMEA method for minority older adults who use telehealth. The FMEA prioritizes problems in evaluating the greatest risk factors and services of telehealth and quantifies the effects using an RPN. The findings of this study can contribute to enhancing telehealth system development and evaluation by making it failure tolerant. In addition, they will provide detailed directions on avoiding potential hazards when initiating telehealth services by clarifying blind spots.

2. Methods

2.1. Study design

This cross-sectional descriptive design study analyzed low-income older adults to prevent problems with telehealth services using the FMEA.

2.2. Study setting

Telehealth biomonitoring services benefit low-income older adults living in Seoul, South Korea. Specifically, we analyzed the clinical decision support system (CDSS) and consultation with a teleconference-expert system mediation process. Medical programs, health consultations, and education were provided based on this information. The telehealth platform focuses on four chronic diseases with high social costs: hypertension, diabetes, asthma, and chronic obstructive pulmonary disease [13,14]. Data on blood pressure, blood sugar, pulse oximetry, and spirometry data were provided by the individuals. Differences in the cost were observed according to additional measuring equipment distributed. According to the protocol, the cost of managing the four chronic diseases was constant [15]. More frequent reviews are required depending on the condition of the participant rather than a comparison according to the disease.

2.3. Project participants

The present study was based on a telehealth system used by 200 low-income older adults from G City, Seoul, South Korea. Patient eligibility criteria were as follows: i) over 65 years of age, ii) able to read and speak Korean, iii) digitally savvy, iv) willing to participate in the project, and v) receiving telehealth services. The exclusion criteria were as follows: i) hearing and vision impairments, ii) cognitive impairment as screened by the Mini-Mental State Examination–Korea (MMES-K), and iii) scheduled for surgery or hospital admission.

2.4. Ethics approval

This study was approved by the ethics committee of the Seoul National University School of Nursing (SNU-IRB-2011-32). All participants understood the purpose of the study and provided written informed consent. All procedures involving human participants during the study were performed in accordance with the ethical standards of the institutional and national research committee and the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

2.5. Study process

The study followed the FMEA method, comprising six steps [16]: i) selection of the research field and process (qualitative method of data collection), ii) formation of the expert research team, iii) collection of data related to the research process, iv) hazard analysis, v) risk priority analysis, and vi) developing risk reduction actions (Fig. 1).

3. Results

3.1. Conduct a FMEA process

STEP 1. Selection of the research field and process

When the service was launched, training on how to use the equipment and information about the available remote consultation services was provided. When measurement problems arose, participants visited a senior center in a public space. With the preparation completed, the users measured their biosignals following the instructions from the gateway (WebDoc; ELBIO Inc., Seoul, South Korea). After each measurement, the results were reported to the user and nurse after being categorized as red, orange, or green according to the CDSS to represent the user's condition. Green enabled users to maintain their status quo, whereas the other colors indicated that they should visit the senior center.

The final stage began with informing those in danger and those showing rapid changes in their situation about their need for remedy. Signs and symptoms were categorized in accordance with the manual, and patients were informed whether they should visit a hospital through video consultations. Triage was performed according to frequently occurring signs and symptoms, and intervention strategies were used as classification criteria [16]. Fig. 2 shows the flow chart of telehealth services for minority older adults.

STEP 2. Formation of the expert research team

The expert team conducted an analysis based primarily on the process of providing telehealth services and checked the risk factors at each step. During this process, they brainstormed, discussed, and questioned their personal work experiences to gather information. The expert team members comprised two registered nurses—including FMEA experts—a doctor, an engineer, two equipment managers and staff, and two building maintenance managers and staff, all of whom had telehealth experience of over two years (Table 1).

STEP 3. Collection of data related to the research process

The telehealth service, after some training, allows the users to

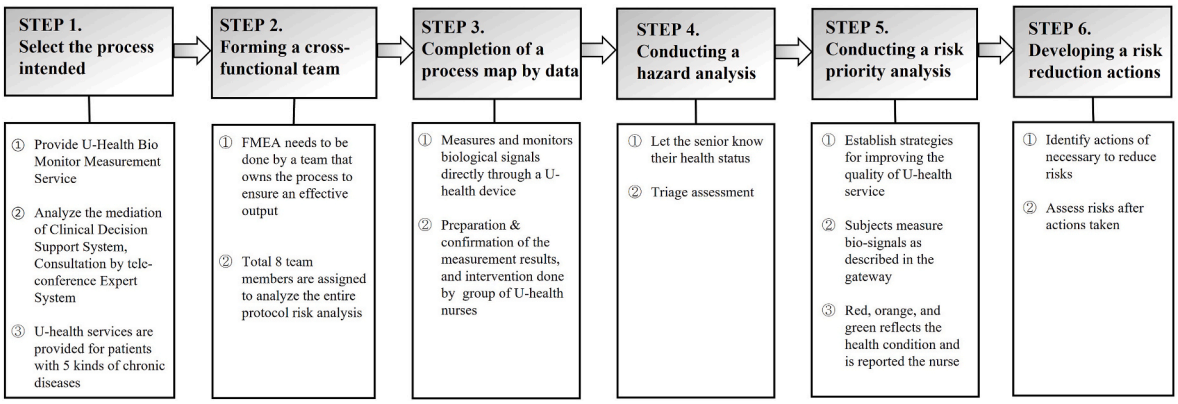

Fig. 1. FMEA process. The workflow shows the six steps followed in the current study: (1) select the process intended, (2) forming a cross-functional team, (3) completion of a process map by data, (4) hazard analysis, (5) risk priority analysis, (6) developing a risk reduction actions.

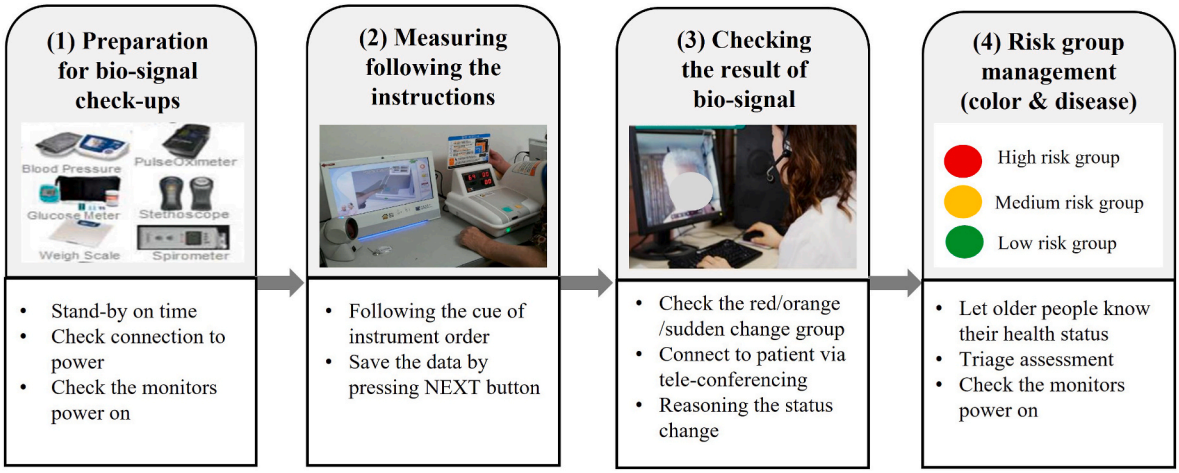

Fig. 2. A flow diagram indicating telehealth service of minority elderly: (1) preparation for biosignal check-ups, (2) measuring following the instructions, (3) checking the result of biosignal, (4) risk group management (color & disease).

Table 1
The profiles of a expert team.

Code	Expert's Position	Experience	Education	Section
C1	Doctor	5 Years	Doctor of Medicine	Algorithm development, review the triages and emergencies
C2	Registered Nurse	20 Years	Bachelor's degree	Management of participants provide intervention
C3	Registered Nurse	2 Years	Master's degree	FMEA Expert, Management of participants
C4	Engineer	2 Years	Bachelor's degree	Interpreting CDSS results
C5	Equipment manager	2 Years	Bachelor's degree	Telehealth equipment installation and maintenance
C6	Equipment manager	5 Years	Bachelor's degree	Telehealth equipment installation and maintenance
C7	Building maintenance staff	20 Years	Bachelor's degree	Head of building maintenance
C8	Building maintenance staff	7 Years	Bachelor's degree	Member of building maintenance

measure and monitor their own biosignals without visiting a hospital or consulting medical staff. This process comprises four steps, and Fig. 2 describes the process graphically. To create these protocols before the study began, 14 project-related professionals with more than 100 h of experience scrutinized the data. Eight FMEA expert team members brainstormed to review the details of defining the beginning and end of the process [16].

STEP 4. Conducting a hazard analysis

The present study prioritizes potential risk factors by multiplying the severity of the event, occurrence, and detection. Each team member assigned an individual score for each failure at each step. An observational checklist was provided to experts to calculate the values. Three factors (severity, occurrence, and detection) were determined from 1 to 5 by considering the prior data reviewed or action performed: (a) Severity—Level 1 indicated no effect on patients, whereas Level 5 indicated that it was fatal; (b) Occurrence—Level 1 indicated a very low possibility of error (1/10,000), whereas Level 5 indicated a very high possibility (1/20); (c) Detection—Level 1 indicated a very high possibility of detection (9/10), whereas Level 5 indicated a very low possibility (0/10). (Table 2).

STEP 5. Conducting a risk priority analysis

The expert team used risk priority number (RPN) scoring to prioritize

Table 2
Rating scales employed to assign severity (S), occurrence (O), and detection (D).

	Severity	Occurrence	Detection
Score	Description of injury	Failure mode probability	Likelihood of detection
1	None or little effect No injury	Very low: 1 in 10,000 episodes	Very high: detected 9/10 times
2	Relatively little effect Temporary injury	Low: 1 in 1000 episodes	High: detected 7/10 times
3	Moderate injury. Increased level of care	Moderate: 1 in 200 episodes	Medium: detected 5/10 times
4	Recurrent failure Repeated increasing level of care	High: 1 in 100 episodes	Low: detected 2/10 times
5	Common failure Death or irreversible level of care	Very high: 1 in 20 episodes	Remote: detected 0/10 times

risk factors. By calculating, the mean of all RPNs was assigned to each failure for every team member. This study refers to the protocol development found in previous studies that proposed a triage for distinguishing between the stages and phases of four targeted diseases. The protocol suggests denoting the emergency status with red, amber, and green (i.e., the lights of a traffic signal) to the participant data [15]. The effects of the results were presented using RPN [17,18] (Table 3). The RPN helped detect risks in the early stages by identifying the highest risk (Table 4). The team leader ensured that each member was acknowledged as an expert. To resolve differences in opinions, we reidentified the process, and reviewed the factors affecting risk priority through clear communication. Fig. 3 presents the findings in a priority matrix. This helps when applying telehealth by deciding the items or steps to focus on. The selected priorities could reduce the clinical risks of low-income older adults who use telehealth services by weighting the clinical actions.

STEP 6. Developing risk reduction actions

This study analyzed the four levels of risks that might arise when measuring the biosignals of low-income older adults and identified vulnerabilities. This study used the FMEA results to develop improvement strategies for telehealth services. It describes the actions suggested by the failure modes ranked on the RPN (Table 4). Based on this, this study proposed an action plan for the implementation of telehealth for minority older adults.

3.2. Analysis of the main reasons for the failure modes

As the risk analysis results were related to the vital sign monitoring process, 24 risk factors and 34 causes were identified in four major steps, with a mean RPN of 90.7 (Table 3). However, risk prioritization indicated four high failure modes, one red group and five orange groups, with a total RPN of 362.7 (Fig. 3). Based on the fundamental causes, the present study categorized risks as oblivescence, economic issues, and technology literacy, with an average score of 27 points. The suggested actions were as follows: i) stabilization of the platform or system, including developing a platform that automatically turns on and is unconstrained and non-intrusive; ii) adding to providers' manpower, such as doctors or nurses, requires continuing education, tele-education, and teleconsultation; and iii) government policy support to correct economic errors (Table 4).

3.2.1. Oblivescence

High-risk groups related to oblivescence in failure in Phase 2 occurred when users measured their biosignals on their own and forgot to push the "Next" button, thereby not saving their data (Phase 2.2, RPN 38.1). Phase 1 was an inaccurate measurement because of users' failure to follow rules, such as relaxing or fasting prior to the measurement (Phase 1.3, RPN 30.7) and making measurements using personal calibration devices without turning the monitor on (phase 1.4, RPN 13.8).

Although not included in the red or orange groups, oblivescence caused other failure modes. Phase 1 included forgetting the measurement method and disabling measurements (Phase 1.2, RPN 25.5), and did not follow the instructions (Phase 2.1, RPN 20.4). In Phase 3, forgetting the remote consultation process scored RPN 23.5 (Phase 3.2) points because it prevented users from accessing training opportunities and preparing for emergencies.

3.2.2. Economic issues

In Phase 4, the cost-related risk group was associated with how, despite the CDSS classifications and the provision of appropriate intervention, it was difficult for users to follow mediation instructions to visit the hospital or change daily living behaviors that required payment (Phase 4.1, RPN 36.5). The other failure modes in Phase 1 include power disconnections (Phase 1.1, RPN 16.1) during the measurement preparation stage. An additional electricity bill allowance of $10 was provided each month; however, that cannot be a solution.

3.2.3. Technology literacy

Some failure modes are related to technology literacy [19]. At the initial stage, some telehealth platforms were unstable and provided different results in residences and public places (Phase 3.4, RPN 15.5). In some cases, data were missing owing to Internet connection loss (Phase 3.3, RPN 16.4) and power disconnections (Phase 1.1, RPN 16.1) during the measurement preparation stage. Instability is a risk factor because the loss of user confidence might cause individuals to refuse the service during the initial stage.

Additionally, there were shortages of supplies and equipment parts (Phase 4.3, RPN 35.66) because users required additional alcohol swabs, injection needles, or replacements for equipment that they lost unexpectedly.

3.3. Suggested actions for the failure modes

Another contribution to these related fields is the enhancement of the existing steps of telehealth services, especially for minority older adults. In addition, in the initial stage of telehealth implementation, the findings and strategies have safety aspects by reducing the risk factors. Fifteen suggested actions were made from the 15 failure modes, according to the RPN score. At the initial stage of telehealth, the representative failure mode was investigated as follows: missing the calculated data, insufficient budgets of participants, lack of equipment and tools for intervention, careless user condition (unwilling to respond), and insufficient preparation for measurement at home (take a rest or fasts). To solve these, the following actions were suggested: i) development of stabilization of the platform, ii) staff and users double-checking for the data and participants, iii) adding the support of government policy, and iv) recurrent education (Table 4).

4. Discussion and future direction

This study aimed to enhance the quality of telehealth services by reducing errors and creating a safe user environment for low-income older adults. It used the FMEA methodology to conduct a stepwise review of the multidisciplinary service provision process (preparation, measurement, result confirmation, and intervention) and to provide suggestions for improvement. When a local community provides telehealth services for low-income older adults to measure biosignals via telemonitoring, providers should consider issues related to oblivescence, cost, and technology literacy to prevent failure modes.

Table 3
Failure modes, reason, effects, and RPN of the telehealth service.

Phase	Failure mode	S	O	D	RPN	Reason for failure	Effect	RPN Total (%)
1. Preparation to measure bio-signal	Monitor power disconnected	1.8	2.8	3.2	16.1	- Turning off the power due to worry about electricity expenses	Prevention measure periodically; requiring repeated education	86.2 (23.7%)
	Unable to make measurements	2.4	3.8	2.8	25.5	- Fear of using the device - Forgetting measurement method - Forgetting measurement method and are reluctant to ask the nurse again	Frequent education needed; Increase dropout of the participants; Increased costs in recruiting	
	Insufficient preparation for measurement at home (Takes a rest or fasts)	2.4	3.2	4.0	30.7	- Decrease in perception of importance - Forgetting	Generating inaccurate data; Increased workload of the nurse due to the frequent rechecks	
	Turns on the measurement device and turns off the monitor	1.8	3.2	2.4	13.8	- Forgetting measurement method - Monitor power button located inconspicuous location; power must be pressed hard to operate	Loss of measured data	
2. Measurement of bio-signal following the instruction from the personal device	Measurement without following instructions	2.0	3.0	3.4	20.4	- The user feels that 3 min waiting time is too long	Generating inaccurate data; Requiring repeated education	93.9 (25.9%)
	Data not stored	2.8	3.4	4.0	38.1	- Thinking that the results showing up on the screen means the completion of the whole process, the user forgets to push "next" button. - The user does not understand the importance of storing the data.	Data loss or difficulty in finding meaningful data due to insufficient data	
	Difficultly moving smoothly to the next step	2.2	2.6	2.4	13.7	- The program is not elder-friendly with small-sized letters with poor legibility. - The speed of narration not suitable for elders	Consumption of the manpower due to repeated education Taking long time for the first-time users to get used to it	
	Measuring with calibration device without turning monitor on	2.2	2.6	3.8	21.7	- Forgetting to turn on the power - The failure of data transmission, which happens occasionally, decreases credibility.	Difficult to discern of the subjects' condition due to the loss of the data	
3. Confirmation of the measurement result	User careless in his/her condition; unwilling to respond	3.0	3.8	2.8	31.9	- Less interest in managing their health condition because the subjects prioritize daily earning for survival - Tiresome concerning daily check-up	Frequent dropout out of the service	87.3 (24.0%)
	User forgets how to use tele-consultation service	3.0	2.8	2.8	23.5	- Difficult to follow the tele-consultation mode which is not used on daily basis	Prevent opportunities to creating rapport	
	Poor data transmission	2.4	3.8	1.8	16.4	- Poor management of internet installers	Distrust and negative attitude in using the device	
	Misclassification of data	2.2	2.2	3.2	15.5	- An error in the process of bringing the subjects' information from the CDSS	Low reliability of the data; Increased workload due to frequent rechecks	
4. Intervention followed by groups with a nurse	Nonapplicable Intervention classification	3.8	3.0	3.2	36.5	- Insufficient budget - Miss classified the intervention group for the subject	Difficult to draw behavioral change of the participants	95.3 (26.4%)
	Emergency occurs before the nurse can contact the user	3.0	1.8	4.4	23.8	- Elderly has high incidence rate of chronic and vascular disease which can make sudden emergency status	Possibility of temporary, permanent injury or death	
	Lack of equipment and tools for Intervention	3.8	2.6	3.6	35.6	- Not all items related to the services and interventions are available in community-based service (unlike hospital)	Delays timely response to the patient	

4.1. Interpretation within the context of wider literature

During the COVID-19 pandemic, telehealth services attracted attention because of their ability to meet user needs through customized services, medical specialization, and diversification [20]. Tele-monitoring, a form of telehealth, facilitates the early detection of diseases and exacerbations, thereby guaranteeing patient safety and satisfaction [21]. Telehealth is helpful for individuals practicing social distancing because it provides equal medical benefits, facilitates mental health care, and reduces costs [22].

The results of this study support previous findings that changes in perceived feasibility, which affects the oblivescence typical of older adults, and fostering the capability to recalibrate are critical to the adoption of telehealth technologies [7].

This study supports the finding that the ability to adopt new inventions declines with age, and that the income gap among older adults affects the gap in technology use [23]. Therefore, we conclude that low-income older adults have relatively less experience than other older adults. This contrasts with the reviewed research on the use of information and communications technology (ICT), which indicates that although age and education level have significant effects on performance [24], sex and income level have little effect [25]. However, in this study, low-income status also meant a relatively lower level of education, and thus, increased vulnerability to risks. As such, compared to other older adults, the individuals in this study required more time and effort to receive education on the need for health management and to learn to use the equipment. Service providers who were in contact with low-income older adults in the senior centers of their residence blocks

Table 4
Ranking of failures modes according to RPN scores and suggested actions.

Failure mode	RPN	Rank	Suggested Actions
Missing the calculated data	38.1	1	- Stabilization of Platform - Staff and users double-check for the data and participants
Insufficient budgets of participant	36.5	2	- Add the support of government policy
Lack of equipment and tools for Intervention	35.6	3	- Add the support of government policy
User careless in his/her condition; unwilling to respond	31.9	4	- Recurrent education and consultation of their health and social condition - Develop a platform that is unconstrained and nonintrusive
Insufficient preparation for measurement at home (Takes a rest or fasts)	30.7	5	- Recurrent education (Frequent tele-education and tele-consultation) - Develop a platform that includes pop-up questions for preparation
Unable to make measurements	25.5	6	- Recurrent education - Frequent tele-education and tele-consultation
Emergency occurs before the nurse can contact the user	23.8	7	- Add an automatic alarm system - Develop a platform that is unconstrained/nonintrusive
User forgets how to use tele-consultation service	23.5	8	- Recurrent education (Frequent tele-education and tele-consultation)
Measuring with calibration device without turning monitor on	21.7	9	- Platform auto power on
Measurement without following instructions	20.4	10	- Repeat education (Frequent tele-education and tele-consultation)
Poor data transmission	16.4	11	- Stabilization of Platform
Monitor power disconnected	16.1	12	- Stabilization of Platform
Misclassification of data	15.5	13	- Stabilization of Platform
Turns on the measurement device and turns off the monitor	13.8	14	- Stabilization of Platform - Repeat education (Frequent tele-education and tele-consultation)
Difficultly moving smoothly to the next step	13.7	15	- Stabilization of Platform - Repeat education (Frequent tele-education and tele-consultation)

had to explain the method repeatedly. It is necessary to simplify the service as much as possible and redesign the interface to match user level.

Telehealth helps low-income older adults maintain and enhance their healthy lives and obtain hospital services as quickly as possible during emergencies [26]. Thus, various groups received distinctive training based on their conditions. However, the observations of this study indicate that many older adults suffer from insufficient financial resources and movement difficulties. Thus, telehealth services for low-income older adults should be a minimum-cost system with consultation and intervention services. Jurisdictional and organizational support is necessary for the successful provision of telehealth services to low-income older adults to improve their access to health services [19].

The power disconnection issue is in line with previous studies, showing that cost is a critical factor in ICT adoption [27]. This result is in line with previous studies on technology acceptance predictors and home telehealth services for older adults, which could not overcome the limitations of pilot operations or niche markets [28]. Other than the risk aspect, this is an important factors affecting the continuous use of a service [27].

Recently, low-cost mobile technology-based healthcare services that provide mediation to many people using the Internet or SNS have received considerable attention [16]. However, many low-income older adults do not have a cell phone with an Internet connection. Thus, it would be more effective to consider utilizing what they already have—2G mobiles, televisions, or telephone services. Additional recommendations include creating older adult-friendly interfaces or adding functions that might help them remember better (e.g., setting alarms for consultation and automatic calibration times).

System developers should prepare for emergency cases that may occur before the patient is connected (4.2, PRN 20). Older adults typically have more than one disease, and a high proportion of them have cardiovascular disorders. Thus, it is necessary to create a strong link between telemonitoring, which allows quick detection of changes in their conditions, and hospitals, which can take emergency measures. For this system to work, we must first analyze patients' diseases to create a detailed response protocol and train the participants.

4.2. Strengths, limitations, and future direction

During the COVID-19 pandemic, a period of high online activity and care aimed at low-income older adults with potentially high risks could be applied in advance outside the standard medical system. This is the first FMEA study to examine the application of non-face-to-face healthcare or telehealth to minority older adult patients.

This study identified potential problems prior to the event and prioritized them to identify the greatest risk factors and services for minority older adults. Based on the FMEA analysis, this study also presented risks and improvement measures related to telehealth services for low-income older adults. However, a trial project involving smart home healthcare for minority older adult patients served as the basis for the FMEA. The FMEA performed a risk analysis and created time limits for monitoring changes.

In this study, the expert team progressed to Step 6 before eliminating risk factors in the field. It measures potential future risks before taking risk reduction steps. Future studies should consider applying telehealth to older, low-income individuals using the actions suggested. Concerns about the standardization of priority calculations can be assumed as a limitation. Currently, without any options for analyzing patient safety in an experimental study, RPN scores were obtained for the telehealth service initiated for minority older adults.

4.3. Implications for policy, practice, and research

Future research directions include additional application studies to eliminate risk factors while using the results of this study. This study contributes to the body of knowledge concerning the identification of risk factors and develops guidelines applicable to low-income older adults, based on real telehealth experiences.

This study found the following potential failures: oblivescence, economic issues, and technological literacy. The results of this study indicate that practitioners of telehealth aimed at low-income older adults might need to consider i) repeated education to prevent forgetfulness, ii) additional employees for the provider, iii) stabilization of the platform or system, iv) policies that support solving economic issues, and v) easy tailored programs aimed at addressing technology issues.

The selected priorities could reduce the risks of low-income older adult patients who use telehealth services by weighting the actions for minority older adult patients. The following actions were recommended: stabilization of the platform or system, expansion of the provider workforce, promotion of supportive government policy, and recurrent education.

5. Conclusion

Telehealth services are a solution for disease management, with increasing untact (non-face-to-face) issues during the pandemic. Particularly for low-income older adults, it saves time and cost, and

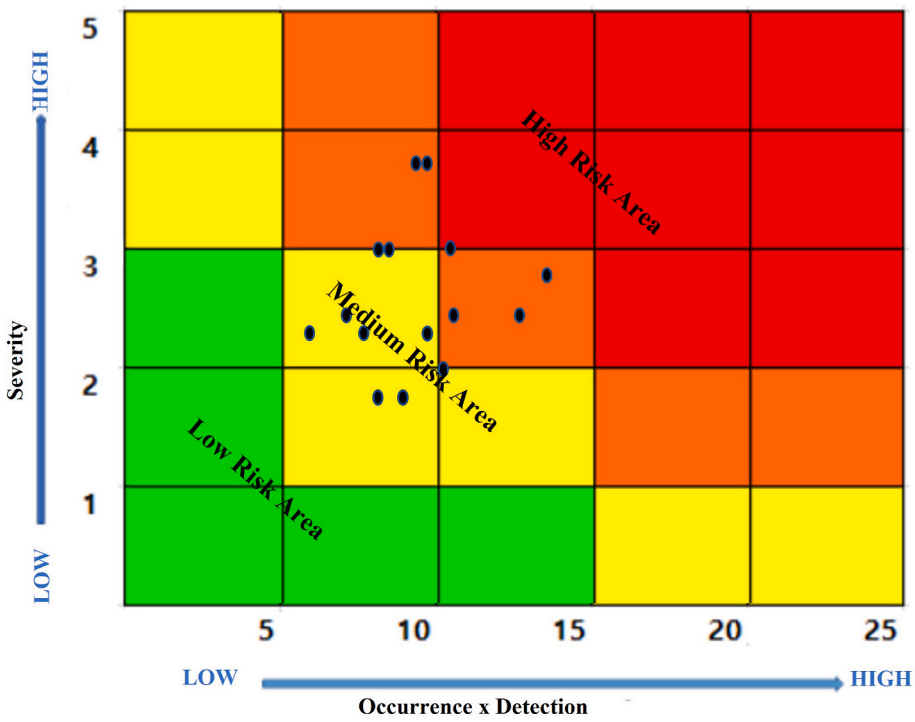

Fig. 3. Risk priority matrix. This identifies the results of RPNs, which evaluate risk and prioritize corrective actions. RPNs rate X-axes number, occurrence multiply detection, multiplying Y-axes numbers severity. Green means low, yellow means moderate, orange means high, and red means extreme. Green indicates that no corrective action is required. Yellow indicates that corrective action is needed if the detection rating is equal to or greater than given number. Red and orange indicate that corrective action is needed.

prevents infection. Minorities and older low-income older adults have many risk factors; therefore, continuous and diverse research on patient safety for telemedicine services is needed.

This is the first FMEA study to examine the application of telehealth in minority older adult patients and visualize the results quantitatively. Therefore, this study makes a novel contribution to the literature by analyzing aspects of patient safety related to telehealth services for minority older adults using RPNs. Using the FMEA, the study identified 24 risk factors and 34 causes in four major phases, with a mean RPN. Based on fundamental causes, this study categorized risks as obliviescence, economic issues, and technology literacy. To correct these failure modes, stabilization of the platform or system, adding to the providers' manpower and support for government policies are recommended. In the future, these actions should be applied to telehealth of low-income older adults. The selected priorities could reduce the risks of low-income older adults using telehealth services by weighting their clinical actions.

Summary table

1. Telehealth services are important solutions for disease management with rising untact issues during the COVID-19 pandemic for digital transformation of a sustainable society.
2. This is the first failure mode and effects analysis (FMEA) study to examine the application of telehealth in minority older adult patients and to quantitatively visualize the results.
3. The selected priorities could reduce clinical risks of low-income older adults who use telehealth services by weighting clinical actions.

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Ethical approval

The research protocol was approved by Seoul National University, School of Nursing of Institutional Review Board in Korea (SNU-IRB-2011-32).

Data sharing statement

The primary data associated with this study are available on reasonable request from the Decision Support Services of Nambu University.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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