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Social innovation for life expectancy extension utilizing a platform-centered system used in the Iwaki health promotion project: A protocol paper

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Abstract

Introduction: We are trying to create a platform for social innovation to extend life span.

Methods: Since 2005, health data (approximately 3000 items per person as of 2020) of approximately 1000 adults have been collected each year during the Iwaki Health Promotion Project. The industry, government, academia, and citizens have involvements in data collection, aiming to build a platform that encourages societal innovation and subsequently extends life expectancy in Aomori. The Iwaki Health Promotion Project has been supported financially by the Japanese government since it was selected as the Center of Innovation program in 2013.

Results: Since the numbers of academia, industries, governments, and citizens involved in the Iwaki Health Promotion Project increased over the years, the big data produced during the project has become increasingly pluripotent and adaptable. It has been used to promote public health, which has also created a stronger partnership among companies and research organizations. Consequently, the amount of data collected from the project has gained attention and became more open to companies and researchers participating in the Iwaki Health Promotion Project, resulted in establishing a larger platform. It also led to the acquisition of external funding, publications of numerous research papers, creation of new health examinations, and the establishment of the Health Promotion Center (an institution for cultivating health volunteers).

Conclusion: The Iwaki Health Promotion Project aims not only to produce a pluripotent big data but also to improve the average life expectancy of Aomori by creating a large platform in the society. Its positive impact in the future is infinite and will keep growing as long as it is maintained by the society.

Keywords

Iwaki Health Promotion Project, social innovation, center of innovation program, life expectancy, pluripotent data, survey study

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Introduction

Aomori Prefecture has the shortest life expectancy among all 47 Japanese prefectures, and breaking away from this cycle has been a major social issue.

Among the Japanese prefectural life expectancy rankings in 2015, Aomori Prefecture was at the bottom of the ranking for both genders[1] (Table 1). In the past 11 rankings that have been made public since 1965, Aomori Prefecture has always received the lowest position for both genders. Furthermore, the difference in life expectancy between males in Nagano Prefecture (prefecture with the longest life expectancy in Japan) and Aomori Prefectures is 3.3 years, which is a

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Table 1. Life expectancy ranking in the 47 Japanese prefectures.

	2000		2015	
	Males	Females	Males	Females
1	Nagano	Okinawa	Shiga	Nagano
	78.9	86.1	81.8	87.7
2	Fukui	Fukui	Nakano	Okayama
	78.6	85.4	81.8	87.7
3	Nara	Nagano	Kyoto	Shimane
	78.4	85.3	81.4	87.6
4	Kumamoto	Kumamoto	Nara	Shige
	78.3	85.3	81.4	87.6
-				
44	Saga	Ibaragi	Wakayama	Akita
	77.0	84.2	80.0	86.4
45	Kochi	Tochigi	Iwate	Ibaragi
	76.9	84.0	79.9	86.3
46	Akita	Osaka	Akita	Tochigi
	76.8	84.0	79.5	86.2
47	Aomori	Aomori	Aomori	Aomori
	75.7	83.7	78.7	85.9

Table 2. Mortality rate by age group in Aomori and Nagano (per 100,000, 2015, males).

Age group (years)	Aomori Prefecture		Nagano Prefecture	
	Mortality	Position	Mortality	Position
<5	45 (1.0)	9th	44	7th
10–14	0 (0)	1st	7	9th
15–19	3 (0.3)	2nd	12	32nd
20–24	42(1.8)	44th	24	19th
25–29	92 (1.8)	46th	51	20th
30–34	59 (0.7)	21st	79	37th
35–39	58 (1.2)	14th	48	4th
40–44	109 (1.2)	45th	92	29th
45–49	267 (1.2)	46th	214	31st
50–54	447 (1.6)	47th	276	4th
55–59	691 (1.5)	47th	460	7th
60–64	1113 (1.5)	47th	731	4th
65–69	1653 (1.6)	47th	1053	2nd
70–74	2631 (1.4)	47th	1906	3rd
75–79	4236 (1.5)	47th	2894	1st
80–84	7074 (1.3)	47th	5623	2nd
>85	15,357 (1.1)	46th	13,580	3rd

considerable difference. For example, if Aomori citizens died at the same rate as Nagano citizens, the total number of deaths would decrease by 2500 (approximately 15% of total death in Aomori).

The mortality rate (per 100,000 population) of Aomori is 1.3–1.9 times higher than that of Nagano, except among teenagers and people in their 20s (Table 2).[2] Using the data, we can calculate the average life expectancy and come up with a single figure representing the difference in average life expectancy between the two prefectures: 3.3 years. The analysis of death statistics in Aomori Prefecture revealed two characteristics as follows:

1. While all generations have high mortality in Aomori, the mortality rate for those in their 40s was particularly high (Table 2).[2]
2. High mortality was associated with three major causes: cancer, heart diseases, and stroke (Table 3).[2]

In total, 70% of Japanese adults (including those in Aomori) die from the three major lifestyle-related causes after a latent period of about several decades. Hence, preventive measures need to be taken at a very early stage. Therefore, in addition to the regional healthcare activities, health education for children and health promotion in workplaces with younger employees are important. In other words, healthcare activities must be there to target all generations and parts of societies.

Statistics revealed the background of Aomori Prefecture's short life expectancy as follows:[3] unhealthy lifestyles (high rate of smoking, high percentage of obesity, heavy drinking, high salt intake, low vegetable intake, etc.), low health checkup rate (Table 4), delayed visit to the hospitals, and insufficient outpatient visits (data are not shown).

However, such evidence represents just the tip of the iceberg and only shows approximately 10% of the problem. There are many other fundamental elements causing this problem, such as weak economic power, low educational level, conservative culture, cold climate, and people's general temperaments that need to be considered. The evidence above indicates the need for the following actions to break this cycle of short life expectancy. First, since anyone at all age groups needs to be targeted, it is necessary to set the field that covers all areas, including schools, workplaces, and homes. Furthermore, along with the activities for healthcare promotion, health literacy and health education, particularly in schools, must be emphasized. Second, comprehensive measures are indispensable and, hence, the development of such measures should involve industry, the government, academia, and citizens. Finally, to ensure the collaboration of industry, local governments, and academia, a strong platform that attracts all of them is required. In our research, the big data of the Iwaki Health Promotion Project (IHPP) was positioned at the platform of social innovation for health promotion in Aomori Prefecture.

In the last decades, several epidemiological studies have been carried out around the world to investigate factors that can have positive impacts on public health. However, they very often conducted cohort studies,[4,5] which mainly focused on hypothesis-based testing, and in fact, there have not been many studies that measured a large number of items. A possible explanation is the economic and physical constraints that make the surveys, involving multi-items, considerably

Table 3. Age-adjusted mortality rate (per 100,000 population) according to the main cause of death and the position (ranking) among 47 prefectures in 2015.

	Males		Females	
	Aomori Prefecture	Nagano Prefecture	Aomori Prefecture	Nagano Prefecture
All causes	585.6 (47th)	434.1 (1st)	288.4 (47th)	227.7 (1st)
Malignancy	201.6 (47th)	132.4 (1st)	103.0 (47th)	76.6 (2nd)
Heart disease	76.8 (42nd)	60.8 (13th)	36.6 (32nd)	28.3 (3rd)
Cerebral stroke	52.8 (47th)	41.0 (32nd)	28.2 (45th)	22.2 (30th)
Pneumonia	49.1 (47th)	26.5 (1st)	19.6 (44th)	10.7 (1st)

Table 4. Value and the position among 47 prefectures of related parameters for life expectancy.

	Aomori Prefecture		Nagano Prefecture	
	Male	Female	Male	Female
Prevalence of smoking rate (%, 2003)	47.7 (47th*)	5.4 (33rd)	29.4 (11th)	3.1 (20th)
Prevalence of alcohol consumption (%, over 3 go**, /day, 2001)	14.1 (47th)	2.8 (40th)	9.5 (5th)	1.8 (15th)
Salt intake (g/day, 1995–1999)	15.3 (41st)	13.6 (41st)	15.8 (43rd)	13.7 (46th)
Vegetable intake (g/day, 1995–1999)	303 (30th)	299 (22nd)	338 (8th)	328 (11st)
Obesity prevalence of $>$ 25 of BMI (%, 2004)	33.7 (44th)	22.7 (46th)	28.1 (11th)	16.8 (9th)
Examination rate of gastric cancer screening (%, 2007)	28.8 (10th)	31.3 (35th)	30.6 (8th)	38.2 (8th)
Steps number (/day, 2006–2010)	7795 (46th)	6578 (41st)	8437 (19th)	7593 (11th)
No. of community nurses (/population) (2010)	41.6 (30th)		61.9 (2nd)	
No. of medical doctors (/population) (2010)	191.9 (41st)		213.9 (33rd)	
Prefectural income (USD, per capita) (2011)	2.4 (40th)		2.7 (30th)	

BMI: body mass index.
*Position (ranking) among 47 prefectures in order from the best to the worst.
**3 go (go is a unit used to measure Japanese sake, about 15% of alcohol) = 540 mL.

difficult. Therefore, such studies cannot guide private and public policy interventions that can positively affect industrial production, medical expenses for local governments, and individual health of citizens simultaneously. In today's society marked by the rapid progress of information technology (IT), collection, and the importance of big data have been gaining attention. These include data from medical examinations and checkups, clinical data provided by medical clinics or hospitals, lifelog data provided by information and communications technology-based service companies, and various miscellaneous health data obtained by other health-related organizations. As a result, large volumes of data with no apparent context are available, and artificial intelligence (AI)-based methods are increasingly being used for data analysis. The analyzed results can provide new insights into many fields, although these data often include various errors. Moreover, health is a hyper-multifactorial construct and collecting highly accurate data from different sources that can meet the requirements of useful analyses is extremely difficult.

Therefore, the authors started the IHPP in 2005,[6] an annual large-scale health survey that collects a very large number of data items. The IHPP is intended to build a social innovation system to extend the prefecture's average life expectancy by creating a consortium with industry, government, academia, and citizens as stakeholders centering on these big data. The project is supported by the Ministry of Education, Culture, Sports, Science and Technology as part of the Center of Innovation (COI) programs for the period between 2013 and 2022.

Hence, this concept (protocol) paper illustrates the project's background, structure, main contents, and results to date.

Methods

The strategy for achieving the goals in this study is as follows.

Putting IHPP's pluripotent data at the center of the platform, gathering industry, government, academia, and citizen, building a real-world data, and utilizing the results obtained from it (QOL health checkups, etc.) to help improve the health of Aomori Prefecture, which will lead to overcome short-lived prefectures.

The steps to succeed are as follows:

- Motivation: Aomori to overcome the lowest position of average life expectancy in Japan: improved measures for all ages and disease. This should include the entire society—in other words, citizens, industries,

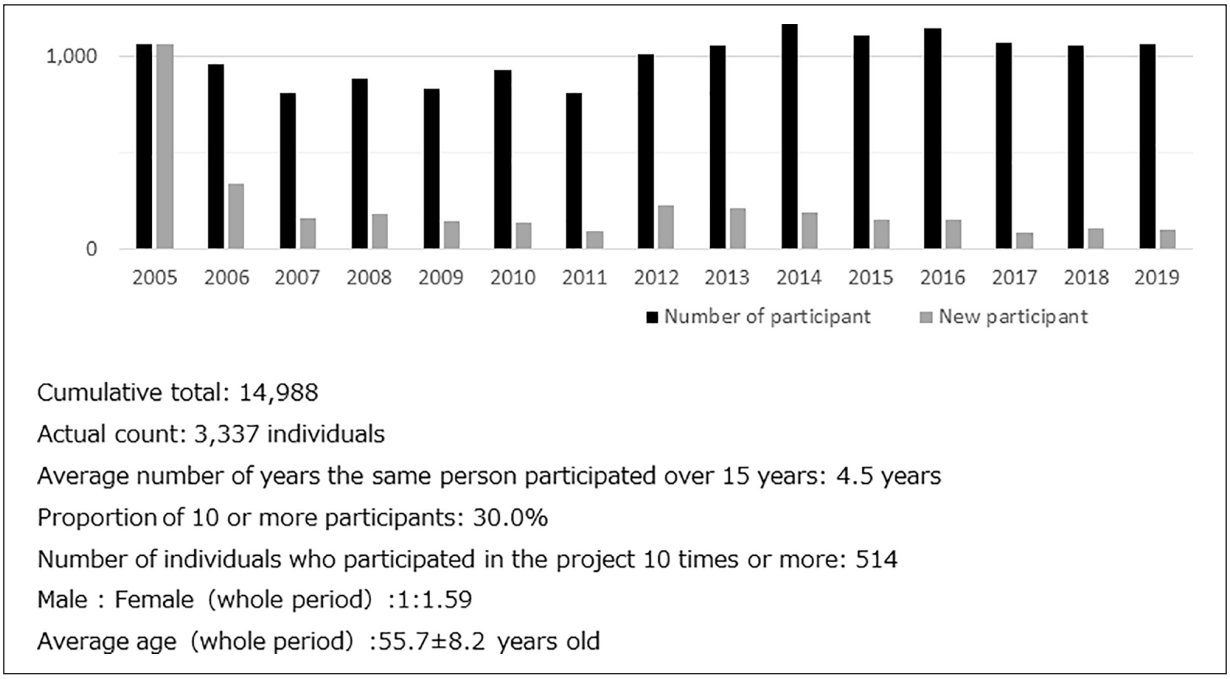

Figure 1. Participants of the Iwaki Health Promotion Project.

academia, and local governments must all be stakeholders.

- Building a central platform (IHPP): the IHPP began collecting ultra-multi-item data that are highly versatile and attractive to citizens, industries, academies, and local governments.
- Building the real-world data: connecting data from the IHPP, including QOL health checkups, with data from other universities in Japan (Kyoto Prefecture Medical University, Wakayama Medical University, Meio University, Kyushu University, Hiroshima University, etc).
- Adding pluripotency to the real-world data: Multiple analysis, analysis between items that have never been considered before, big data analysis, and proposal of a new item to the general health checkup.
- Opening up the real-world data to industries/companies and researchers.
- Gather together four stakeholders: citizens, industries, academia, and local governments.
- Social innovation for health promotion based on the scientific evidence and by the societal power.
- Improvement of a position in life expectancy ranking in Aomori Prefecture.
- This article is written according to these strategies and procedures.

IHPP

Participants. Among the residents of the Iwaki district of Hirosaki City (comprised of approximately 6000 people aged above 20 years as of 2019), adult men and women above 20 years of age who wished to attend the IHPP were the subjects in IHPP, thus no selections were made.

As shown in Figure 1, approximately 1000 subjects (ranging from 885 to 1116) have been participating in the study each year. They are male and female residents above 20 years of age with the average age of 55.8 ± 14.7 years (as of 2019). The number of subjects varies every year, as it was up to each person to decide whether or not they wanted to participate in the study that year.

Venue. The Cultural Center and the Central Community Center in Iwaki district, Hirosaki City, Aomori Prefecture, Japan.

Survey period. The annual survey is conducted for 10 consecutive days in May or June every year since 2005. IHPP will continue until 2035.

Examiner/supporting staff. A total of 350 people from Hirosaki University, company research staff, citizens, Hirosaki City office, Aomori Prefectural General Medical Examination Center, as well as non-medical and medical students from Hirosaki University attended the survey to support as the examiners. Companies and researchers were allowed to participate in the IHPP on the condition that they acquire at least one data/measuring item of their own to be added to the IHPP big data.

Measurement items. The number of survey items has been increasing every year. In 2005, the number of measurement

Table 5. Items measured in the Iwaki Health Promotion Project.

1. Questionnaire (see supplementary table): Family structure, educational history, medical history, family history, current medication, lifestyle (smoking, alcohol, exercise), motion and time study, activities of daily living, oral hygiene, menstruation status, number of pregnancies or deliveries, bone fracture history
2. Short Form Health Survey (SF36)[7] (Licensed from iHope International Co., Ltd., Kyoto)
3. Perceived Health Competence Scale (PHCS)[8]
4. Bowel movement: Rome III criteria[9]
5. Self-efficacy regarding general health-related behavior: Perceived Health Competence Scale[10]
6. Diet: Brief-type self-administered diet history questionnaire (BDHQ)[11] (Licensed from DHQ Support Center, Tokyo)
7. Overactive Bladder Symptom Score (OABSS)[11]
8. Body composition: % fat, muscle volume, visceral fat volume, etc.
9. Bone density (using ultrasonography)
10. Cardiovascular-related items: blood pressure, electrocardiography, echocardiography, brachial-ankle pulse wave velocity, ankle brachial index (ABI), fundus examination
11. Abdominal ultrasonography (for liver, pancreas, gall bladder, etc.)
12. Pulmonary function (using spirometer)
13. Physical fitness (20 items): Grip strength, sit-and-reach, lateral jumps, long jump with standing, standing balance with opened eyes, bar gripping reaction time, etc.
14. Blood examination:

①Basic items (50 items): Leukocyte number, platelet number, hemoglobin, liver function, renal function
②Immunoglobulins, complements, uric acid, electrodes, etc.
③Trace elements (14 items): Manganese, zinc, selenium, chrome, nickel, etc.
④Glucose, lipid, and bone metabolism: HbA1c, blood glucose, LDL-/HDL-cholesterol, triglyceride, etc.
⑤Amino acids (36 types), fatty acids (21 types)
⑥Hormones (15 types), cytokines (7 types) and vitamins (10 types)
⑦Neutrophil function: Reactive oxygen production capability, phagocytic activity, serum opsonin activity

15. Depressive state: Center for Epidemiologic Studies Depression Scale (CES-D)[13]
16. Cognitive function: Yamaguchi fox-pigeon imitation test (YFPIT),[14] Clock Drawing Test (CDT),[15] Mini Mental State Examination (MMSE)[16] (Licensed from Psychological Assessment Resources, INC, Florida, USA)
17. Feces: Microbiota (16S-rRNA × MiSeqb method, shotgun analysis method)
18. Urine (10 items): 8-OHdG, trace albumin, cortisol, aldosterone, equol, etc.
19. Hearing, vision, and olfactory tests
20. Sleeping status: Pittsburgh Sleep Quality Index,[17] polysomnography
21. Oral cavity: Oral flora, microbiota (16S-rRNA × MiSeqb method, shotgun analysis method), number of remaining teeth, periodontal disease, occlusal function, etc.
22. Orthopedic findings and questionnaire (20 items): joint movable range (knee, hip joint), hydrarthrosis (knee), joint fissure (carpal tunnel), MRI images (knee, cervical vertebra, lumbar vertebra), bone fracture history, etc.
23. Skin (five items): transepidermal water loss, horny layer moisture, carotenoids, PH, skin typing
24. Advanced glycation end products
25. Exhaled gas (six types): NO CO, H2, CH4, etc.
26. Whole genome analysis
27. Metabolome analysis (blood)

items, including questionnaire about basic items (Supplementary Table), was 600 per person, and the number has grown and currently exceeds 3000 items per person as of 2019. Table 5 summarizes the measurement items obtained at the venue between 2005 and 2019.[7–17] The blood test is outsourced to a testing company or specialists. This blood test data is the multi-item data, where it is used to understand the general condition of the whole body. It is important to analyze the data comprehensively, as most modern illnesses are super multi-factual. These multi-item data are tied to the pluripotent data described later.

Data management. Other data are registered in the host database immediately after acquisition. The details are not mentioned here owing to space limitations. The IHPP dataset is managed by the data management office of Hirosaki University, and the University of Tokyo and Kyoto University, which have supercomputers, are networked to ensure comprehensive management.

In addition to complying with the law regarding the protection of personal information, this program is controlled under strict management of personal information.

First, samples and information are anonymized at the same time as they are collected, and the correspondence table between personal identification information and codes is strictly managed. The analyzed data, including genomic information, are also strictly managed under the responsibility of the "IHPP

Management Steering Committee" established within Hirosaki COI. In sharing the genomic information obtained from the Hirosaki COI program, special measures have been taken regarding the protection of personal information of research participants. As a general rule, data provision destinations, including genomic information, are limited to companies and researchers conducting joint research, and joint research institutes are required to establish a system for protecting personal information. If the information is provided to other organizations or institutes by joint research institutes, then the personal information management system at the destination is examined. Exceptionally, when information is provided to anywhere other than joint research institutes, the management system of personal information at the destination is examined. Prior to the provision, it is confirmed that the person receiving the provision has a confidentiality duty and that if it is violated, legal action may be taken. In addition, a confidentiality agreement was signed between Hirosaki University and each participating company/universities/research institutes.

Conflict of interest. When publishing research results, conflict of interest can be used as a basis for determining whether or not the results are biased. All researchers are required to disclose it when presenting their research.

Funding. The IHPP has been supported by Japan Science and Technology Agency (JST), and the Center of Innovation Program which was launched by the Ministry of Education, Culture, Sports, Science and Technology (JPMJCE1302).

Ethics and registration. The study was approved by the Ethics Committee of Hirosaki University School of Medicine and conducted in accordance with the principles of the Declaration of Helsinki (2014-377). Written informed consent was obtained from all participants prior to the study. This study was registered in the University Hospital Medical Information Network (UMIN-CTR, https://www.umin.ac.jp) prior to the analyses (UMIN ID: UMIN000040459).

Making the IHPP a powerful platform: conversion of the IHPP big data to pluripotent data

A true innovation cannot be achieved without facilitating a well-balanced collaboration among industry, government, academia, and citizens, and it requires a large and powerful platform. The major point that needs to be focused to create a platform is to make sure it meets everyone's needs, interest, and expectations, as each of them take part in the IHPP for different reasons and with expected outcomes. The participating companies (industry) aim to increase their profits and expand their businesses using the data obtained from the IHPP. For local government, the data could be used for town development as well as to improve the control of medical expenses for the citizens. For universities, taking part in IHPP will benefit in their researches and education. For citizens who participate in the IHPP will be able to understand their health conditions at no cost. Therefore, creating a well-balanced "industry-government-academia-citizen" platform that is appealing to each one of them is extremely important.

The IHPP has devised a mechanism to allow industry, government, academia, and citizens to gather their own initiative as follows.

The IHPP has been producing the world's largest number of health data with more than 3000 items recorded per person per year. The ultimate goal of the IHPP is to improve the short life expectancy in Aomori Prefecture. Therefore, we need to focus on chronic diseases that are associated to lifestyle risk factors, as they are the main causes of death, and the prevalence of dementia and bedriddenness, which have been rapidly increasing in recent years. Since these conditions and diseases are extremely multifactorial, comprehensive items (over 3000) have been identified (Table 5) to measure each function of the entire body as comprehensively as possible. Therefore, using this big data, various researches are possible, but not limited to the following:

- New combination of studies that no one would have ever imagined possible, for example, association between exhaled gas and dementia, and relationship between oral health and intestinal microbiota.
- Elucidation of the relationship between each measurement item and overall health level, for example, when new substance "A" was proposed as a health marker, it was added to the 3000 measurement items of the IHPP, and the correlation between "A" and 3000 other items can be analyzed. Thus, the IHPP big data can be used for such tests.
- Big data analysis that comprehensively captures overall health that can be used for the application of AI methods.
- Proposal of new medical examination methods; for instance, proposal of a new medical checkup (QOL health checkup). The measurement items used for QOL health checkups were selected from the measurement items used in the IHPP.
- Accessibility to the big data: companies and researchers participating in the IHPP are permitted to access and use data with some limitations. Hence, many research organizations and companies have agreed to participate in the IHPP. Figures 2 and 3 depict the lists of participating companies and research organizations, respectively.

Building the real-world data

We are currently in the middle of constructing the real-world data by adding the following data to the IHPP data.

- Connection with the data from 12 other universities throughout Japan (Kyoto Prefectural Medical University, etc.).

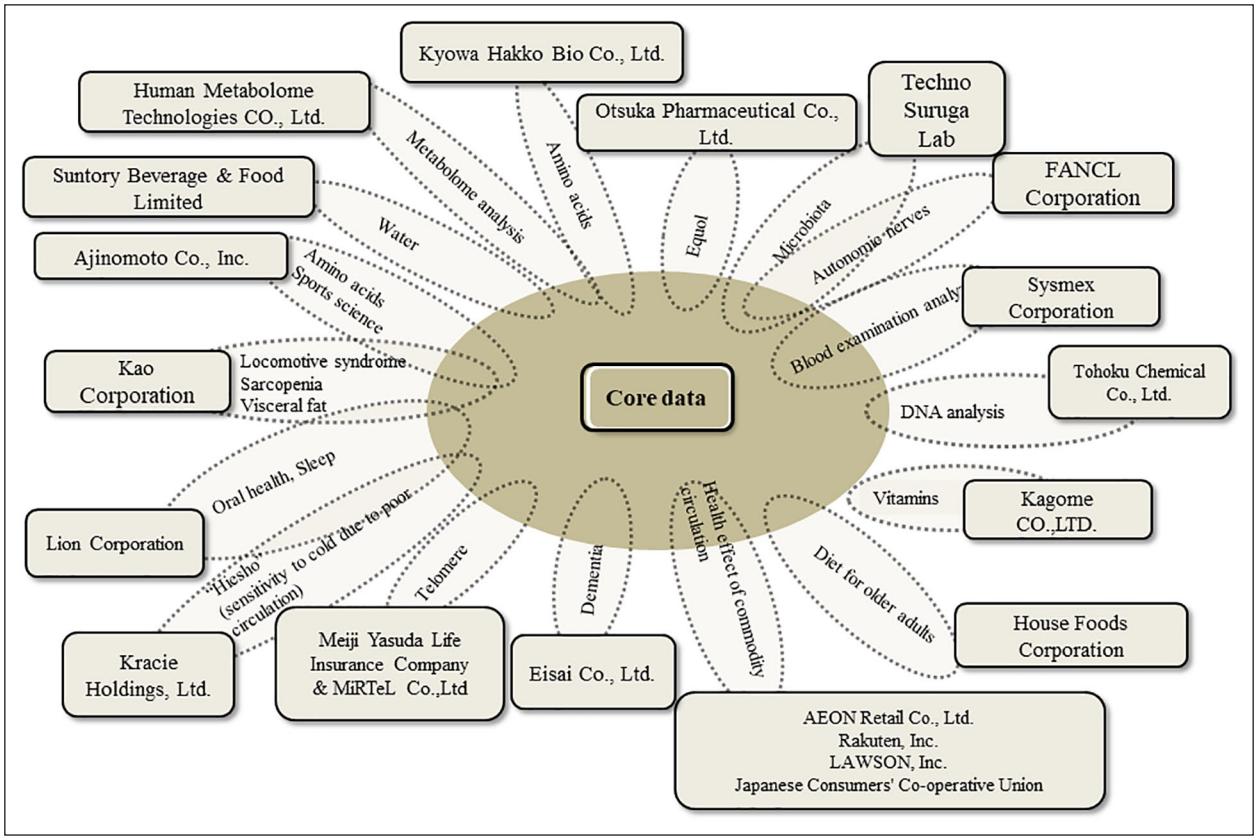

Figure 2. Collaborations with companies. Participated companies and their interests/contribution to the core data.

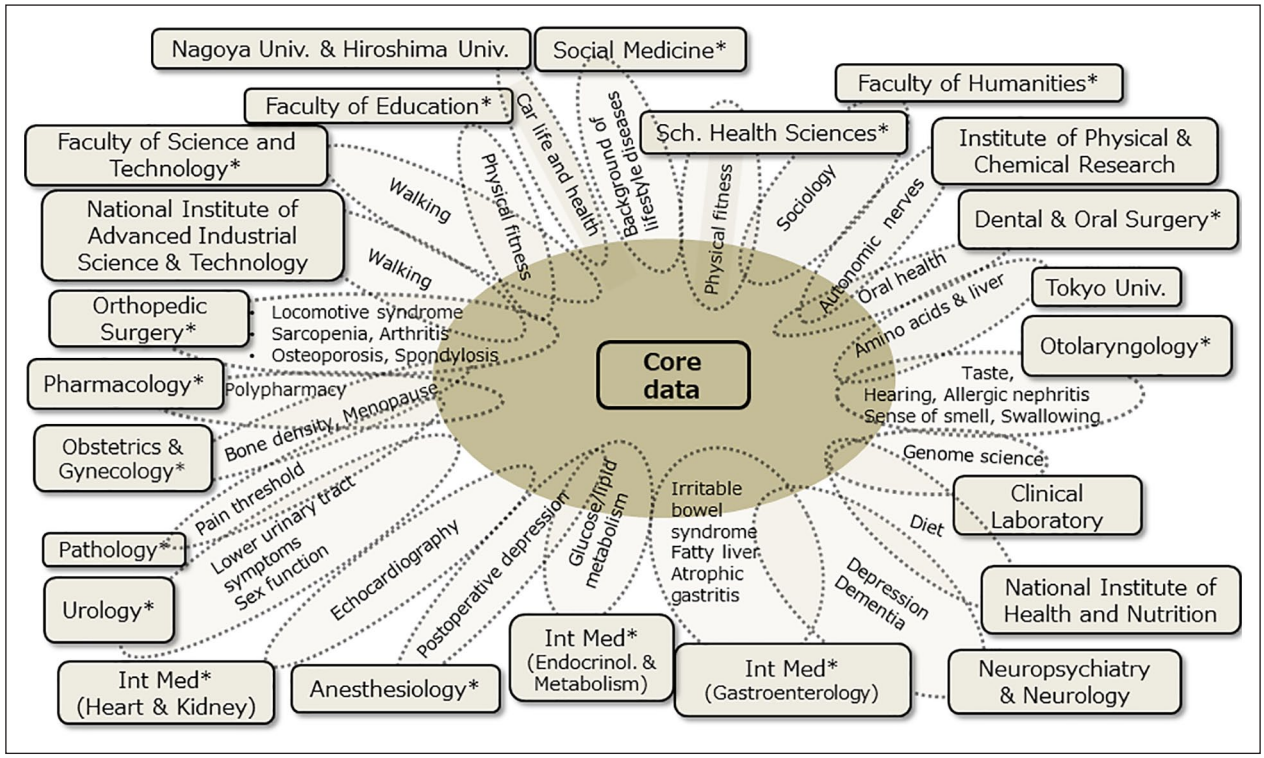

Figure 3. Collaboration with researchers from Hirosaki University and other research institutes.
*At Hirosaki University. Participated departments from Hirosaki University and other research institutes, and their interests/contribution to the core data.

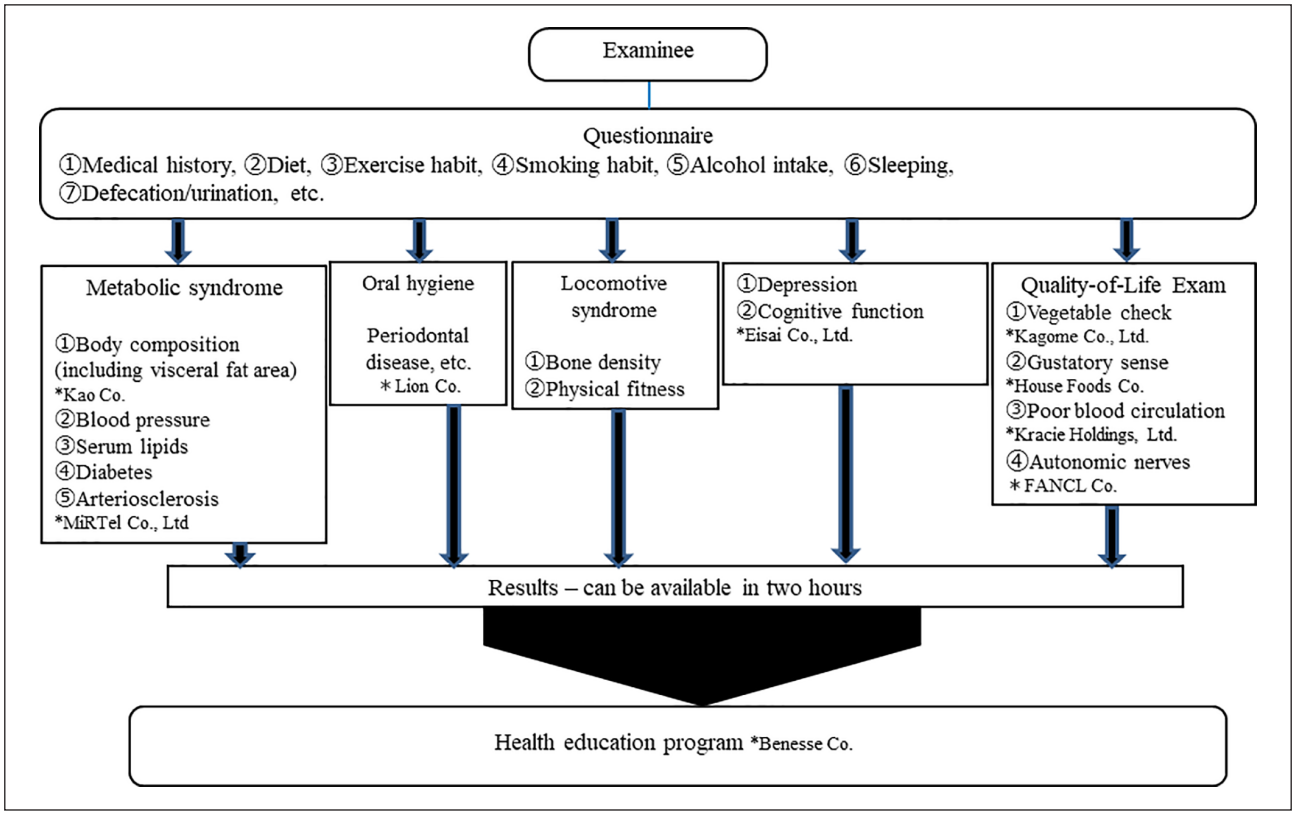

Figure 4. QOL** medical examination flow chart.
*Company in charge.
**QOL: Quality of Life.

- Data on QOL health checkups (examination) (Figure 4): The numbers of measurement items from IHPP were selected to simultaneously assess metabolic syndrome, locomotive syndrome, oral cavity hygiene, and mental/cognitive states to determine the QOL of subjects. The whole assessment process is completed in approximately 2 h, and the subjects can obtain their health checkup results and receive suitable consultation from health professionals on the spot. The purpose of this QOL health checkup is to promote healthcare activities in Aomori Prefecture by introducing health education in the community, schools, and workplaces. In this medical checkup, companies can introduce their own equipment to measure health levels. Furthermore, the data from QOL health checkups are collected by utilizing Internet of Things (IOT) devices.
- Medical, medical care, and welfare-related data from local government.
- Addition of other data to the IHPP Big Data: The real-world data is built by adding ①, ②, and ③ to the IHPP big data (Figure 5). The authors called this platform as "Iwaki Platform."

The real-world data (Iwaki Platform) will stimulate further research, enhance economic activities, and revitalize towns. This will result in improved quality in diagnosis, including efficient decision-making by medical professionals. It will further reduce expenses for healthcare, nursing care, and medical expenses.

Building a big data analysis team

Big data management and analysis require powerful computers (e.g. supercomputers, such as Kei in Kyoto University and Shirokane in Tokyo University) and at least two or three data scientists with expertise in statistics and bioinformatics skills. This team includes experts in health promotion, clinical medicine, social welfare, economics, education, and sociology.

In response to the coronavirus disease 2019 (COVID-19) epidemic, remote analysis using VPN was started in June 2020.

Health promotion activities in Aomori Prefecture

Since our health promotion activities have been carried out in Aomori Prefecture, it is extremely important to collaborate with the prefecture's local government, companies, academia, and citizens. To strengthen cooperation between the IHPP and Aomori Prefecture, the real-world data construction required data from many activities within the prefecture, such as:

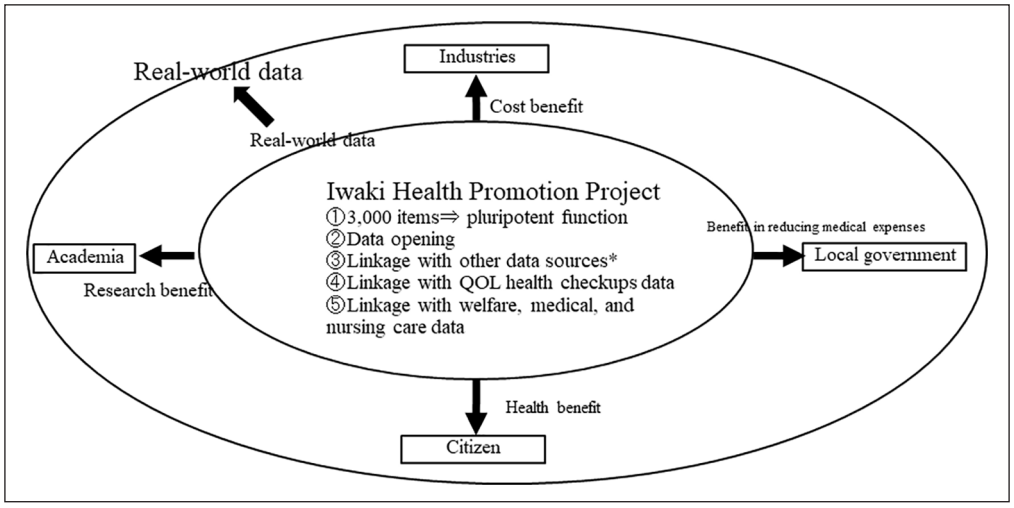

Figure 5. Strategy for building real-world data.
*Kyoto Pref Univ Med, Wakayama Mad Univ, Meio Univ, Kyushu Univ, Tohoku Univ, Juntendo Univ, Ritsumeikan Univ, Tsukuba Univ, Hiroshima Univ, Osaka Univ, Meijo Univ, Nagoya Univ, etc.

First and foremost, we involved industry, the government, academia, and citizens in the IHPP. In order to implement the IHPP, approximately 350 staffs need to be on duty on each checkup day. (100 staffs from Hirosaki University, 120 staffs from companies, 30 staffs from Hirosaki City government, 20 staffs from medical examination organizations, and 30 Hirosaki citizens). The involvement of these people helps industry, the government, academia, and citizens share their knowledge on the IHPP goals and issues, and to promote social health. In addition, approximately 50 students from Hirosaki University participated as part of their school curricula.

Second, we utilized the IHPP big data in research and development at the company, or scientific research.

Third, we established the Health Promotion Center: The health promotion organization cooperates with Aomori Prefectural government, the Aomori Medical Association, the Hirosaki University COI, and two local private banks to provide health promotion advice and to train the health promotion leaders. The existence of social capital is essential according to the principle of primary health care specified by the Declaration of Alma-Ata, "health of the people, by the people, for the people,"[18,19] thus the Health Promotion Centre was established in 2016.

Figure 6(b) summarizes these activities as mentioned above.

Synergistic effect of industry, government, academia, and citizens utilizing platform centered on IHPP

Companies participated in the Iwaki Platform for product development and actively participated in QOL health checkups to launch their products. To comply with health declaration, local governments have trained health leaders and have begun to actively incorporate health promotion systems (QOL health checkups, etc.) obtained from data, such as IHPP into residents' activities. The university realized the scientific value of living data of citizens obtained from activities, such as IHPP, and produced many scientific papers, so they began to actively participate in health promotion activities starting from the Iwaki Platform to collect data. Citizens became active and more involved in health promotion through QOL health checkups under the guidance of local government leaders. In this way, the industry-government-academia-citizens gathered on the Iwaki Platform is stimulating their activities while satisfying their respective interests, and its synergistic is increasing the movement for health promotion in Aomori Prefecture as a whole.

Support from COI program

In 2013, the Hirosaki University COI[20] was selected as the COI program launched by the Ministry of Education, Culture, Sports, Science and Technology (Japan Science and Technology Agency), under the project titled "Construction of a breakthrough disease sign detection system and development of prevention methods by fusing dementia/lifestyle-related diseases with big data analysis." Hirosaki University COI is one of the 18 COI projects that was selected as COI program.

The COI's mission is to collaborate universities with companies to revitalize businesses and facilitate social innovation. With the immense support extended by this national project, the construction of a large-scale platform to create the IHPP-centered social innovation and the improvement of prefecture's short life expectancies based on this platform (regional health promotion activities) are progressing (Figure 6(a)).

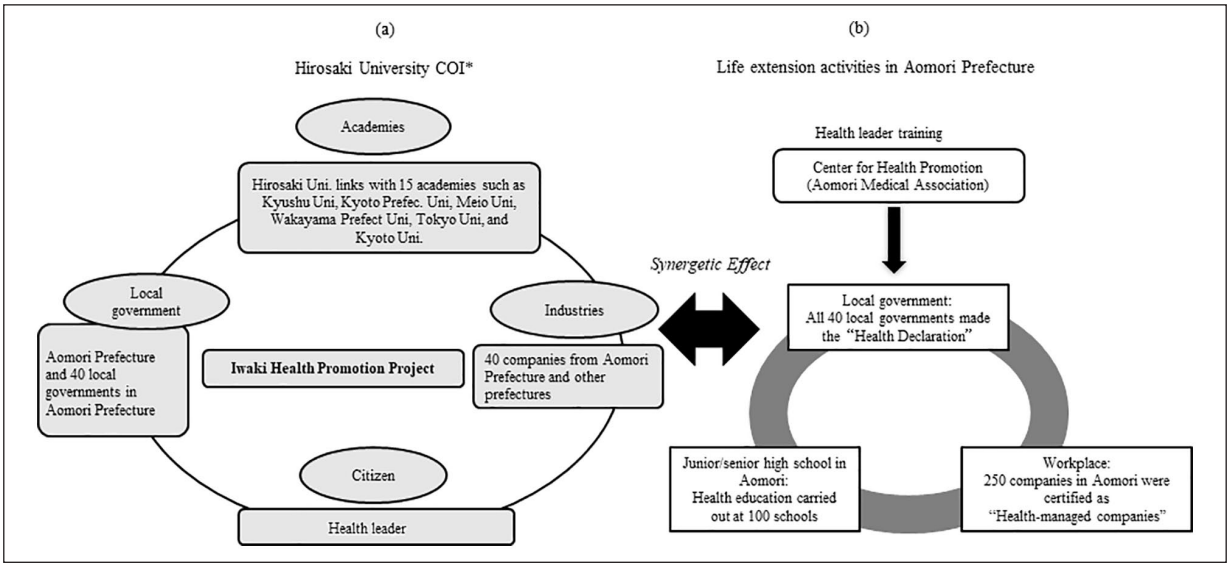

Figure 6. Linkage of Hirosaki University Center of Innovation with life extension activities in Aomori Prefecture: (a) Hirosaki University COI is made up of industry-local government-academia-citizens collaboration; (b) life extension activities are being carried out in the fields of local governments, school, and companies in Aomori.
*COI: Center of Innovation.

Results

This article is a protocol paper of a part of a larger study/trial, as this study is not yet completed and is currently ongoing. Therefore, this section describes the results of our project activities to date. Since the IHPP started in 2005, the following outcomes have been observed:

- Number of companies participating in the Hirosaki University COI: The number of participating companies increased from 5 to 42 between November 2014 and May 2020. During the same period, the number of donation courses and joint research courses increased from 0 to 15, and the total amount of external funding reached US$3.5 million per year in 2020.
- Number of research institutions participating in the Hirosaki University COI: Between November 2014 and May 2020, the number of participating research organizations and universities increased from 0 to 23.
- Economic effects: According to Shoji et al.,[21] the effect of the IHPP in reducing medical cost over 10 years is equivalent to US$200 million only for arteriosclerotic diseases in Aomori Prefecture. This has a significant benefit for both public institutions (including local governments) and individual citizens.
- Health promotion activities in municipalities: Since the health declarations were made by the mayors of all 40 municipalities in Aomori Prefecture, more people have been trained to become the health leaders and that led to increased activity of health promotion at municipality level.
- Provision of enhanced health education in schools: In Aomori Prefecture, 100 out of 450 elementary and junior high schools started providing systematic and comprehensive health education to their students.
- Health promotion activities in workplace: The Aomori Prefectural Government introduced the Aomori Prefecture Health Management Certification System in 2017, and through its effort, 246 companies had been certified as of May 2020.
- Number of published research papers: Based on PubMed, there were 140 IHPP-related papers with impact factors in September 2020, with the total impact factor of 350.
- QOL health checkups: It has been conducted at eight companies in Aomori Prefecture over the past 3 years, including two Japanese companies located in Hai Phong, Vietnam, with the total number of participants of 1000.
- Training of health leaders utilizing the Health Promotion Center: Through the efforts of the center since 2013, more than 3000 citizens were trained and became health leaders.
- Awards: This project has been receiving significant national attention; it was awarded with the first Japan Open Innovation Award (Prime Minister's Award) in March 2019, the Seventh Platinum Award (award by the Minister for Internal Affairs and Communications) in November 2019, and the Open Innovation Net Award 2020 (award by the Minister of Education, Culture, Sports, Science and Technology) in July 2020.

Discussion

Health promotion requires literacy-based health awareness and behavioral changes. For that purpose, governments, social leaders, and professionals need to be the ones who are

responsible for empowering citizens.[18] Thus, we have to build a robust platform first and foremost to satisfy everyone's needs and make a great use of recent technological innovations at the same time.[22] The authors have set the ultimate goal to motivate the Aomori citizens to achieve the goal of making Aomori a place known for its long life expectancy.

Social innovation is necessary for the health promotion of the entire citizen. Many social determinants must be understood and dealt with in order to cause social innovation.[22–29]

However, there is no perfectly correct answer to the procedure for improving health, and that is the reason why no one has achieved it yet. It is also considered that there is a certain difference between innovation for health promotion and innovation for corporate and economic revitalization. In particular, the former is required to contribute more to non-profit activities.[23] However, for certain, industry-government-academia-citizen collaboration (open innovation) is necessary for social/open innovation and it requires a mechanism that involves the construction of a wide and robust platform.

Therefore, the Hirosaki University COI aims to facilitate multipurpose-social innovation while satisfying every stakeholder's interest by ensuring the IHPP-centered collaboration of industry, the government, academia, and citizens. Moreover, the IHPP can produce these pluripotent data in response to social demands, and we believe that a new form of social innovation is underway in all fields, including health promotion. In summary, the authors aim to achieve the goal by continuously strengthening the state illustrated in Figure 6.

When transferring this research to another area or organization, the most important element is to create a broadly based and robust platform that is appealing to industry, government, academia, and citizens. The creation and use of the big data is an ideal way to build this platform, as it satisfies interests of every part of the society. Also, a recent advancement in IOT and AI has made data collection and analysis easier for many people. The era of building a platform that utilizes big data and connecting it to social innovation has arrived.

The time has come when big data can be collected and analyzed. In many fields, data platforms (including digital platforms) are being constructed, and activities to create innovations have been carried out using them.[30–37] However, it is still rare to achieve a collaboration that involved a huge number of fields and areas in the society like IHPP. Many experts and stakeholders come together at IHPP, and it will grow into a global innovation by branching out further to new areas continuously. At this point, the purpose of this innovation is not only limited to health improvement but also the possibility of its methodology that enables a new social innovation in the future.

The main limitation of the IHPP and its platform is that the size of the IHPP data is currently not large enough yet to perform highly reliable analysis. The function of real-world data could work more effectively with larger data input. Thus, our work here is not yet done and still has a space for development. Another possible limitation is the questionnaire that was used in this study, as it was not pre-tested prior to the investigation.

Furthermore, the strength of industry-government-academia-citizen collaboration is currently insufficient to overcome the short-lived prefecture, and it is necessary to further enhance the achievement indices in each process.

Conclusion

Over the past 15 years, the foundation of IHPP and its functionality have been established as follows. First, the value of the IHPP big data has been recognized, due to its pluripotency. Second, it has brought together industry, government, academia, and citizens with health as a common interest. Third, collaboration between the industry, government, and academia has been established to further health promotion activities and health education. Fourth, the project's progress and results are now socially visible and have enabled the creation of even stronger social partnerships. Finally and subsequently, a larger platform is building to enable social innovations. The IHPP is a multipurpose research activity that was initiated through a comprehensive health measurement. The IHPP plays a central role in providing a platform for an industry-government-academia-citizen collaboration to improve the health of the citizens of Aomori Prefecture, the prefecture with the shortest life expectancy in Japan.

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Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical approval

The study was approved by the Ethics Committee of Hirosaki University School of Medicine and conducted in accordance with the principles of the Declaration of Helsinki (2014-377).

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Informed consent

Written informed consent was obtained from all participants prior to the study.

Trial registration

This study was registered in the University Hospital Medical Information Network (UMIN-CTR, https://www.umin.ac.jp) prior to the analyses (UMIN ID: UMIN000040459).

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Supplemental material

Supplemental material for this article is available online.

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