Developing Innovation Ecosystem in Biomedical Field by Establishing Organized Physician-Scientists Nurturing System in Korea

By

RA, Sangwook

THESIS

Submitted to

KDI School of Public Policy and Management

In Partial Fulfillment of the Requirements

For the Degree of

MASTER OF DEVELOPMENT POLICY

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Abstract

In the post-corona era, Korea should strive to secure a new growth engine by creating an innovative ecosystem in the biomedical field and become a global first mover in biomedical technology. To this end, it is necessary to establish an organized physician-scientists training system, and to support growth as a leading independent researcher rather than simply participating in research. In addition, it is necessary to encourage doctors to participate in research by providing many benefits through institutional support, rather than for doctors to participate in research out of simple personal curiosity, and to increase the proportion of physician scientists in the long run. When looking at cases from other countries, the proportion of physician scientists in Korea is very low, and if many physician scientists are nurtured by benchmarking the cases of excellent physician scientists, it will be able to contribute to the development of biomedical technology in Korea.

The purpose of this study is to analyze the systematic method for nurturing physician scientists using AHP and to analyze the method for creating a hospital-centered innovative ecosystem. To this end, an AHP analysis model consisting of 13 detailed items and two areas of increasing incentives for research participation and supporting the growth of independent researchers was constructed.

Through this study, it was found that if the hospital provides an environment for research, such as reducing treatment hours and providing research facilities and space, participation in research increases. However, in the case of reduction of treatment hours, it is necessary to come up with a plan to compensate for the financial disadvantage of doctors.

In addition, institutional support is needed so that doctors can challenge start-ups to create a hospital-centered innovation ecosystem, and by establishing regional research-focused hospitals, the industry, academia, and research circles can collaborate with hospitals, and they should be linked to create a synergistic effect. Most of the existing major bio clusters in Korea have weaknesses in clinical trials and licensing. To solve this problem, it can be said that the participation of hospitals is essential.

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I. Introduction

Hospitals are the final demand for medical technology to be applied to patients, and the participation of hospitals and doctors is very important in the R&D and commercialization process to revitalize the biomedical industry. Hospitals in Korea have innovative potential such as concentration of excellent manpower and world-class information systems, but have focused on clinical trials rather than R&D. For this reason, doctors had no choice but to lack opportunities to participate in the research, and the conditions for improving the doctor's research capacity, such as the heavy treatment schedule, were very weak.

The purpose of this study is to analyze the causes of the shortage of medical scientists in Korea, to identify the role of hospitals to solve unmet needs in the biomedical field, and how to establish a systematic system for nurturing physician scientists. Hospitals can be said to be the center of research and innovation as the starting point and final demand for original technology research. Therefore, it is necessary to promote the development of the Korean medical industry by spreading the innovative ecosystem formed around the hospitals.

In the post-corona era, Korea must secure a new growth engine in the biomedical field and make efforts to become a global first mover in medical technology. To this end, it is necessary to establish a systematic physician-scientist training system, and to support growth as a leading independent researcher rather than simply participating in research. In addition, it is necessary to encourage doctors to participate in research by providing many benefits through institutional support, rather than for doctors to participate in research out of simple personal curiosity, and to increase the proportion of physician-scientists in the long term. When looking at the cases of other countries, the proportion of physician-scientists in Korea is very low. If many physician scientists are nurtured by benchmarking the cases of excellent physician scientists, it will solve the unmet needs of the biomedical field and contribute to the development of national biomedical technology.

Innovative Physician Scientist Joint Research Program, supported by the Ministry of Science and ICT, the Ministry of Health and Welfare, and National Research Foundation of Korea, has attempted to encourage doctors to participate in research by reducing medical treatment time and securing research time for doctors in hospitals. It is a four-year program that started in 2019 and is about to end this year. By conducting a survey on physician scientists who received support through this project, we intend to draw conclusions about the systematic training of physician scientists by collecting opinions from the medical field and supplementing the deficiencies.

II. Literature Review

2.1 Physician-Scientist

2.1.1 Concept of Physician-Scientists

Although the concept of physician-scientists has not been clearly defined, researchers who commonly hold a medical license (MD) and conduct medical-related research are classified as physician-scientists. Many experts have similar but slightly different definitions of physician-scientists. Davila (2016) defined a physician-scientist as a person who plays a unique role in linking basic science research and clinical practice, enabling new discoveries in the treatment, and understanding of human diseases (Davila, 2016). Also, Schwartz (2012) defined a physician-scientist as a researcher who plays a role as a bridge between medicine and science and has an important influence on the development of medical knowledge affecting human health (Schwartz, 2012). In summary, a physician-scientist can be defined as a translational researcher who combines medicine or basic science in a related field among doctors who conduct clinical trials (Choi et al., 2018).

An understanding of science and medicine enables physician scientists to ask clinically relevant questions in a research setting and integrate scientific inquiry into patient care (HH & TJ, 2022). Physician-scientists are needed for both disease mechanism research and bench-to-bedside translation. (Harding et al., 2017)

2.1.2 Importance of Physician-Scientists' Participation in Research

Since doctors perform lots of treatments, they easily find unmet needs in medical field. It is the role of physician-scientists to solve problems by researching based on these unmet needs. In other words, physician scientists are problem posers and problem solvers as well (Gotian & Andersen, 2020).

In the era of the 4th industrial revolution, nurturing physician-scientists is essential. The 4th industrial revolution is centered on new technological innovation and convergence, which will have a great impact on applied life science fields such as pharmaceutical research and bioindustry. Especially, for the development of the bio-industry that will lead the 4th industrial revolution, it is a very important issue to foster creative physician-scientists who can achieve convergence and complex technologies in the field of basic life science and clinical application (Choi et al., 2018).

In addition, the change in the medical paradigm of precision medicine is increasing the importance of nurturing physician-scientists. Whereas conventional medicine focused on disease symptoms and clinical results, precision medicine focuses on individual and diverse information such as genes, biomarkers, and life information. Basic scientific knowledge should be the basis to use this information for diagnosis, treatment, and prevention of diseases. Medical education, which does not know basic science and simply diagnoses according to symptoms, has the potential to significantly lag in the new paradigm of customized medical care that requires scientific knowledge (Choi et al., 2018).

Looking at the current flow of life sciences around the world, as the boundary between basic life science research and applied research is disappeared, the cycle from basic research results to the development of new drugs and new treatment technologies is getting shorter. In order to keep up with this trend, it is imperative to train a physician scientist who can play the role of an intermediary between basic life science research and clinical applied research and can oversee all processes from the planning stage of life science research to clinical application (Choi et al., 2018).

2.2 Current Status of Physician Scientists in Republic of Korea

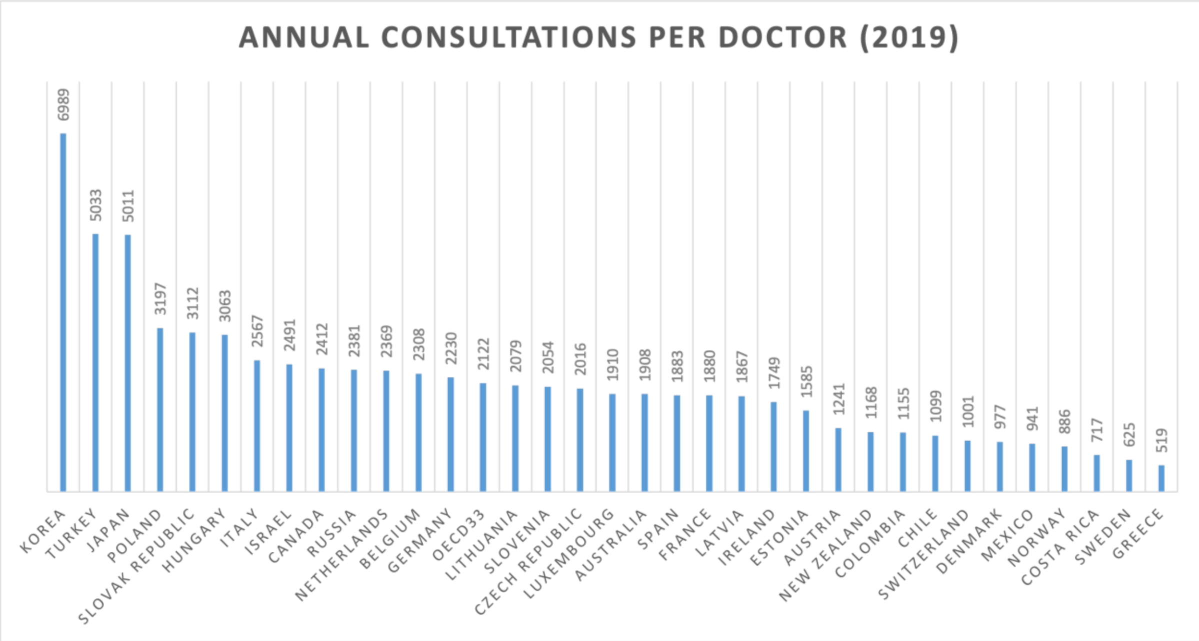
2.2.1 Shortage of Physician-Scientists

The educational goal of most medical schools in Korea is to train doctors who will give medical treatment. Therefore, the curriculum related to basic medicine is relatively reduced, and as a result, the scientific thinking ability of medical students and the development of basic research competency are gradually being distant. In other words, medical students' interest in the importance and necessity of basic medicine is decreasing because basic medicine is less important than clinical medicine in the medical school curriculum. This problem is leading to the reality that medical students avoid choosing basic medicine as their major. According to the Korean Academy of Medical Sciences (2014)'s 'Basic Medicine Nurturing and Physician Basic Medical Scientist Training Plan for Advancement of Medical Science', the number of majors in six fields, which do not provide clinical treatment, including anatomy, physiology, biochemistry, pharmacology, microbiology, and parasitology, is rapidly decreasing. In addition, the ratio of professors in these six basic medicine-related departments has been reduced from 60% in medical schools in the past to 40% as of 2014 (Choi et al., 2018).

Over the past 20 years, the best students in Korea have been concentrated in medical schools, so clinical skills have reached a high level. However, training for physician-scientists is lacking, and doctoral programs in basic medicine are being filled with graduates from basic science and engineering colleges instead of medical doctors. This may be due to the idea that the future of basic medicine is relatively uncertain compared to the future of medical clinicians. Shortcomings in future careers and lack of economic motivation can also be reasons. Intensive investment in this field is a global trend, and research results in this field are actually helping to treat patients worldwide, so active support and investment in the field of basic medicine are required (Song et al., 2022).

Hospitals in Korea have innovative potential such as concentration of excellent manpower and world-class information systems, but have focused on medical treatment rather than R&D. The conditions for improving the research capacity of doctors are weak, such as lack of opportunities to participate in research and heavy treatment schedule. According to OECD, in 2019, the number of in-person doctor consultations per person is 17.2 in Korea, which is the highest. The OECD average was 6.8 consultations per person per year, with most countries reporting 4-10 consultations(OECD, 2021). Moreover, Information on the number of doctor consultations per person can be used to estimate the annual numbers of consultations per doctor. As shown in Figure 1, Korea has the highest estimated number of consultations per doctor among OECD countries(OECD, 2021). Although this indicator cannot be said to be an absolute measure of the productivity of doctors, it can be indirectly shown that it is difficult for Korean doctors to devote time to research in such an environment. In this circumstance, it is not easy to encourage doctors to participate in research and increase the number of physician-scientists.

Figure 1. Estimated Number of Consultations per Doctor (OECD Health Statistics, 2021)



2.2.2 Medical Scientist Nurturing Program in Korea

Korean medical scientist training course officially started in 2009 when the medical graduate schools and the National Research Foundation of Korea established the MD-PhD course in the medical graduate schools (Choi et al., 2018). The MD-PhD is a combined medical science degree program that combines a professional degree program (MD) and an academic doctoral degree program (PhD). However, as major universities such as Seoul National University and Yonsei University abolished the medical graduate school system from 2010, the MD-Ph.D. course has become a nominal system. With financial support from the Ministry of Education and the National Research Foundation of Korea, the MD-PhD was maintained in the medical graduate school system, but since major universities such as Seoul National University and Yonsei University abolished the medical graduate school system, the program can no longer be continuously implemented and managed (Choi et al., 2018). In the end, MD-PhD support through the National Research Foundation of Korea has not been supported for new researchers or physician-scientists since 2016. Currently, Ministry of

Science and ICT, and Ministry of Health and Welfare are supporting physician-scientists through the Innovative Medical Scientist Joint Research Program and the Convergence Medical Scientist Nurturing Project. It is necessary to create a system that can systematically nurture physician-scientists through the analysis of the performance and complementary points of these projects.

Despite the social atmosphere in which excellent students enter medical school and the world-class medical environment, Korean medical school students are not willing to choose the path to become a medical scientist. According to Sang-Jeong Kim (2013) (Kim, 2013), the reason why doctors do not choose this career path is that uncertainty of future prospect, lack of social awareness of professionalism, and insufficient financial reward. The reasons why medical students do not choose the path of physician-scientists vary from personal problems to social systemic problems, and the root cause can be explained by the absence of a systematic curriculum for nurturing medical scientists. In the case of Korea, it is true that there is not enough support for physician-scientists to settle down as independent researchers compared to the United States. Physician-scientists in Korea are supported mainly by human resources training programs such as tuition support for master's and doctoral degrees and opportunities to participate in research for new clinicians. There were various institutional supports for nurturing medical scientists in Korea, but they were not activated due to the burden of clinical doctors on full-time doctoral programs, problems with remuneration, and disadvantages due to discontinuation of clinical careers.

2.3 Case Study of Nurturing Physician Scientists in Leading Countries

2.3.1 United States

The U.S. medical scientist training program started in the late 1950s when some medical schools introduced the MD-PhD (combined degree program) experimentally. In the case of Johns Hopkins School of Medicine, a representative MD-PhD educational institution, the MD-PhD combined degree program began as some students who were in the clinical course at the time temporarily stopped the clinical course and conducted experimental research. These MD-PhD programs were institutionally established in the early 1960s when the National Institutes of Health (NIH) began providing financial support to MD-PhD students (Lim, 2008). As of 2016, there were more than 90 active MD-PhD programs in the United States, 45 of which were supported by MSTP, for a total of 988 trainee slots. Since 1964, more than 10,000 students have received MSTP applications (Harding et al., 2017).

Table 1. MD-PhD Curriculum at Major U.S. Universities (Choi et al., 2018)

University	1Y	2Y	3Y	4Y	5Y	6Y	7Y
Harvard	Preclinical course lab rotation		Core clinical clerkship	Thesis research			Clinical clerkship
Stanford	Preclinical course		Graduate course thesis research	Thesis research		Preclinical course	
Yale	Preclinical/Basic science coursework		Clinical clerkship	Thesis research			Clinical clerkship
Columbia	Medical school course and graduate level course		Thesis research				The major clinical year

The general MD-PhD curriculum in the US is operated for 7-8 years in a 2+4+2 system. After completing the first two years of medical college education and four years of PhD research, students return to medical colleges and receive two years of clinical education. MD-PhD students who start the graduate PhD program must pass the thesis qualification test within one year and start the degree experiment in the laboratory of their choice while listening to the lecture. As a result, the time required for MD-PhD students to become medical scientists is usually 3-4 years (thesis Research period), somewhat shorter than 5-6 years for general PhD students (based on graduation from medical school). In the case of students, they can receive scholarships from the NIH, enabling efficient education (Lim, 2008).

Most medical schools that implement the MD-PhD curriculum ensure flexibility within the curriculum, such as course selection, interdisciplinary research environment, and individualized education, considering the uniqueness of students in the MD-PhD program. Harvard offers a variety of PhD courses that students can choose from the MD course (Yun-Hee Noh, 2005).

According to the results of a large-scale survey of US medical students from 2000 to 2006, MD-PhD students were more likely to plan a research-oriented career path than MD students. Most US MD-PhD students were more interested in applying basic scientific findings to research through clinical intervention than applying evidence-based medicine through clinical practice (Alamri, 2016). Therefore, most of the MD-PhD graduates were engaged in continuous research in the clinical department rather than the basic medicine department, and while they were professors in the clinical department, they invested about 60% of their time in basic research activities. Through this, it can be confirmed that MD-PhD students in the United States are not only providing clinical treatment to patients after graduation but are also very interested in patient and disease-centered biomedical research through clinical trials. In addition, MD-PhD graduates belonging to the Department of Basic Medicine are also doing clinical treatment for a short period of time, helping to advance basic biomedical research in a problem-solving direction without being separated from clinical problems. As such, the MD-PhD program in the United States is contributing to the cultivation of innovative medical scientists by breaking down the boundaries between conventional clinical medicine and basic medicine and providing basic biomedical research and clinical treatment services for patients (Lim, 2008).

The US system, which trains medical scientists through a flexible and flexible MD-PhD curriculum in schools based on a systematic support system at the national level, gives significant implications for nurturing domestic medical scientists. In particular, the US case is quite noticeable considering that 4% of all medical students in the US are trained as basic researchers through this program, and 14 Nobel Prize winners have been produced through this program over the past 15 years. According to the NIH, more than 80% of MSTP graduates continue to pursue careers as physician scientists (Harding et al., 2017).

2.3.2 Switzerland

The Swiss medical scientist training system started in 1992 when the dual degree system for MD-PhD was introduced to medical schools. Since then, Switzerland has established the MD-PhD program as a system operated by the national institutions SNSF (Swiss National Science Foundation) and SAMS (Swiss Academy of Medical) and as an MD-PhD program conducted by Swiss medical schools (Alamri, 2016). In particular, SAMS is expanding the scope of the medical scientist training system by actively providing scholarships not only to the MD-PhD program for nurturing young physician scientists, but also to parts such as clinical research, medical imaging, and biomedical ethics. It is noteworthy that in Switzerland, support for the MD-PhD program is not left to individual universities, but is systematically supported through the national institutions SNSF and SAMS (Choi et al., 2018).

Switzerland is not sparing any national assistance so that the basic medical research of medical scientists can achieve a proper fusion with clinical research. The characteristics of the Swiss medical scientist program is that faculty members of all Swiss medical schools are required to participate in the MD-PhD program. Faculty of the MD-PhD program in Switzerland actively encourage medical students to meet regularly with PhD students in other scientific fields such as physiology, epidemiology, and public health, so that basic and clinical research can be mutually beneficial. For this reason, the results of the MD-PhD program in Switzerland are quite positive in line with the purpose of nurturing medical scientists. As a result of the survey, 98% of students researched enough to write at least one medical journal during the course of the MD-PhD degree (Choi et al., 2018).

2.3.3 Singapore

Singapore's training system for physician scientists began when the National University of Singapore (NUS) launched the MBBS-PhD program in 2000. NUS's program was created with reference to the MBBS-PhD program of Cambridge University in the UK and MSTP in the US, which have been operating since the 1960s. Successful applicants to the MBBS-PhD program will receive scholarships from A*STAR and NUS, which include full tuition and a substantial salary. In addition, the option to pursue PhD programs at major UK institutes including Oxford University, Cambridge University and University of London is available (Choi et al., 2018).

A combined degree at NUS usually takes 8 years (3+3+2), including years of medical school, and can be completed in 7 years for outstanding students. Unlike in Korea, Singapore's medical scientist program is very competitive. For example, the MBBS-PhD program at NUS is highly competitive, with only 3-4 students selected out of 21-70 applications each year because it offers scholarships, overseas research opportunities, and a variety of early experiences on career tracks (Alamri, 2016).

Graduates of the MBBS-PhD program have a variety of career paths, such as the Clinical Research Track, the Basic Research Track, and the A*STAR Industry Track. In other words, in Singapore, the selection of the Physician Scientist program is of great interest among medical students because it not only fosters a research perspective, but also serves as an advantage when choosing a career in the clinical field in the future.

As such, Singapore's case is quite attractive in that it provides full support to students who have selected the Physician Scientist program at the national level. In particular, guaranteeing training opportunities at leading medical schools in the UK, providing prior experience on career paths, providing scholarships, and collaborating with scientific and technological research institutes are significant motivating factors for medical students in Singapore to enter the research path. This practical support has great implications for the Korean medical scientist training system, which tends to leave the selection of physician scientists to only the interests of medical students (Choi et al., 2018).

2.4 Biomedical Innovation Ecosystem

2.4.1 Bio Cluster in Korea

The Korean medical cluster is not a cluster that is built around hospitals, as it is a case in which bio-related companies and research institutes are planned or voluntarily accumulated and formed. However, recently, the establishment of a hospital-centered bio cluster has been planned and in progress. Severance Hospital in Songdo Biofrontier, Incheon, will be established as a regional research-oriented hospital, and KAIST and POSTECH are also planning to establish a research-oriented hospital and medical school.

Korean bio clusters began to be formed in 1997 centered on the private sector and local governments, and from 2009, government-led clusters, namely, medical-related industries, schools, and research institutes, began to be formed in each region as they were integrated. The government-led type is Biofront in Daegu, Gyeongbuk and Osong, Chungbuk, and the private-led type is Gangwon Wonju Medical Device Techno Valley. Currently, there are more than 16 domestic bio clusters by region, and there is an opinion that to discover successful cases of domestic clusters, synergies should be sought through linkage and cooperation instead of dispersion due to regional approaches (KHIDI, 2019).

Table 2. Current Status of Support by Major Bio Clusters in Korea (Yoon, 2017)

Location	Area(m^2)	Field	Strong Point	Weak Point
Wonju	3,795,000	Medical Device	Excellent support system for overseas market entry	Insufficient medical device clinical trial and licensing support system
Gwanggyo	420,312	New Medicine, Bio Venture	Excellent in providing equipment necessary for R&D and joint equipment for prototype production	Insufficient follow-up support such as commercialization support after prototype production
Daegu	1,030,000	Medicine, Medical Device	Excellent support system for R&D facilities, equipment, and commercialization	Insufficient support for clinical trials and licensing
Daejeon	11,563	Convergence Technology	Active R&D and establishment of growth environment centered on bio companies	Difficulties in clinical and licensing phases and insufficient support system
Hongneung	21,937	Bio Venture	Excellent support for start-up incubation and start-up support	Many overlapping projects with related organizations
Songdo	900,809	Biomedical Industry	Professional services related to clinical trials are provided mainly by overseas global companies	There are companies that produce pharmaceuticals such as biosimilars, but there is no production service linked with SMEs.
Osong	1,131,054	Medicine, Medical Device	Excellent support centered on efficacy and safety evaluation, which is the pre-clinical trial stage from the discovery of candidate substances	Insufficient support services related to clinical trials and licensing

According to a recently published study (Yoon, 2017), major bio clusters in Korea show differences in strengths and areas in need of supplementation by value chain stage (R&D, prototype development, preclinical testing, clinical trials, licensing/evaluation, production and sales). These differences need to be used as a win-win strategy to share the strengths of each cluster and compensate for the weaknesses through linkage and cooperation between clusters. It is necessary to approach and materialize the linkage and cooperation plans between clusters by each detailed topic. For example, cooperation for the advancement of source technology, business incubation, cooperation for innovative start-up of SMEs (sharing methods of expanding investment attraction, etc.), and fund formation for attracting and nurturing SMEs can be reviewed (KHIDI, 2019).

2.4.2 Hospital-Centered Innovation Ecosystem

Looking at overseas cases, hospitals can be a factor driving the development of the health industry one step further. Looking at the changes in our society over the years, specific industries have developed in the form of leading national development based on excellent talent. The heavy chemical industry in the 70s and the IT industry in the 90s would be a typical example. Even though hospitals are densely populated with talented people in the 21st century, they do not show significant activities in industrial aspects other than patient care (KHIDI, 2019).

Hospitals are the endpoint of the health industry, and doctors are the end-users. However, despite their clear presence, they were unable to deviate from advisory-level activities, and because they were immersed in medical care, they did not have time to contemplate or contribute to research related to the health industry. The UK, like Korea, has an Academic Health Science Center (AHSC) system which is research-oriented hospitals. Research-oriented hospitals are formed through partnerships between universities and NHS (National Health Service) institutions for the purpose of bringing basic research capabilities to technology commercialization. If selected as a research-oriented hospital, government-run programs for research-industry communication, R&D-related tax benefits, patent tax reduction benefits, knowledge transfer-related fund support and investment fund creation are supported (KHIDI, 2019).

The Boston cluster in Massachusetts, USA is a successful representative example of active exchange between hospitals and industries in the hospital-centered health industry. The Boston cluster is a cluster formed spontaneously around Harvard University, MIT's research-oriented hospitals, and Massachusetts General Hospital. Boston is a cluster focused on biotechnology. As of 2016, Boston was the most NIH-funded city in the United States for 22 consecutive years, with more than 12,000 biotech jobs created. 18% of jobs in Boston are in the health industry, and 5 in 10 large employers are in hospitals. MassBio, a non-profit organization in the Boston area, is supporting the cluster. It receives annual fees to member companies to provide tax benefits, administrative convenience, legal, accounting, public relations, and advisory services, and requests the federal government to improve related systems. In addition, by holding regular meetings, it is playing a role in supporting information exchange and networking with biotech companies and clusters in the US as well as in the Boston area (KHIDI, 2019).

In Korea, high-quality manpower, companies, jobs, and large hospitals in the bio sector are concentrated in the metropolitan area, making regional clusters less competitive. Of the 10 research-oriented hospitals, 9 are in the metropolitan area except Kyungpook National University Hospital, and only Seoul, Incheon, Gyeonggi, and Daejeon have large hospitals with more than 1,000 beds.

Boston Regional Hospital is actively commercializing research results in cooperation with universities and companies. We actively commercialize the research results by utilizing the technology commercialization organization in the hospital and form cooperative groups with companies and universities for efficient commercialization and actively exchange. In Korean hospitals, it is difficult to establish a subsidiary for technology commercialization according to the Medical Law, etc., so when commercializing hospital research, the hospital does not directly do it, but utilizes the industry-academic cooperation group belonging to the same school corporation or conducts it mainly by individual doctors. In the end, all the profits from commercialization of hospital research go to the university's industry-academic cooperation foundation, so it is impossible to reinvest these profits in hospital R&D again. Because of these aspects, there is a limit to commercializing hospital research. Therefore, there is a need for institutional arrangements and an organization dedicated to commercialization of research-oriented hospitals so that the research results of hospitals can be commercialized, and the profits can be reinvested in hospital research. In addition, it is necessary to increase the number of research-oriented hospitals, which are concentrated in the metropolitan area, by region and to create a hospital-centered innovation ecosystem to revitalize regional base clusters (MassBio, 2021).

III. Methodology

3.1 Data Collection

Since this study is a study on the systematic nurturing of physician-scientists, data was collected for the purpose of establishing indicators for systematic nurturing of physician-scientists and investigating the priority of application.

The data investigation was conducted in two stages. First, through an expert advisory meeting including university and hospital professors, the method for nurturing medical scientists was discussed, and then indicators were set for systematic nurturing of medical scientists. After setting the index, the priority of application for the corresponding index was investigated through AHP analysis.

Second, based on the set indicators, a survey was conducted targeting young physician-scientists who participated in the Innovative Physician Scientist Joint Research

Program promoted by the government (Ministry of Science and ICT, Ministry of Health and Welfare). The contents of the survey consist of young physician-scientists on the indicators previously investigated through AHP analysis by experts in the field, the effect of reduction of treatment hours and securing research time, thoughts on starting a business, etc.

3.2 The Analytic Hierarchy Process (AHP) Analysis

T. L. Saaty developed the Analytic Hierarchy Process (AHP) in 1971-1975 at the Wharton School (University of Pennsylvania, Philadelphia, Pennsylvania). Analytic Hierarchy Process (AHP) is used to derive ratio scales from discrete and continuous pairwise comparisons. These comparisons can be made on actual measurements or on base scales that reflect the relative strength of preferences and emotions. It has been widely applied in multi-criteria decision-making, planning and resource allocation, and conflict resolution. In its general form, AHP is a non-linear framework for conducting deductive and inductive thinking without the use of syllogisms by considering multiple factors simultaneously, allowing dependencies and feedback, and making numerical trade-offs to arrive at a synthesis or conclusion (Saaty, 1987).

The basic multi-criteria decision analysis procedure through the AHP technique is generally carried out through five steps: 1st hierarchical structure formation, 2nd pairwise comparison, 3rd weight calculation, 4th consistency evaluation, and finally, final option selection (Yoon, 2019).

3.3 Setting Indicators for Nurturing Physician-Scientists

An expert advisory meeting was held to set the indicators for systematic nurturing of physician-scientists and to investigate the priority of application. The advisory council consisted of 6 professors at university or hospital. The members composed of 2 hospital vice presidents, 2 MD-Ph.D., 2 young physician-scientists. The advisory meeting discussed how to create incentives for Korean doctors to participate in research and how to systematically train medical scientists. Based on the discussion, indicators for systematic nurturing of physician-scientists were established.

After setting the indicators for systematic nurturing of physician-scientists, the priorities of the indicators were investigated through AHP analysis for 6 experts who participated in the advisory meeting. The survey for AHP analysis was performed using the cloud Social Science Research Automation (SSRA) site (ssra.or.kr). SSRA is a cloud-based system that helps social science researchers fill out questionnaires, supports data collection using web and mobile, and supports statistical processing of collected data to improve research productivity, and it is known to eliminate errors that may occur and ensure transparency in the research process (Yoon, 2015).

This study used a 13-point scale survey, a comparative judgment matrix was prepared for everyone using the pairwise comparison figures for each respondent's evaluation criteria (competence domain, competency item), and the relative importance of each competency factor considered by each respondent was calculated (Saaty, 1988).

Validity was secured by calculating the inconsistency index and compatibility index to check the logical consistency of the response data for each expert and to identify the degree of outliers in individual opinions.

The AHP model analysis of this study was performed using the AHP analysis function provided by SSRA. SSRA's AHP analysis function was constructed using R, an open-source software, and it provides reliability analysis and a function to collectively calculate the importance of each evaluation item calculated by the geometric average method of the response value for each respondent.

3.4 Description of the Survey Data

In 3.3, indicators were set for the hospital-centered systematic nurturing of physician scientists. Based on the set indicators, a survey was conducted for young physician scientists who participated in the Innovative Physician Scientist Joint Research Program, which was promoted by the government (Ministry of Science and ICT, Ministry of Health and Welfare) and is about to end. For the set indicators, the priority of application was investigated among young physician-scientists. In addition, a survey was conducted on the effects of reduction of treatment hours and securing research time supported through the Innovative Physician Scientist Joint Research Program, thoughts on starting a business, and continued participation in research in the future. The survey items are shown in [Table 3] below.

Table 3. Contents of Survey

No.	Questions
1	Overall, do you think Korean doctors' treatment hours are excessive?
2	Was the reduction of treatment hours through the Innovative Physician Scientist Joint Research Program helpful in conducting research?
3	Do you think the rate of reduction of treatment hours and securing of research hours (40%) for the Innovative Physician Scientist Joint Research Program is appropriate?
4	If you can start a business through research, would you do it in the future?
5	Do you think that research-oriented hospitals for each regional base are necessary to foster physician scientists and create a hospital-centered innovation ecosystem?
6	Are you willing to do research as a full-time basic medical scientist without medical treatment anymore?
7	If the hospital grants a reduction in treatment hours and secures research time even after the end of the project, are you willing to continue your research as a physician scientist while providing medical treatment?
8	If the hospital no longer offers a reduction in treatment hours after the end of the project, are you willing to continue your research as a physician scientist while providing medical treatment?
9	Please select all items that you think are important for systematic nurturing of physician-scientists (Increasing incentives for research participation)
10	Please select all items that you think are important for systematic nurturing of physician-scientists (Support for the growth of independent researchers)

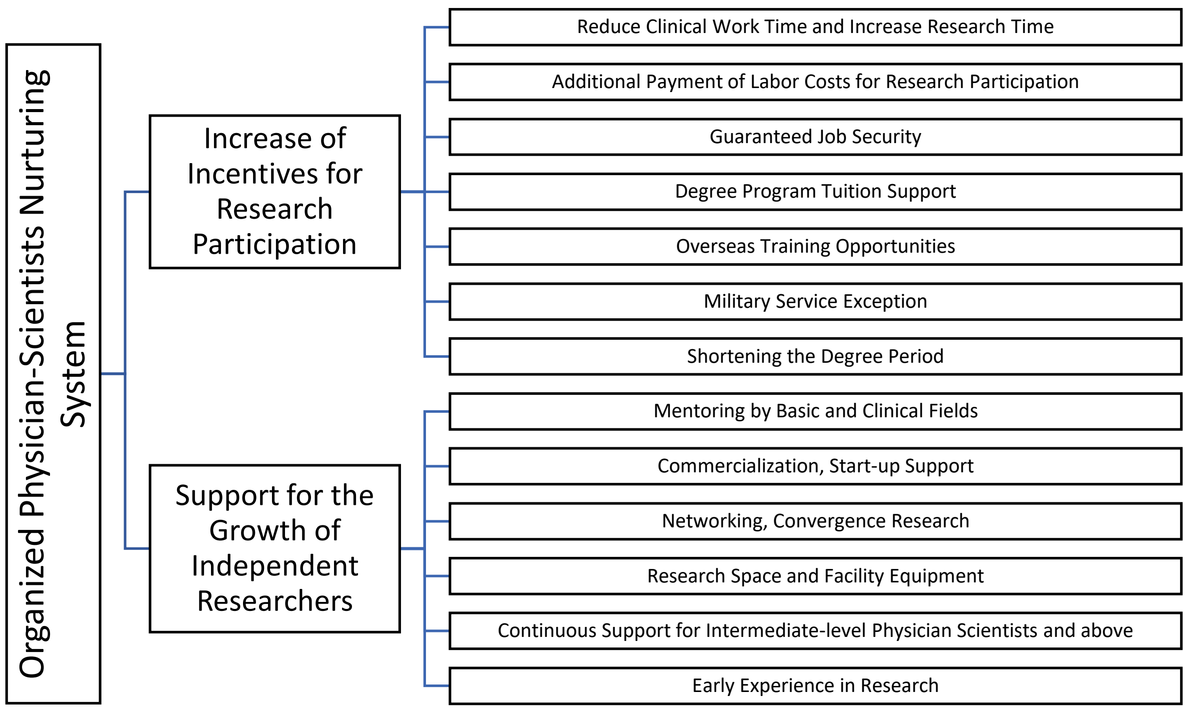
IV. Data Analysis

4.1 Design of AHP

4.1.1 Design of Hierarchy

First, in the AHP technique, a hierarchical structure is formed for the overall goals, evaluation criteria, and alternatives for the multi-criteria decision-making problem. A hierarchical structure was formed as shown in [Figure 2]. To analyze hospital-centered systematic physician-scientist nurturing, the AHP analysis model was composed of 13 items included in two areas: expanding incentives for research participation and supporting the growth of independent researchers.

Figure 2. Hierarchical Structure of Hospital-centered Systematic Physician-Scientists Nurturing



4.1.2 Weighted Evaluation

After designing the Hierarchy, a priority survey was conducted with 6 experts for 13 items. After sufficiently discussing the systematic nurturing of physician-scientists, pairwise comparisons were made for each of the 13 defined items to evaluate their relative importance.

The survey was conducted using a ratio scale from 1 to 7 and a 13-point scale. Weights are calculated through pairwise comparison, which means the relative importance and preference of each item.

According to Yoon (Yoon, 2019), weight calculation consists of a three-step process. In the first step, a pairwise comparison matrix is calculated. In the composition of the pairwise comparison matrix, the measured value obtained by the opponent is expressed as a fraction, and the inverse is given to the opposite side centered on the diagonal. Step 2 normalizes the pairwise comparison matrix. The normalization of a matrix is a new matrix created by dividing the sum of the corresponding columns of the matrix, and the sum of each column becomes '1'. Step 3 calculates the final weight by averaging each row of the normalization matrix created in step 2. In this case, the sum of the weights becomes '1'. The weights for the two fields were calculated as shown in the table below, and the weights for each item were rounded up to the third decimal place.

Table 4. Evaluation of Weight and Priority (Increase of Incentives for Research Participation)

Increase of Incentives for Research Participation	Weight	Priority
Reduce Clinical Work Time and Increase Research Time	0.212	2
Additional Payment of Labor Costs for Research Participation	0.258	1
Guaranteed Job Security	0.149	4
Degree Program Tuition Support	0.061	6
Overseas Training Opportunities	0.055	7
Military Service Exception	0.150	3
Shortening the Degree Period	0.115	5
Total	**1**	**-**

Table 5. Evaluation of Weight and Priority (Support for the Growth of Independent Researchers)

Support for the Growth of Independent Researchers	Weight	Priority
Mentoring by Basic and Clinical Fields	0.127	3
Commercialization, Start-up Support	0.101	5
Networking, Convergence Research	0.088	6
Research Space and Facility Equipment	0.277	2
Continuous Support for Intermediate-level Physician Scientists and above	0.282	1
Early Experience in Research	0.126	4
Total	**1**	**-**

4.1.3 Consistency Analysis

AHP verifies reliability by checking the Consistency Ratio (CR) to confirm that the respondents of the questionnaire performed the evaluation with consistency. The consistency ratio means the value obtained by dividing the Consistency Index (CI) by the Random Index (RI), and a value of 0.1 to 0.2 or less is reliable. In this study, the reliability of the questionnaire for experts was verified using less than 0.1 as a standard value, and the consistency ratio of all six experts who participated in the questionnaire was less than 0.1, which was judged to be reliable.

$$CI = \frac{\lambda_{max} - n}{n-1}, \qquad CR = \frac{CI}{RI}$$

Random Index (RI) can be calculated according to the size of the matrix. RI values according to the size (n) of the matrix are shown in the [Table 6] below (Saaty & Vargas, 2001).

Table 6. RI according to the size of the matrix (n) (Saaty & Vargas, 2001)

n	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
RI	0	0	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

For Increase of Incentives for Research Participation, n=7, RI=1.35, and for Support for the Growth of Independent Researchers, n=6, so RI=1.25. The RI, CI, and CR values are shown in the [Table 7] below, and it can be considered that there is no problem in consistency.

Table 7. Calculation of Consistency Ratio (CR)

Section	**n**	**RI**	**CI**	**CR**
Increase of Incentives for Research Participation	7	1.35	0.0219	**0.0162**
the Growth of Independent Researchers	6	1.25	0.0074	**0.0059**

4.2 Design of Survey

A survey was requested from 80 young physician scientists who participated in the Innovative Physician Scientist Joint Research Program as PI (Principal Investigator), but 24 of them responded to the survey. Respondents were provided with benefits such as reduced treatment hours, research space and facilities, research funds, and education from the hospital for at least 2 years and up to 4 years through this project. The average age of 24 respondents is estimated to be 39.9 years old.

4.2.1 Adjustment of Treatment Hours to Secure Research Time

The first question is about the overall working hours of Korean doctors. 100% of the respondents agreed that Korean doctors' treatment hours were excessive. Among them, 79.2% selected that they strongly agreed that the treatment hours of Korean doctors were excessive.

The second question is whether the reduction of treatment hours and securing of research time for doctors in the Innovative Physician Scientist Joint Research Program helped the research performance. Of the respondents, 75% said it was helpful, and 8.4% said it was not helpful.

The third question is whether it was appropriate to allocate 40% of working hours to research hours by reducing medical hours for doctors in the Innovative Physician Scientist Joint Research Program. 37.5% of the respondents answered that it was appropriate, and 54.2% answered that it was insufficient (requires more than 50% of research time). There was no respondent who chose 40% of the research time as excessive, but there was an opinion that it is necessary to review a method that can guarantee the disadvantages of securing the forced research time.

Table 8. Survey Results (Adjustment of Treatment Hours to Secure Research Time)

<table>
<tr><th colspan="8">Q1: Overall, do you think Korean doctor’s treatment hours are excessive?</th></tr>
<tr><td>Strongly Agree</td><td colspan="4">Agree</td><td>Neutral</td><td>Disagree</td><td>Strongly Disagree</td></tr>
<tr><td>79.2%</td><td colspan="4">20.8%</td><td>-</td><td>-</td><td>-</td></tr>
<tr><th colspan="8">Q2: Was the reduction of treatment hours through the Innovative Physician Scientist Joint Research Program helpful in conducting research?</th></tr>
<tr><td>Strongly Agree</td><td colspan="4">Agree</td><td>Neutral</td><td>Disagree</td><td>Strongly Disagree</td></tr>
<tr><td>37.5%</td><td colspan="4">37.5%</td><td>16.7%</td><td>4.2%</td><td>4.2%</td></tr>
<tr><th colspan="8">Q3: Do you think the rate of reduction of treatment hours and securing of research hours (40%) for the Innovative Physician Scientist Joint Research Program is appropriate?</th></tr>
<tr><td rowspan="2">Appropriate
(40%)</td><td colspan="4">Insufficient</td><td rowspan="2">Excessive</td><td colspan="2" rowspan="2">Other Opinion</td></tr>
<tr><td>50%</td><td>60%</td><td>70%</td><td>80%</td></tr>
<tr><td>37.5%</td><td>16.7%</td><td>25%</td><td>8.3%</td><td>4.2%</td><td>-</td><td colspan="2">8.3%</td></tr>
</table>

4.2.2 Creating a Hospital-Centered Innovation Ecosystem

The fourth question asked about ideas about starting a business. 4.2% of the respondents had never thought about starting a business, and 95.8% of the respondents were interested in starting a business. When an item is discovered through R&D, the highest number of respondents (37.5%) said they were willing to start a business at any time. In addition, 33.3% of the respondents said they were interested in starting a business but lacked time, and 25% said they were interested in starting a business but were concerned because of the risk.

The fifth question is whether regional research-focused hospitals are needed to train physician scientists and create a hospital-centered innovation ecosystem. 75% of the respondents answered that they need a regional research-focused hospital, and 12.5% of the respondents answered that they don't.

Table 9. Survey Results (Creating a Hospital-Centered Innovation Ecosystem)

Q4: If you can start a business through research, would you do it in the future?				
Haven't thought about starting a business yet	If startup items are discovered through R&D, willing to start a business at any time.	Interested in starting a business, but not enough time	Interested in starting a business, but worried about the risk	No intention to start a business
4.2%	37.5%	33.3%	25%	-
Q5: Do you think that research-oriented hospitals for each regional base are necessary to foster physician scientists and create a hospital-centered innovation ecosystem?				
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
54.2%	20.8%	12.5%	4.2%	8.3%

4.2.3 Continue to Participate in Research

The sixth question is whether you are willing to do research as a full-time basic medical scientist without any further medical treatment. 33.4% of the respondents answered that they could do research as a full-time basic medical scientist without further treatment, and 54.2% of the respondents answered that they do not intend to become a full-time basic medical scientist.

The seventh question is whether the research will be continued while providing treatment at the hospital if the hospital continues to reduce the treatment hours and secure the research time. 91.7% of the respondents said they would continue to do research, and 4.2% of the respondents said they would not continue to do research anymore.

The eighth question is whether the research will be continued while providing treatment at the hospital if the hospital no longer provides a reduction in treatment hours and separate research hours. 41.7% of the respondents said they would continue to do research, and 33.4% of the respondents said that they would not continue to do research anymore.

Table 10. Survey Results (Continue to Participate in Research)

Q6: Are you willing to do research as a full-time basic medical scientist without medical treatment anymore?				
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
4.2%	29.2%	12.5%	37.5%	16.7%
Q7: If the hospital grants a reduction in treatment hours and secures research time even after the end of the project, are you willing to continue your research as a physician scientist while providing medical treatment?				
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
66.7%	25%	4.2%	-	4.2%
Q8: If the hospital no longer offers a reduction in treatment hours after the end of the project, are you willing to continue your research as a physician scientist while providing medical treatment?				
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
16.7%	25%	25%	29.2%	4.2%

4.2.4 Priority Survey

The relative importance considered by young physician-scientists with the same items for the indicators defined in 4.1.1 was investigated (multiple selection possible).

The ninth question was asked to select all the indicators that were considered important among the indicators for the expansion of incentives for research participation. Regarding the expansion of incentives for research participation, the part about the payment of labor cost or additional allowance for research participation was the most important, and the part about reducing medical hours, securing research time, and guaranteeing job stability was the next most important priority. The degree program tuition support was the lowest priority, and it is judged that there is no great merit in participating in the research.

The tenth question was asked to select all the indicators that were considered important among the indicators for the growth support of independent researchers. Regarding support for the growth of independent researchers, the importance of continuous support for mid-level and above medical scientists was the highest, and the provision of infrastructure such as research space and facilities, and activation of convergence research such as networking was the next most important priority. The part about supporting the early experience of research had the lowest priority, and it is judged that there is no great merit.

Table 11. Survey Results (Priority Survey)

Q9: Please select all items that you think are important for systematic nurturing of physician-scientists (Increasing incentives for research participation)		
Increase of Incentives for Research Participation	**Importance**	**Priority**
Reduce Clinical Work Time and Increase Research Time	70.8%	2
Additional Payment of Labor Costs for Research Participation	95.8%	1
Guaranteed Job Security	45.8%	3
Degree Program Tuition Support	8.3%	7
Overseas Training Opportunities	37.5%	4
Military Service Exception	25%	5
Shortening the Degree Period	16.7%	6
Q10: Please select all items that you think are important for systematic nurturing of physician-scientists (Support for the growth of independent researchers)		
Support for the Growth of Independent Researchers	**Importance**	**Priority**
Mentoring by Basic and Clinical Fields	33.3%	4
Commercialization, Start-up Support	33.3%	4
Networking, Convergence Research	50%	3
Research Space and Facility Equipment	58.3%	2
Continuous Support for Intermediate-level Physician Scientists and above	79.2%	1
Early Experience in Research	20.8%	6

V. Discussion

5.1 Result of Survey

According to the results of the survey in 4.2.1, doctors in Korea think that Korean doctors' working hours are excessive. Also, according to the OECD, it is estimated that Korea has the highest number of patient care per doctor in the world. In such a situation, it is clearly difficult to devote personal time to research, and there is a need for institutional support.

The Innovative Physician Scientist Joint Research Program provided institutional support for doctors to reduce their treatment hours and allocate research time in hospitals. Assuming 100% of the total work hours, at least 40% of them were allocated to research time, and 75% of the survey respondents said that this support was very helpful in carrying out the research.

In addition, more than 50% of the respondents answered that they needed more research time than 40%, suggesting that it was effective policy to reduce treatment time and allocate research time. In the future, it is necessary to review the direction of providing more research time.

In the survey of 4.2.2, the establishment of a hospital-centered innovation ecosystem was investigated. First, no one responded that they would not start a business, and it was investigated that they were willing to start a business if they found a good start-up item and had time to spare. If R&D support for discovering start-up items is diversified, Korea will have more doctors interested in start-ups like the United States.

75% of the respondents answered that regional research-focused hospitals were needed to nurture medical scientists and create a hospital-centered biomedical innovation ecosystem. Currently, major hospitals in Korea are concentrated in metropolitan areas such as Seoul and Gyeonggi-do, and regional research-focused hospitals are needed to link bio clusters and hospitals in each region. Like Boston's bio cluster, Korea needs to establish a network with large hospitals, excellent universities, and various companies that can conduct research and clinical trials and create an excellent environment for nurturing talented physician-scientists.

In the survey of 4.2.3, a questionnaire was conducted on the continued participation of doctors in research. First, it was investigated whether it is possible to transform into a full-time basic medical scientist who only conducts research without providing medical treatment.

First, it was investigated whether it is possible to turn into a full-time basic medical scientist who only conducts research without providing medical treatment. As a result of the survey, more than 50% of the respondents said that they would not be a full-time basic medical scientist. This shows that it is not practically easy for doctors to give up their main occupation of treatment and focus on research.

The same respondents were asked what they thought of providing medical treatment and conducting research at the same time. First, more than 90% of the respondents answered that they would continue research in parallel with medical treatment if hospitals support the research environment. On the other hand, when hospital support is no longer available, only about 40% of the respondents answered that they would continue their research in parallel with treatment. This means that the hospital's research support should be supported continuously, not temporarily.

Table 12. Comparison of Research Participation According to Hospital Support

Options	Continue to Participate in Research	
	with Support from Hospital	without Support from Hospital
Strongly Agree	66.7%	16.7%
Agree	25%	25%
Neutral	4.2%	25%
Disagree	-	29.2%
Strongly Disagree	4.2%	4.2%

5.2 Result of Priority Analysis

Through the AHP analysis and survey, a priority survey was conducted on the indicators for the systematic nurturing of medical scientists centered on hospitals. The priorities generally tended to be similar, especially in each part of increase of incentives for research participation and support for the growth of independent researchers, the 1^{st} and 2^{nd} rankings of AHP and the 1^{st} and 2^{nd} rankings of survey are coincided.

Combining the AHP and the survey, the priorities that need to be applied were derived. First, as incentives for doctors to participate in research, financial compensation for research participation is required first, and it is necessary to reduce excessive treatment time and provide sufficient research time.

Second, for doctors to grow as independent researchers, it is necessary to continue to provide support from hospitals, such as reduction of treatment hours, for medical scientists of intermediate level or higher. In addition, it is judged that providing sufficient research space, research facilities, and equipment for medical scientists in hospitals will help medical scientists to grow as independent researchers.

Table 13. Priority Results of AHP and Survey

Increase of Incentives for Research Participation	**Priority**	
	AHP	**Survey**
Reduce Clinical Work Time and Increase Research Time	2	2
Additional Payment of Labor Costs for Research Participation	1	1
Guaranteed Job Security	4	3
Degree Program Tuition Support	6	7
Overseas Training Opportunities	7	4
Military Service Exception	3	5
Shortening the Degree Period	5	6
Support for the Growth of Independent Researchers	**Priority**	
	AHP	**Survey**
Mentoring by Basic and Clinical Fields	3	4
Commercialization, Start-up Support	5	4
Networking, Convergence Research	6	3
Research Space and Facility Equipment	2	2
Continuous Support for Intermediate-level Physician Scientists and above	1	1
Early Experience in Research	4	6

VI. Conclusion

6.1 Findings

Through this study, it was found that if the hospital provides an environment for research, such as reducing treatment hours and providing research facilities and space, participation in research increases. However, in the case of reduction of treatment hours, it is necessary to come up with a plan to compensate for the financial disadvantage of doctors. Moreover, according to the survey, there are many opinions that it is not enough to allocate 40% of working hours to research time, so it is necessary to increase the proportion of research time to treatment time. In the future, when planning a human resources training program or R&D support project to support physician scientists, these aspects should be additionally considered.

In addition, institutional support is needed so that doctors can challenge start-ups to create a hospital-centered innovation ecosystem, and by establishing regional research-focused hospitals, the industry, academia, and research circles can collaborate with hospitals, and they should be linked to create a synergistic effect. Most of the existing major bio clusters in Korea have weaknesses in clinical trials and licensing. To solve this problem, it can be said that the participation of hospitals is essential.

In this study, indicators necessary for systematic nurturing of physician scientists were established, and the relative importance of each indicator was investigated. As a result of the AHP analysis and survey, it was found that the above-mentioned financial compensation for research participation, reduction of treatment hours and securing of research time were relatively more important to expand incentives for doctors to participate in research. In the case of the United States, research expenses can be included in internal labor costs, so you can receive more labor costs as much as you participate in the research.

By benchmarking some of these systems, a system should be prepared so that the financial disadvantage caused by the decrease in the number of medical treatments can be covered by research funds. If such a system is in place, doctors can participate in research as much as they want, and hospitals can secure labor costs as much as doctors participate in research, so there is no need to demand excessive treatment. Also, if the burden of labor costs is eliminated by research funds, it is possible for hospitals to reduce the treatment time at the hospital and provide sufficient research time without burden.

According to the AHP analysis and survey, for doctors to grow as independent researchers, they must provide continuous support to physician scientists who are senior researchers or higher, and provide sufficient infrastructure support such as research space, facilities, and equipment. If the hospital's support, such as reduction in treatment hours, research space, and facility equipment support, is stopped midway, there is a high possibility that existing studies may be discontinued. Therefore, there is a need for institutional support so that the career as a physician scientist can be maintained throughout the entire cycle rather than a short-term project.

6.2 Policy Recommendations

To create an innovative ecosystem in the biomedical field, it is necessary to systematically nurture physician scientists, and to prepare a plan for cooperation and linkage with hospital-centered bio cluster. To this end, I would like to make some policy proposals. First, to reduce the treatment time of doctors in hospitals and provide sufficient research time, institutional supplementation should be made so that the research expenses can be used to cover the labor costs. Currently, research expenses cannot cover the labor costs of doctors in hospitals, so they get financial losses as they provide less medical treatment. It is necessary to create a research environment so that doctors receive labor costs from research funds as much as they participate in research in consultation with hospitals and receive labor costs from hospitals as much as they participate in medical treatment, so that doctors can freely invest their time in research.

Second, the institution needs to be improved so that profits from business start-ups and technology transfer in hospitals can be reinvested in hospitals. As a non-profit organization, hospitals cannot receive external investment, and hospitals cannot invest in start-up companies. In addition, when doctors or researchers starts a business in a hospital, the hospital cannot earn a profit, and even if a business is supported through a university-industry-academic cooperation foundation, the virtuous cycle structure of reinvesting in the hospital is blocked. The system needs to be improved so that profits from startups can be returned to hospitals through the establishment of a technology holding company, etc., and lead to follow-up research.

Third, in order to create an innovative ecosystem in the biomedical field, regional research-focused hospitals should be established to establish a hospital-centered bio cluster. Clusters are needed due to the nature of the biomedical technology industry, which is technology-intensive and requires close cooperation between industry actors from reliable clinical trials to production. There are many bio clusters in each region of Korea. However, collaboration and connection with hospitals is lacking, and clinical trials and licensing are analyzed as weaknesses in most major bio clusters in Korea. To overcome these weaknesses, hospitals will have to become the center and doctors will have to participate in research to provide unmet needs in the medical field, and to compensate for deficiencies in clinical trials and licensing. Furthermore, it is necessary to expand and strengthen the linkage between hospitals and industries to activate biomedical technology investment, IPO, M&A, and other commercialization.

Fourth, it is necessary to come up with a plan to provide full-cycle support for physician scientists rather than short-term research support. It would be great to create an education system that students can be interested in research as well as medical treatment from their undergraduate days and create a continuous research environment for young medical scientists to mid-level medical scientists. Through full-cycle support, research should not be interrupted, and physician scientists should be able to continuously participate in research by balancing medical treatment and research.

Through this systematic nurturing of physician scientists and the creation of a hospital-centered biomedical innovation ecosystem, it will be possible to lead the world's biomedical technology in the rapidly changing 4^{th} industrial revolution and post-corona era, and eventually secure a new growth engine for Korea. Medical schools and hospitals in Korea have a high concentration of talented people, and it's time to plan a long-term roadmap to effectively support these talented people and create excellent outcomes.

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