I. Introduction

According to Statistics Korea, people over 65 years of age constitute 11.0% of the total population of Korea [1]. It is predicted that the proportion of the aged will reach 24.3% by 2030 and 38.2% by 2050, which will mean a transfer to an extremely aged society. One of the methods to increase the quality of life of the aged, their ultimate health goal, is to promote a healthy lifestyle for them as well as the effective management and prevention of disease.

There exists digital divide with socio-demographic factors when it comes to the application of information and communication technologies (ICT), including the Internet [2,3].
The concept of the digital divide can be explained in terms of social differences between individuals, groups, and countries at different socio-economic status levels. The digital divide appears in an unequal form in terms of the opportunity to access, physically possess, and practically apply ICT [4].

Korea has carried out two-phase comprehensive program to reduce the digital divide. Phase I (2001–2005) emphasized the preparation of a basis for the access and use of information. Phase II (2006–2010) focused on the practical use of ICT. The Ministry of Health and Welfare of Korea recently launched a community-based pilot project for a ubiquitous healthcare service which manages metabolic syndromes at community health centers. The Korean government has also initiated increased awareness of using ICT in healthcare areas [5-7].

Previous studies investigated the factors that influence individuals’ acceptance of ICT, which were the basis for the development and validation of the Information and Communication Technology Acceptance Model [4,8-10]. However, few studies on testing this model employing an aged population exist. The Internet, which allows quick searches and easy handling of all types of information, even including information related to emergency situations, can be of use to the aged, who typically have psychological, physiological, and physical limitations [11].

According to a 2007 Korean fact-finding survey on the digital divide, there was a gap between ages: 37.4 among middle-aged people and 13.7 among aged people per every 100 used the Internet [5]. In a 2009 survey, compared with Internet use by 77.0% of the general population, Internet use among middle-aged people in their 50s stood at 55.9%. Among the aged more than 60 years old the percentage was 21.8% [6,7]. According to a recent survey by the Korea Internet Security Agency [12], Internet use by the aged in their 60s increased from 33.8% in 2010 to 35.9% in 2011 (Figure 1). However, there is insufficient semantic research on whether or not this Internet use is productive.

The aged who use the Internet mostly want to search for and locate information regarding activities related to their leisure and hobbies. They also search for and use online content related to aging [13]. Accordingly, the number of Internet portal sites exclusively for the aged has been increasing. Some websites for the aged allow the sharing of information with people having similar interests. Despite the fact that the aged have gradually started to use the Internet, they still account for only a part of the aged population [12]. Moreover, a study examining the health information literacy of Finns aged 65–79 years also reported that the aged lack health information literacy and that there are significant relationships between education level, interest in health information, seeking activity, self-rated current health, and the dimensions of health information literacy [14]. Previous studies have consistently reported the necessity to develop a curriculum on how to use the Internet and how to locate information targeting aged populations [2,14,15]. In addition, the literature states that there is a need for a systematic research on aspects of their Internet use.

Considering the rapid social changes in the 21st century, it is predicted that the aged will not always remain passive consumers seeking health information and services on the Internet. To expect positive outcomes regarding the active use of health information by the aged, scientific studies of their health literacy and the use of online health information are needed. Therefore, this study aims to review and analyze previous studies on health literacy and the use of online health information by those aged 65 years and over. The studies were obtained from the PubMed database of the National Library of Medicine (NLM). Medical Subject Heading (MeSH) keywords of the studies were analyzed using a social network analysis (SNA) method.

II. Methods

1. Subject

1) Paper extraction

To extract published articles on health literacy and the use of health information by the aged over 65, predefined and selected MeSH terms from the PubMed database of the NLM were used. Search was initially conducted, with repeated articles excluded afterwards. The keywords in all of the extracted articles were reviewed to make a final selection of the articles for the analysis.

The search requested articles related to health literacy of the aged over 65. A total of 361 articles were extracted. Among them, 127 articles concerning the aged over 65 were selected. After the repeated articles were removed, 110 articles were finally included in the analysis, which include the following
MeSH terms with the corresponding number of selected articles: health communication AND aged (9 out of 23); health literacy AND aged (61 out of 191); computer literacy AND aged (39 out of 104); computer literacy AND health education AND aged (18 out of 48).

Subsequently, articles related to the use of online health information by the aged over 65 were selected. Using the same extraction process used for ‘health literacy,’ 26 articles were selected. After the repeated articles were removed, the final 19 articles were included in the analysis. These include the following MeSH terms with the corresponding number of selected articles: Internet/utilization AND consumer health information AND aged (7 out of 34); Internet AND consumer health information AND aged (6 out of 87); Internet/utilization AND health education AND aged (13 out of 161).

2) Keyword extraction
From the 110 articles related to health literacy, a total of 1,021 MeSH keywords were extracted. After removing repeated keywords, a final 401 keywords were selected. It was difficult to construct a network of and distinguish the relations between the 401 keywords; therefore, a pruning method was used. Pruning is applied to reconstruct a network based on keywords with a degree higher than a certain cut-off level that establishes the boundaries of a network [16-18]. After applying the pruning method (pruning = 5), the network was reconstructed based on a final number of 71 keywords. Regarding the use of online health information, a total of 144 MeSH keywords were obtained from the 19 articles. After removing repeated keywords, 74 keywords were finally selected.

2. Statistical Analysis
SNA is a statistical method that can be widely used in interdisciplinary fields [18,19]. SNA converts the relationships between studies and their results into easily understood visual models [18,20,21]. In Korea, research using SNA has recently been published in healthcare [22-26]. Of these studies, only a few extracted MeSH terms from the NLM database [22,27,28].

The core of SNA is the degree and the density of nodes. The degree plays an important role in the SNA process [29]. If a group size increases, the density decreases accordingly, and if networks are of different sizes, standardization is required [29,30]. If a node moves to the center and has many connections to other nodes, its degree centrality increases in the network [29,31]. A higher degree centrality indicates a more central keyword; therefore, it can be interpreted as a keyword that has been actively studied in the literature [18,32].

NetMiner v.3 (Cyram Inc., Seoul, Korea) was used to construct keyword networks. For the construction of a network, the keywords of each article were used as the nodes in the network. A method used in SNA, an analysis of co-appearing keywords, was also applied in this study. Co-appearing keywords reflect a semantic connection between articles [17,21,33] and visually present the content of the articles, including the intention and the philosophy of the authors, in the form of pictures [34].

This study applied the notion of weighted degree centrality to investigate the changes in the main keywords in each section of the networks [35]. Normally, degree centrality standardization is performed for networks of different sizes. However, it was not necessary to consider the differences in the densities of the keyword networks in this study because the networks were constructed from separate searches in two different areas. Thus, it was established that there was no need for standardization.

III. Results
1. Keyword Network of Health Literacy
Keywords which appeared in selected articles related to ‘health literacy’ emerged in 1997, and the number of related keywords has increased rapidly since 2010 (Figure 2).

After applying pruning to the 401 keywords, the network was constructed based on the remaining 72 keywords. Among them, keywords with the highest degree centrality in the network were ‘health literacy’ and ‘computer literacy.’ With the exception of these two keywords, the keywords with the highest degree centrality were ‘Patient education as topic,’ ‘Internet,’ ‘Health knowledge, attitudes, practice,’ and ‘Attitude towards computers.’ Table 1 shows the keywords with the highest degree centrality.

Figure 2. Change in the number of keywords for health literacy by year.
Of the top 30 which were most frequently appearing keywords, five were related to computers (Computer literacy; Attitude towards computers; Computer user training; Computer-assisted instruction; User-computer interface), four were related to the role of the patient (Patient satisfaction; Patient participation; Physician-patient relations; Patient compliance), three were related to attitudes (Health knowledge, attitudes, practice; Attitude towards computers; Attitude towards health), two were related to education (Patient education as topic; Health education), and the remaining two were 'Internet' and 'Information services.'

When the relationships between the keywords were interpreted in the keyword network, 'Health literacy' had a strong degree of connection with 'Health knowledge, attitudes, practice' and 'Patient education as topic.' 'Computer literacy' had a strong degree of connection with 'Internet' and 'Attitude towards Computer.' 'Computer literacy' was connected to 'Health literacy' and researched as a parameter of 'Attitude towards health' and 'Patient education as topic.' The majority concerned the acquisition of information related to chronic diseases such as diabetes and high blood pressure (Figure 3).

Table 2 presents the changes in the top 20 keywords by year. This table shows that the degree centrality of 'Computer literacy' was highest before 2010. The degree centrality of

| Rank | Keyword                                      | Frequency | Degree centrality value |
|------|----------------------------------------------|-----------|-------------------------|
| 1    | Health literacy                              | 61        | 2.167464                |
| 2    | Computer literacy                            | 44        | 1.966507                |
| 3    | Patient education as topic                   | 30        | 1.425837                |
| 4    | Internet                                     | 28        | 1.306220                |
| 5    | Health knowledge, attitudes, practice        | 23        | 1.081340                |
| 6    | Attitude to computers                        | 21        | 1.043062                |
| 7    | Age factors                                  | 15        | 0.727273                |
| 8    | Attitude to health                           | 12        | 0.679426                |
| 9    | Educational status                           | 12        | 0.564593                |
| 10   | Self-care                                    | 12        | 0.502392                |
| 11   | Health education                             | 11        | 0.564593                |
| 12   | Health promotion                             | 10        | 0.416268                |
| 13   | Computer user training                       | 9         | 0.483254                |
| 14   | Health communication                         | 9         | 0.401914                |
| 15   | Patient satisfaction                         | 9         | 0.449761                |
| 16   | Computer-assisted instruction                 | 8         | 0.444976                |
| 17   | Patient participation                        | 8         | 0.449761                |
| 18   | Physician-patient relations                  | 8         | 0.440191                |
| 19   | Pilot projects                               | 8         | 0.382775                |
| 20   | User-computer interface                      | 8         | 0.354067                |
| 21   | Activities of daily living                   | 7         | 0.344498                |
| 22   | Chronic disease                              | 7         | 0.339713                |
| 23   | Focus groups                                 | 7         | 0.344498                |
| 24   | Information services                         | 7         | 0.315789                |
| 25   | Patient compliance                           | 7         | 0.287081                |
| 26   | Comprehension                                | 6         | 0.287081                |
| 27   | Geriatric assessment                         | 6         | 0.301435                |
| 28   | Heart failure                                | 6         | 0.287081                |
| 29   | Neoplasms                                    | 6         | 0.267943                |
| 30   | Quality of life                              | 6         | 0.291866                |
'Health literacy' was ranked first in 2010. Moreover, there was a notable increase in both 'Age factor' and 'Socioeconomic factor' related to 'Health literacy.' In 2008, 'Self-care' entered to the top 20 keywords. Both 'Self-care' and 'Self-efficacy' appeared on the list in 2010. More behaviors related to independence and active dealings with health were also observed. 'Health communication' entered the list in 2010, and the scope was extended to 'Physician-patient relations,' 'Communication barriers,' and 'Communication' in 2011. 'Emigrants and immigrants' first appeared on the list in 2011.

| Rank | 2006                     | 2007                     | 2008                     | 2009                     | 2010                     | 2011                     |
|------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| 1    | Computer literacy        | Computer literacy        | Computer literacy        | Computer literacy        | Health literacy          | Health literacy          |
| 2    | Patient education as topic | Attitude to computers   | Internet                 | Internet                 | Patient education as topic | Health knowledge, attitudes, practice |
| 3    | Attitude to computers    | Internet                 | Health education         | Attitude to computers   | Internet                 | Patient education as topic |
| 4    | Computer-assisted instruction | Aging               | Health knowledge, attitudes, practice | Forecasting              | Age factors              | Physician-patient relations |
| 5    | Attitude to health       | Great Britain            | Age factors              | Software                 | Socioeconomic factors    | Health communication     |
| 6    | Program evaluation       | Self-concept             | Patient satisfaction     | Patient satisfaction     | Health knowledge, attitudes, practice | Comprehension |
| 7    | Nursing evaluation research | Antipsychotic agents   | Aging                    | Health services for the aged | Computer literacy          | Self-care                |
| 8    | Online systems           | Awareness                | Quality of life          | Delivery of health care  | Patient participation     | Communication barriers    |
| 9    | Scotland                 | Culture                  | Diabetes mellitus        | Therapy, computer-assisted | Attitude to health        | Age factors              |
| 10   | Computer user training   | Delusions                | Self-care                | Patient acceptance of health care | Attitude to computers | Rural population         |
| 11   | Pilot projects           | Electronic mail          | Access to information    | Telemetry                | Self-care                | Emigrants and immigrants |
| 12   | Nursing assessment       | Parapsychology           | Educational status       | Computer-assisted instruction | Self-efficacy          | Language                 |
| 13   | Risk assessment          | Psychotic disorders      | Chronic disease          | Patient education as topic | Health status            | Early detection of cancer |
| 14   | Attitude of health personnel | Risperidone        | Self-help devices         | Neoplasms                | Educational status        | Health promotion         |
| 15   | Choice behavior          | Cognition disorders      | Attitude to computers    | Learning                 | Medication adherence      | Educational status        |
| 16   | Decision trees           | Day care                 | Attitude to health       | Health promotion         | Health communication     | Patient participation     |
| 17   | Diagnosis, computer-assisted | Mental recall | Information services | Focus groups            | Computer user training | Communication |
| 18   | Health behavior          | Mental status schedule   | Medical informatics      | Health knowledge, attitudes, practice | Qualitative research | Patient compliance |
| 19   | Hypertension             | Pensions                 | Consumer satisfaction    | Analysis of variance     | Health education          | Patient satisfaction     |
| 20   | Life style               | Prejudice                | Intention                | Mental recall            | Dental care              | Focus groups             |
2011; therefore, it can be estimated that, in the future, there will be more research on this newly emerged minority group in relation to the issue of the digital divide.

2. Keyword Network of the Use of Online Health Information

Keywords related to the use of online health information emerged in 2005. A total of 144 keywords were extracted in 2005, 39 in 2007, 67 in 2008, 12 in 2010, and 4 in 2011. After removing repeated keywords, 74 keywords were selected for the analysis. Excluding the initial search terms 'Internet,' 'Consumer health information,' and 'Health education,' the keywords appearing at a high frequency were 'Age factors,' 'Health knowledge, attitudes, practice,' and 'Patient education as topic.' It was found that 'Computer literacy' and 'Self-efficacy' were studied together when a study regarding the use of online health information by the aged over 65 was conducted. 'Information dissemination' and 'Access to information' that can influence the degree of the digital divide were on the list of the top 30 keywords with weighted degree centrality.

A keyword network was constructed after degree centrality was analyzed for all of the 74 keywords (Table 3). Among them, 'Health knowledge, attitudes, practice' had higher degree centrality than 'Health education' and other keywords with the same frequency of appearance (frequency = 6). In addition, of 15 keywords with the same frequency (frequency = 2), 'Self-efficacy' had the highest degree centrality. This indicates that 'Self-efficacy' had extensive direct connections with other keywords and that research on 'Self-efficacy' was actively conducted.

According to the results confirming the relationships between the keywords in the network, studies on the use of online health information were strongly connected to the keywords of 'Health knowledge, attitudes, practice,' 'Consumer health information,' and 'Patient education as topic.' On the other hand, 'Computer literacy' was connected to the keywords of 'Health education,' 'Patient satisfaction,' 'Self-efficacy,' and 'Attitude to computer.' In addition, the keywords of 'Attitude to computer' and 'Computer literacy' showed high degree centrality. Such a result is obvious considering that studies on the use of online health information were conducted with the help of computers (Figure 4).

IV. Discussion

This study utilized SNA to analyze MeSH keywords regarding health literacy and the use of online health information by the aged. According to the results of this study, the year 2009 was revealed in the literature to be a turning point
in the study of the use of online health information on the Internet. In particular, ‘Self-efficacy’ emerged as the top keyword starting in 2010. In terms of access to online health information, the aged are still in the minority when it comes to communication, and they lack the ability to search for, locate, and use online health information [12,14]. Accordingly, ‘Self-efficacy’ is considered to be the keyword which best reflects this phenomenon. In other words, this keyword emerged from the necessity for study on the characteristics of the use of online health information by the aged over 65, who generally accept online information in a slightly passive way [6,15].

Considering the tendency toward the gradual increase in the percentage of ICT use and its practical use by the aged each year [12], social awareness about its usefulness should also be increased. With the increase in the number of the aged who are vulnerable when attempting to obtain and use health information, it is estimated that according to their online health information seeking behavior, personalized health management services should be developed [14]. In addition, by the time middle-aged people, who are currently accustomed to the Internet and who already have self-efficacy, advance in age, they will look for inexpensive and cost-effective, personalized online health information [9,14,15].

In a more comprehensive interpretation of the results, studies of health literacy and the use of online health information by the aged over 65 were conducted together with the keywords of ‘Computer literacy,’ which allows access to the medium to simplify the locating of health information [13,15], as well as ‘Information dissemination’ and ‘Access to information,’ which are related to the digital divide [14,15]. Therefore, there is a need to educate the aged regarding how to use ICT and how to enhance the practical use of online health information. With the help of such education, the aged can efficiently search, locate, and use online health information. Accordingly, based on the results of this study,

| Rank | Keyword                                      | Frequency | Weighted degree centrality value |
|------|----------------------------------------------|-----------|---------------------------------|
| 1    | Internet                                     | 19        | 0.598086                        |
| 2    | Consumer health information                  | 11        | 0.306220                        |
| 3    | Health knowledge, attitudes, practice        | 5         | 0.234450                        |
| 4    | Patient education as topic                   | 5         | 0.215311                        |
| 4    | Age factors                                  | 5         | 0.215311                        |
| 6    | Health education                             | 6         | 0.177033                        |
| 7    | Computer literacy                            | 4         | 0.167464                        |
| 8    | Attitude to computers                        | 3         | 0.133971                        |
| 9    | Medical informatics                          | 3         | 0.119617                        |
| 10   | Educational status                           | 2         | 0.114833                        |
| 11   | Physician-patient relations                  | 2         | 0.105263                        |
| 11   | Survivors                                    | 2         | 0.105263                        |
| 13   | Patient satisfaction                         | 2         | 0.100478                        |
| 13   | Risk factors                                 | 2         | 0.100478                        |
| 13   | Self-efficacy                                | 2         | 0.100478                        |
| 16   | Attitude to health                           | 2         | 0.095694                        |
| 16   | Computer-assisted instruction                | 2         | 0.095694                        |
| 16   | Risk assessment                              | 2         | 0.095694                        |
| 19   | Health services for the aged                 | 2         | 0.086124                        |
| 20   | Breast neoplasms                             | 2         | 0.081340                        |
| 20   | Information dissemination                     | 2         | 0.081340                        |
| 20   | Mass screening                               | 2         | 0.081340                        |
| 23   | Access to information                        | 2         | 0.076555                        |
| 24   | Mass media                                   | 2         | 0.062201                        |
| 24   | Exercise                                     | 2         | 0.062201                        |
| 26   | Income                                      | 1         | 0.057416                        |
| 26   | Sex factors                                  | 1         | 0.057416                        |
| 26   | Information services                         | 1         | 0.057416                        |
| 26   | Models, psychological                        | 1         | 0.057416                        |
| 26   | Neoplasms                                    | 1         | 0.057416                        |
'Self-efficacy' can be viewed as an important keyword that should be studied with other keywords to develop educational programs and/or academic curricula. From this study, it also was confirmed that health literacy and the use of online health information by the aged were studied together with a wide variety of subjects, starting with the daily life of the aged to the management of chronic diseases and self-nursing, and ultimately ending with improvements in health and increases in the quality of life [13-15].

Furthermore, this study used the PubMed database from the NLM. The majority of the studies use the Science Citation Index or the Scopus database for network analysis. Therefore, these databases include journals with impact indexes higher than a certain level, which secure the credibility of the study results. They also offer such benefits as the division of the journals by topic and quotation information, which can be categorized by subject field through a co-citation analysis. Therefore, research tendencies can be visualized accordingly [36,37]. However, when analyses of co-appearing keywords in healthcare are conducted, it is common to use the PubMed database. MeSH terms provide unity and consistency in the index as a knowledge structure [38-41], which distinguishes PubMed from other databases in a creative way. Accordingly, there is consistency in the index of the keywords; thus, the advantage of eliminating author subjectivity was secured when selecting keywords. However, despite the fact that researchers use MeSH terms, an external review process is essential. The headings of MeSH terms are stratified by stage, and index terms are included, which are conventionally granted to an article [39]. In addition, different levels of keywords are granted through the MeSH index. Therefore, there is a need to consider these aspects when extracting and refining MeSH keywords from PubMed.

In this study, keywords in areas of interest were extracted and analyzed to identify the flow of the research in these areas. The centrality index, used to analyze social networks, has a disadvantage in that it does not reflect the weights on

Figure 4. Keyword network of the use of online health information.
This work was supported by a National Research Foundation of Korea Grant funded by the Korean Government (NRF-2011-413-G00006).

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**Conflict of Interest**

No potential conflicts of interest relevant to this article are reported.

**Acknowledgments**

This work was supported by a National Research Foundation.
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