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# Development of the WISH (Well-Aging Indexing for Senior Health) Platform for Happiness

Hang-Sik Park <sup>1,\*</sup>, Hee-Gyoo Kang <sup>2,†</sup> , Myung-Chul Kim <sup>3,†</sup>, Jiyeong Lee <sup>4,†</sup> and Jean-kyung Paik <sup>5,†</sup>

<sup>1</sup> The Faculty of Liberal Arts, Eulji University, Seongnam 13135, Korea

<sup>2</sup> Department of Senior Healthcare, BK21 Plus Program, Graduate School, Eulji University, Seongnam 13135, Korea; kanghg@eulji.ac.kr

<sup>3</sup> Department of Physical Therapy, Eulji University, Seongnam 13135, Korea; ptkmc@eulji.ac.kr

<sup>4</sup> Department of Biomedical Laboratory Science, College of Health Sciences, Eulji University, Seongnam 13135, Korea; bjssw@naver.com

<sup>5</sup> Department of Food and Nutrition, Eulji University, Seongnam 13135, Korea; jkpaik@eulji.ac.kr

\* Correspondence: parkhs@eulji.ac.kr

† These authors contributed equally to this work.

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**Abstract:** Humans now have a life expectancy of nearly 90 years and, as a result, society is rapidly aging. These longer life spans have, however, increased the average length of hospitalization for elderly adults suffering from chronic diseases such as cancer, diabetes, and encephalopathy. In a recent survey of 10 well-being indices for elderly adults, the top demands for well-being are physical, spiritual, and psychological. Thus, we developed the WISH (Well-aging Indexing for Senior Health) Platform to enhance the normalizing exponents using survey data. Nowadays, the incidence of many chronic diseases is increasing. Thus, we designed the WISH Platform using clinical research on depression, cerebral infarction, coronary artery, and rheumatism, which are common diseases in Koreans. By applying this study to chronic diseases, which manifest differently among elderly adults across different countries, it is possible to determine influential nutrition and life patterns to create a standardized index. Such an index will help create value for the happiness of active elderly people, which in turn will aid in their efforts to maintain health; it may even benefit health promotion in other age groups.

**Keywords:** senior health; happiness; well-aging; openness; convergence; bio-marker

## 1. Introduction

Humans have long lived within a society where survival is highly competitive; however, with the advent of the 21st century, many are becoming increasingly interested in the “value of happiness” [1]. Over the years, international organizations such as the United Nations (UN) and the Organisation for Economic Cooperation and Development (OECD) have conventionally utilized gross domestic product (GDP) as a means of distinguishing between developed and developing countries or regions. However, use of GDP has been criticized because it merely presents the calculated value of economic activities, and does not reflect any external, non-economic activities or quality of life [2].

Nowadays, the average life expectancy of humans can reach as high as 90 years, which is leading to the rapid aging of society [3]. While the increase in life expectancy is largely positive news, it brings some problems such as an increase in the elderly population with chronic diseases such as cancer, diabetes, and brain diseases, many of whom must be hospitalized for extended periods.

Moreover, we are seeing an unprecedented acceleration in the development of the Internet of Things (IoT), Big Data, artificial intelligence (AI), etc. These technological changes are expected to

influence development in all current industries, and the healthcare industry is, in particular, expected to shed its current defining boundaries. The definition of a “healthy life” is also changing as a result of the advances in digital and bio technology, and healthcare services, which have traditionally focused on treatment and diagnosis, are expected to shift towards disease prevention and prediction of disease outbreaks through analysis of Big Data on health monitoring and genetic information [4].

Based on these findings, this paper proposes the following: In Section 2, we review past research and its limitations, and argue for the necessity of a standard model of senior health and the current demand for a new index of happiness. In Section 3, we outline the research framework for devising this standardized index of happiness (called the Well-Aging Index for Senior Health, or WISH) using an open innovation system. In Section 4, as the first step of the study, we examine the potential for general application of the index by explaining the status of current studies. In Section 5, we explain the research required to progress from this first stage to the second stage. We further explain the process of standardizing the proposed index and the transfer of relevant technology to firms. Finally, we examine the potential effectiveness of the WISH Platform and plans for future research.

## 2. Literature Review

Research on happiness indices for humans has been actively carried out by international organizations as well as by government institutions. While GDP remains widely used as an indicator of a nation’s economic activity, it has been consistently found that happiness does not necessarily increase with income. Indeed, while income rose by two to three times over the last 50 years in many industrialized countries, people’s overall levels of happiness and satisfaction have not changed. Furthermore, depression and other mental problems have become more common [5].

For this reason, many researchers have argued for a new indicator to replace GDP that incorporates the concepts of quality of life and sustainable development. However, others have noted the inherent difficulty of quantifying quality of life and happiness. Nevertheless, many international organizations and experts agree that it is necessary to have a happiness index that incorporates not only economic value (e.g., GDP) but also life satisfaction, future expectations, unemployment rate, self-esteem, hope, and love [6].

In 1990, the UN developed the Human Development Index (HDI), which was based on 206 separate indices to determine standards of living around the world. Since 2006, the HDI has been used by the UN to quantify the social well-being of a country, utilizing annually updated data on the world’s social and economic changes. Specifically, the HDI measures happiness by utilizing indices such as income, education, poverty, rate of silver, environment, health, religion, etc. GDP is one of the factors used to calculate the HDI, but because it is not a core factor, the HDI can vary substantially among countries with a similar GDP. For example, the GDP of New Zealand (\$23,737 per capita) and that of Bahamas (\$23,029 per capita) are similar, but their HDIs were ranked 5th and 53rd, respectively, in 2011 [7,8].

The World Happiness Report released by the UN in April 2012 included the results of surveys of 1000 people aged 15–60 conducted in 156 countries worldwide from 2005 to 2011. This report clearly indicated that it is possible to measure happiness in an objective way by combining methods and theories from psychology, medicine, economics, sociology, etc. The main findings of the happiness report are as follows [9]:

- (1) It is necessary to increase the average income in many countries, as those who belong to the low-income bracket often suffer from food shortage, poor accessibility to health care services, lack of stability in basic necessities, and lack of educational opportunities;
- (2) Income directly affects about 8% of all factors influencing happiness;
- (3) When basic living standards are satisfied, happiness is more influenced by mental and physical health and values at the communal and individual levels;
- (4) For individual values, adopting an altruistic attitude appears to make people happier than if they adopt a more income-seeking attitude;

- (5) In terms of relationships, people who can rely on colleagues when they need help are happier than are those who do not lean on others.

In 2011, as part of celebrating the 50th anniversary of its founding, the OECD developed the “Better Life Initiative” (BLI) to create a happiness index for its 34 member nations. The BLI calculates a happiness index using 11 factors, including residential environment, income, employment, community, education, environment, political participation, health, life satisfaction, security, and work–life balance. Although the national incomes and economies of these 34 member nations have increased over those 50 years, the OECD wanted to focus more on “human value”, which, as noted above, cannot be measured using only the GDP. Moreover, the OECD developed the “Better Life Index,” which is an intermediated result measuring a better life, and has recommended developing a new indicator that can help enhance the national welfare of member nations.

According to a British think-tank, the New Economics Foundation (NEF), in June 2012, a national happy planet index (HPI) can be calculated by evaluating life satisfaction, life expectancy, and environmental pollution indicators in the world’s 151 countries [10].

Many nations are also discussing the calculation of their own index to measure the sincere happiness of one’s own country in different environments. For example, in Bhutan, King Jigme Singye Wangchuck announced in 1974 that he would rule his country based on an indicator he termed Gross National Happiness (GNH), rather than GDP. In other words, he meant to focus on enhancing the levels of psychological well-being and health, protection of the environment, and preservation of national identity, all of which are factors that increase people’s happiness. GNH is calculated using 9 domains, including health status, time usage, community, psychological happiness, culture, education, environment, and good governance [11]. Bhutan’s size—it had between 700,000 and 800,000 people at the time—is likely what made it possible to determine regional and individual data on well-being and directly integrate these data into its economic policy.

Apart from Bhutan, other countries have discussed the use of an index of happiness. In 2008, the President of France, Nicolas Sarkozy, directed Professor Stiglitz of the University of Columbia to establish the Economic and Social Progress Committee and develop an indicator that would enable measurement of overall economic achievement. Furthermore, the Canadian Index of Well Being and the British Research Indicators of Happiness (the latter of which was created by David Cameron’s government) were also developed, leading to important policy changes [12–15].

To date, the evaluation of a quality-of-life and happiness index for the elderly has been approaching in terms of industrialization and business dynamics that are in line with changes in national economic competitiveness or national composition ratio. However, there are few approaches based on experience and choice for the elderly. Therefore, it is expected that it will be meaningful to improve the quality-of-life and happiness index for the elderly when standardizing the posterior probability value by analyzing the statistical reasoning value and the variable value while carrying out the study in the future.

Although many indices of happiness have been developed and applied, most were devised with consideration of the size and growth of the economy; as a result, some have argued that actual happiness is not actually reflected by these indices (Human Development Reports, 2010) [16]. Furthermore, there is no happiness index specifically designed for elderly people, and no domains for use in devising such an index have even been selected.

As noted earlier, researchers are becoming increasingly interested in the elderly population because of the worldwide rapid progression of societal aging (wherein societies are progressing from aging to aged and, eventually, super-aged societies) [17]. Furthermore, the recent wave of technological changes (called the “4th industrial revolution”) has led to the creation of terms such as “senior health industry” and “elderly familiar industry”. However, these terms are only suitable for describing age groups, rather than actual industrial groups. For example, by establishing the value of shoes for elderly people by considering their functionality, stability, and convenience, a purchasing group can be formed. This approach is meaningful and necessary, but commercialization that focuses solely on the supplier’s

side cannot accurately satisfy consumers' needs. Through the process of commercialization, suppliers are likely to experience difficulties and errors before reaching success and value. This phenomenon is due to a lack of standardization of development for and by the elderly.

In this paper, we develop the WISH Platform as a standardized index of happiness by analyzing the happiness indicators most in demand by elderly adults out of the top 10 known indicators. As shown in Figure 1, these were physical, spiritual, and psychological happiness.

In March 2013, the OECD published subjective guidelines on wellness measurements. This guideline suggested subjective happiness, including life satisfaction, happiness, and similar views. Until now, it has been widely acknowledged that measuring well-being, along with other social and economic dimensions, is an essential part of measuring quality of life. As a first step to improving the quality-of-life scale, the OECD has developed guidelines that provide advice on the collection and use of subjective welfare measures. It was produced as part of the OECD Living Improvement Initiative in 2011 with the goal of measuring social progress across 11 wellness areas. However, most of the measures on the non-economic aspects of this well-being have been pointed out as having limitations in the lack of a common measurement system. Therefore, as a solution to these problems, research to measure well-being is becoming an important issue that should include standardization of quality-of-life measurement.

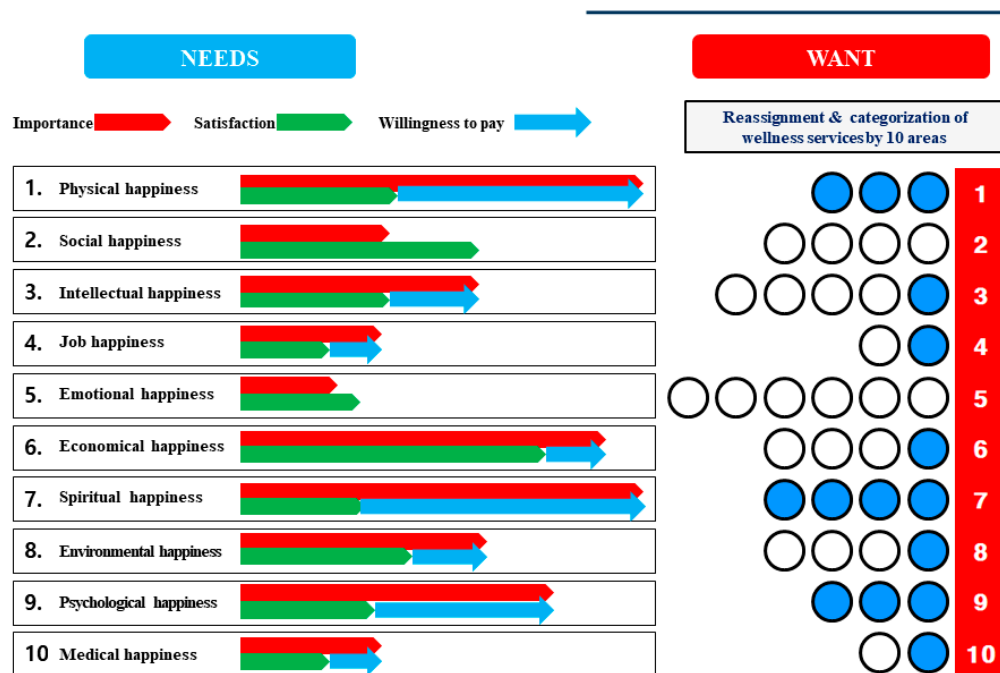


Figure 1. Top 10 indicators of happiness for elderly adults. [OECD guidelines on measuring subjective well-being (2013)].

### 3. Development and Open Innovation of WISH Platform

To create a health index, we first conducted a blood-based multiomics analysis. This is a well-known method of devising a standard health index. In this study, we used it to identify diagnostic biomarkers in elderly patients for diseases of the central nervous system (i.e., depression and cerebral infarction), musculoskeletal system (rheumatoid arthritis), and cardiovascular system (coronary artery disease). We chose these diseases because, according to a disease report by the World Health Organization (WHO), cardiovascular disease (heart disease/cerebrovascular disease) has been the main cause of death in humans since 2005. Furthermore, depression imposes the third highest lifetime burden of disease, and is expected to have the highest burden by 2030, while diseases of the musculoskeletal system are considered representative of elderly patients [18].

We collected blood samples from 200 elderly patients (based on a power analysis using G\*power) and 1000 control participants, and analyzed them via mass spectrometry. The results were then utilized in a proteomic approach to construct a platform of disease prediction/diagnosis. We also intended to build an integrated database of elderly patients and control group participants that includes clinical/health information, omics information (genomes, proteases, metabolites, etc.), nutritional status, life patterns, etc.

To construct the integrated database shown in Figure 2, which includes various dietary/lifestyle patterns, we conducted a survey on elderly adults' cognitive ability and dietary patterns (including dietary factors, intake patterns, and nutritional status).

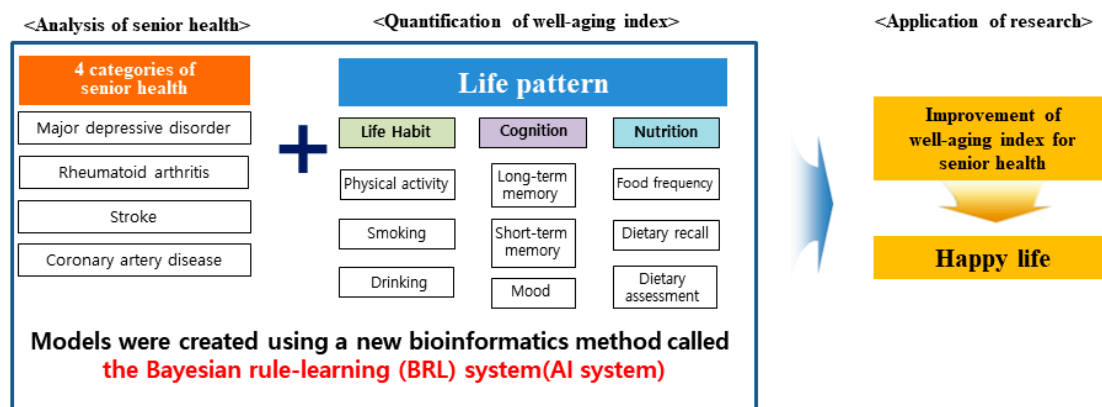


Figure 2. Concepts of well-aging indexing.

The Bayesian rule-learning (BRL) system is a method of statistical reasoning in which the posterior probabilities of the objects are inferred through the prior probabilities of the objects to be inferred and additional information. The BRL system is an effective algorithm for performing reasoning and learning, and is used to model knowledge in fields such as bioinformatics, pharmacy, document classification, image processing, data fusion, and decision support systems. The questionnaire comprised items on cognitive ability (14 items), life habits (11 items), and dietary habits (24 h diet recall interview, Food Frequency Questionnaire), and took about 10 min to complete. The targets of the questionnaire survey were (1) healthy and active elderly adults and (2) elderly adults who had been hospitalized for a disease.

The analysis results yielded clear differences in life patterns and related factors between the healthy and disease groups. Analyzing the dietary and life patterns of a large number of elderly helped us conceive a guideline for the WISH (Well-aging Indexing for Senior Health) platform (which concerns following desirable life patterns).

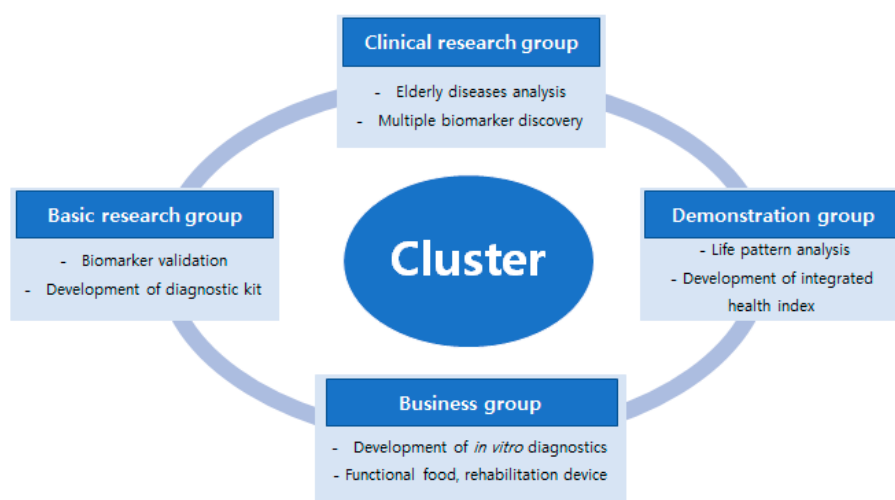
The creation of a consortium is necessary for achievement of goals related to technological development. Such a consortium has to have a diversity of perspectives and skills. As shown in Figure 3, four teams were created to form a consortium: the clinical research group, which focused on analyzing the four diseases noted above; a basic research group to verify the biomarkers of the four diseases and develop a practical kit; a practical demonstration group to collect data on blood biomarkers, dietary habits, and life patterns of the control group and to develop the combined health index; and a business group to oversee transfer of the developed technology.

To ensure that the different research teams coordinate effectively, it is essential to make available all the accumulated information and data, and to encourage understanding towards achievement of a research goal. To this end, we introduced the concept of open innovation.

To cope with a rapidly changing environment in the performance of innovative activities, external knowledge is utilized because there are limitations to relying on internal knowledge [19]. External knowledge refers to the demands or information derived from external customers (e.g., universities,

research institutes, competitors, consumers), while internal knowledge refers to internal resources (e.g., internal research institutes, managers, other departments). The ceaseless pursuit of openness to the acquisition of new knowledge leads to creativity [20]. Research on the increasing number of social firms supports the notion that fewer such firms depend on only internal sources when compared with those exercising the concept of open innovation [21].

This network formation can be connected to the law of increasing return, and can be understood in light of the concept of “economic development via creative destruction” asserted by Schumpeter [22]. There is always a trade-off between the scope of information and the quality of that information. However, an internet-based network has successfully eliminated this trade-off. The Internet is not limited to only that information that others are willing to deliver, which means that it is conducive to the creation of global networks [23]. There are several widely known successful cases (e.g., IBM and Apple), and recently there has been an increase in interest in biotechnology, new medicine, etc.



**Figure 3.** Composition of cluster for technological development.

#### 4. Status of the First Stage of the Research

To develop the WISH platform, we needed the participation of hospital clinicians, university professors, demonstration centers, etc. Eulji University has significant advantages to this end, as it has a focus on the health and medical sciences and has an affiliated university hospital. In addition, Eulji University runs senior firms consigned to Seongnam City, making it easy to access groups of elderly people.

A basic research group was composed, and in 2016, nearly 4.5 million USD in funding (to be delivered over the next 5 years) was granted by the Korea Research Foundation. The research group selected four diseases (related to the central nervous system, cardiovascular system, and musculoskeletal system) which are the most commonly occurring diseases among individuals aged 50 years old and above. The research group then sought to determine whether those diseases were natural consequences of aging or a result of the inter-relationships of other factors such as nutrition, exercise, etc. Drawing on the results of the blood-based multiomics analysis, we created a control group composed of healthy people of a similar age to those in a disease group, and examined the dietary and life patterns of both groups. This research is ongoing, and further comparisons between the groups are being conducted.

The main results of this research so far are outlined below.

- (1) We identified disease markers by utilizing blood-based multiomics analysis. We verified that ischemia resistance plays a significant role in patients suffering from transient ischemia, so we decided to utilize this to help standardize clinical practice for transient ischemia. Furthermore,

we identified that protein therapy using proteins related to rheumatism in serum could help us confirm musculoskeletal disorders. Protein therapy was also found to help in identifying candidate markers for diagnosing depression, and may be highly usable in the field of mental health.

- (2) We are in the process of statistical/epidemiological verification and the development of diagnosis and prediction models. The status of aging diseases was analyzed using backward cohort analysis (via National Health Insurance data). A search on the prevalence of these elderly diseases and their relative risks was also conducted, and the risk factors of each disease were analyzed. Furthermore, the associations between the biomarkers and diseases for various models were analyzed. Finally, a method for understanding the interactions between biomarkers and diseases or genes was developed, and its applicability was confirmed.
- (3) The nutritional markers for elderly diseases are in the process of being identified. An analysis of elderly adults' nutritional status and metabolism, as well as their interactions with various diseases, was conducted. Furthermore, the complex actions of various nutrients and their physiologically active substances were identified. Through the integrated hospital information service (HIS) proposal, which is based on dietary and life patterns, it was highly applicable to design by targeting the gradually increasing elderly population.
- (4) An analysis system for an integrated database (of clinical, nutritional, and life data) was built. An empirical study was conducted using a smart system/service, and guidelines pointing out relations between certain life patterns and diseases were developed via a comparison of life patterns between healthy and patient groups. In addition, questionnaires on the health of elderly people were administered and analyzed, and the study utilizing this analysis was successful.

The results of the above studies have been summarized in Table 1.

**Table 1.** Detailed goals and comparison of values.

Detailed Goals	Portion (%)
Identify disease markers	
Identify the relationship between diseases and investigated biomarkers Clinical/health information, omics (e.g., genome, proteome, metabolome), creation of integrated depression database using nutritional patterns and life patterns	20
Statistical/epidemiological verification and development of diagnosis and prediction models	
Analysis of relationship between biomarker diseases using various models	10
Analysis of the status of elderly diseases using backward cohort analysis/publishing an Science Citation Index (SCI)-level paper overseas	10
Development of information service system for various diseases	
Development of an information service system for elderly people	10
Establishment of guidelines for life patterns for the prevention of different diseases	10
Technological development of disease prediction/diagnosis based on biomarkers	10
Development of a prediction system based on an index of elderly diseases	10
Creation of an empirical cohort and data analysis technology	15
Development of models for health, dietary, and life patterns and their verification	15
Evaluation of a research tool and development of index indicators	15
Development of a nutrition index for use in database construction	15
Integrated database construction of elderly dietary patterns	10
Measuring the cognitive ability and life patterns of elderly patients	10
Based on an analysis of National Nutritional Research data, the overall dietary patterns of elderly adults were researched, and the difference in life patterns between different experimental groups was analyzed.	10
Total	100

### 5. Study Plan and Goal of the Second Stage

In the second stage of research, we aim to establish commercialization and standardization. Specifically, as shown in Figure 4, we seek to (1) standardize a medical examination program for patients based on relevant biomarkers; (2) develop indicators for use in the food industry that target elderly people, and standardize the utility of these indicators for senior health; and (3) establish an evaluation index for musculoskeletal and nervous system diseases. We intend to establish and verify the WISH Platform by fulfilling the above goals and developing a program for customized rehabilitation treatment.

After selecting the health variables that fit each aspect of WISH, we intend to evaluate the reliability of biomarkers for use in a health examination program that focuses on immune system, metabolic, musculoskeletal, and skin diseases. A classification of biomarkers for each disease has been made, and the frequency of each biomarker was analyzed as part of a re-evaluation of their representativeness for each disease in order to validate the use of these biomarkers in an evaluation program and for health checkups.

Moreover, by developing a service standardization model, which offers health-related information through application of a health index and an existing program for elderly health checkups, a health communication service model will be developed to provide patients with information on their checkup results, as well as provide a service model for lifestyle guidance.

Evaluation of the efficacy of the information and communication technology (ICT)-based clinical exercise programs for the elderly, and the development of evaluation systems for cognitive skills and customized functional improvement programs are progressing. The ICT-based contents of the elderly exercise programs, evaluation system for cognitive skills, and web-based customized skill-improvement program will be developed for use in clinical practice. In addition, we intend to develop a related program for various areas of nutritional therapy, and provide recipes for elderly adults based on the results of nutrition assessments. To conclude, through this progress, a pilot model of the WISH Platform will be established and the efficacy of the WISH Platform will be evaluated through pilot studies.

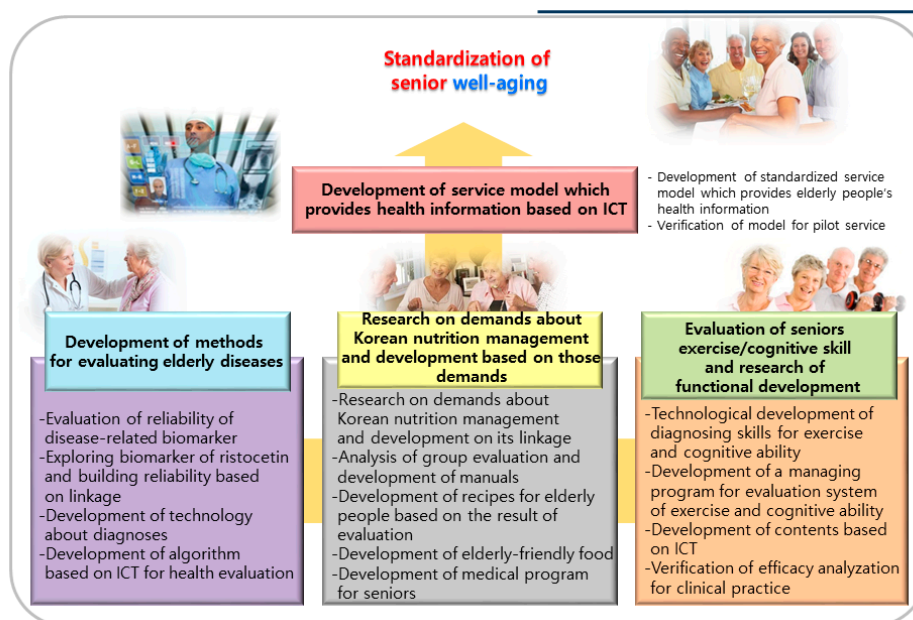


Figure 4. Studies of each department and their goals.

Table 2 provides a more detailed description of the findings and objectives of the three areas of study presented in Figure 4.



**Table 2.** Final research details and objectives.

Parts	Research Area		
Final Research Details	Development of new biomarkers and diagnostic technologies for four types of elderly diseases	Development of food- and nutrition-related programs by nutrition care area	Investigation of biomarkers related to elderly exercise and information technology (IT) and develop an IT diagnosis kit
	* Mental health index	Development of recipes for elderly people depending on the results of nutrition evaluations	Development of elderly exercise program, evaluation of IT index, and development of the system
	* Musculoskeletal disorders index	Development of integrated elderly exercise and cognitive ability improvement program	
	* Cerebrovascular disease index		
	* Cardiovascular disease index		
	Development of a health screening program using the disease markers linked to the 4 diseases		
	Development of a health evaluation algorithm based on ICT technology for seniors—the WISH (Well-aging Indexing for Senior Health) Platform		
Final Objectives	Development of an ICT-based elderly-specific health evaluation algorithm and development of a related program		
	Development of a service model to provide systematic and customized information about health through analysis of relevant data		
	Technological development of standardized elderly health business related to well-aging		

(\*) Index is the value of the risk factors of those diseases, which is parameter of the medical part of well-aging indexing.

## 6. Conclusions

As society has aged, how to live well in old age has become an increasingly important question. For many people, the answer to this question is “well dying”. This answer was initially proposed in a study by the British Economist Research in 2010, which was investigating a “quality-of-death index” using data on 40 OECD countries. This index, which defines what is considered an “elegant death”, was based on the relationship between aging and death. In the past, maintaining dignity in the face of death involved “humbly accepting death”, “not prolonging life”, “accepting death boldly”, and “returning property to society and ending without a disturbance”. However, nowadays, elderly society is confronting the idea that “facing death involves exploring life issues”, rather than facing death with dignity. Accordingly, well-aging is considered to have significant value in the current aging society.

In addition, technical development such as of the IoT, Big Data, and AI has led to an era of super creative destruction. Hence, no matter the age, provision of a standardized index of nutritional and life patterns for maintaining health could be helpful in designing an index of happiness for active elderly adults. However, developing such an index requires considerable time, cost, and effort from researchers. Furthermore, research on elderly people is not easy to conduct compared with other age groups. Nevertheless, we have conducted clinical research on depression, cerebral infarction, coronary artery, and rheumatism, which are common diseases in Korea, in order to develop a service model for providing systematic and customized health information using an ICT-based health diagnosis algorithm, programs, and information analysis. We expect that the goal of implementing standardized technology for elderly health will be realized.

In previous papers, only a variety of well-being measures based on national economic levels were presented, and most of the non-economic aspects of well-being (subjective) lacked common measures. As emphasized in the OECD Guidelines, an integrated approach to economic and non-economic aspects is needed to assess the realm of life. It is pointed out that the scale that can be utilized in aging society is very limited based on the statistics of diseases and social relations. In addition, since there is no process to adjust the supply system and the demand of the elderly for practical and useful products in order to reflect social needs specialized for the elderly in aged society, this paper aims to improve the quality of aged life.

The result of this paper is to standardize the happiness index for the elderly. To accomplish this, we will conduct simultaneous analysis on the effects of clinical application from the medical point of view, an exercise and cognitive function evaluation system in terms of life pattern, and a customized function improvement management program and clinical application. It is anticipated that the establishment of this standardization will have a proactive impact throughout the life of the aged society. It is also expected that each parameter value will be algorithmized and learned, which will help to present a solution to the individual and society, leading to a healthy life.

By applying the results of this study to chronic diseases, which appear differently in different countries among elderly people, it is possible to determine influential nutrition and life patterns for creating a standardized index. Moreover, international cooperative research is necessary in the future.

**Author Contributions:** The authors focus on value of happiness for elderly adults by comparing disease and healthy control groups in a multiomics analysis.

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**Conflicts of Interest:** Those authors declare that they have no conflict of interest.

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