

## Network Service to Enhance Self-Improvement Activities for Health: A Challenge to Change Passive Social Model to Active Health Creation and Disease Prevention

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**Abstract**—Redirection of the literacy of the general public as well as the public policies and industry strategies to change the passive social model depending on medicines and surgery after disease are found to active health creation and disease prevention was proposed by JATES, an industrial society, based on its Sensor Network Study Project on Health and Medical Care. Application and management of the sensor network technology and associated services were urged for the purpose. Social experiments to explore the feasibility of the proposal and followed founding of the start-up, Health Improvement Net Service, LLC, to realize the proposals as business has offered promising prospect for the ultimate change of the social model. Although the challenge is at an early stage, there have been encouraging findings for the bottom up, emergency approach utilizing the sensor network and associated services as follows:

1) **Benefit of the sensor network platform for continuous sensing and interactive communication.**

The platform also serves as a test bed of new sensor devices for manufacturers.

2) **Effectiveness of continuous and regular sensing and offering motivators.**

It has been shown that linearly scaled indices and interactive communication are most effective for urging clients to self-improvement activities and stepping up the activity stages.

3) **Solution by self-improvement activities for urgent problems as a strong, killer motivator.**

It has been shown that the self-improvement solution for urgent problems can be a strong, killer motivator to urge clients to habitual actions for health.

4) **Positive feedback cycle formation to encourage each to step up the stages**

Formation of positive feedback cycles have been observed, where motivated actions improve health indices and improvement further motivates actions, allowing for each to step up the activity stages

The bottom up, emergency approach will hopefully generate convinced clients to become opinion leaders and influence a large number of population. Based on the accumulated evidence on the effectiveness of the service, collaboration with health insurance associations as well as large organizations are pursued to acquire the scale required for influential platforms to ultimately change the passive social model.

### I. INTRODUCTION

With the aging of all societies, the growing medical expenditures is pressing the national budget as well as the household expenditures [1]. It is also a keen concern that lifestyle diseases result in a long time of poor quality of life, including confinement to beds [2]. The traditional social model has been passive, depending on medicines and surgery

after diseases are found. It is opinioned widely that creation of health and prevention of diseases should be the strategy. The Japanese Ministry of Health, Labor and Welfare launched an initiative to promote the national health for the period of 2000 till 2012, and the succeeding program started in 2013 [3]. The ministry also set up a guideline for the amount of exercises by defining the unit “Ekusasaizu (Exercise) or Ex ” in 2006 for the use of practitioners and the general public [4]. The guideline refers to everyday activities such as walking or stepping up the stairs for defining specific Ex values. Today many activity meters incorporate measurement of Ex. However, such top down, population approaches have not well penetrated into the general public, and unceasing hike of medical expenditures continues [5]. Now expected is the bottom up, emergency approaches focusing on each individual and complement such top down policies.

As an example, Hiyoshi Oral Health Clinics has offered preventive dental care over 30 years in Sakata City, Japan [6]. According to Dr. Kumagai, Clinics President, it has taken this long years for acceptance by the general public, the authorities and the municipal government [7]. The activity was broadcast by NHK (National Broadcast Station) and Tokyo TV, and raised enormous interest among the general public as well as dental specialists [8], [9], [10]. The preventive care would be as effective in other fields. However, this preceding example has depicted the barriers faced as follows [7]:

- 1) Difficulty to change the mindset of the general public and the local government.
- 2) Time needed to accumulate evidence that preventive care is possible and effective.
- 3) Difficulty to move patients to continuous self-care efforts with no fun and consuming time.
- 4) Higher cost to patients for preventive care not covered by insurance than treatments covered.

However there have been encouraging findings as follows [7], [8], [9]:

- 1) Preventive care has substantially reduced the number of children suffering from teeth decay.
- 2) Preventive care assures better quality of life to be able to chew with one’s own teeth through life.
- 3) Preventive care results in reduction of the medical cost as a whole
- 4) The bottom up, emergency approach moves convinced patients to become opinion leaders.
- 5) The change of the mindset and the behavior of the general

public can move the local government and medical specialists toward changing the passive social model.

Thus it has aroused such expectation that the accumulated evidence and the convinced patients will drive the change. Application and management of the information technology (IT) including sensor networks and associated services over Internet would also be expected to accelerate the change. Such a service would offer a bottom up, emergency approach for a large number of people while focusing on each individual.

WHO guideline for salt intake is 5 grams per day, much lower than the average of around 11 grams in Japan. [2], [5]. WHO has urged its member governments to execute top down, population approaches, such as regulation and education [5]. However, no meaningful improvement has been observed in most countries except the United Kingdom and Finland [11], [12], [13], [14], [15]. The current situation suggests necessity of bottom up, emergency approaches in parallel.

For the purpose of improving residents' health, local governments usually set up healthcare centers where healthcare nurses work for the mission of changing the lifestyle of residents through consultation and guidance [16]. These nurses take reference from many theories and practices on behavior change for health [17]. It was studied and proposed by J. O. Prochaska to classify clients to five stages representing activity levels from no interest to sustained actions and to offer intervention effective to each stage [18]. The theory was first applied to stop smoking and then generalized. The theory of "health belief model" was launched by I. M. Rosenstock. The theory tells that in order to move individuals to action for health, it is necessary to make them realize threats, and let them weigh pros and cons of the behavior change. It tells further that triggers for action is necessary [19]. Based on Psychology, the "theory of reasoned action" was proposed by I. Ajzen and then expanded to the "theory of planned behavior" [20]. The theory tells that a person develops intention driven by three factors, namely, the positive attitude toward the action, the social norm and the feeling about controllability. In the meantime, the "theory of self-efficacy" was proposed by A. Bandura to identify how an individual moves to action from intention [21]. Self-efficacy is composed of two factors, namely expectation to the favorable result of the action and confidence to perform it.

However, they can take care of limited number of people [17] and report difficulties as follows [22]:

- 1) Not easy and time consuming to establish mutual communication with clients.
- 2) Not easy and requiring time to upgrade skills of consultation and guidance.
- 3) Not easy to know clients' motivation and concerns needed for effective advices.
- 4) Patience and long time needed for behavior change of clients.

These difficulties could be overcome by application and management of the sensor network technology and associated information services although such information technology (IT) needs to be well accepted and utilized. V. Venkatesh studied the acceptance and use of information technology and identified necessary factors in his Technology Acceptance Model (TAM). The theory was later generalized as the "Unified Theory of Acceptance and Use of Information Technology (UTAUT)", and then extended to consumer acceptance and use with added factors as UTAUT2 [23]: The identified factors can effectively be reflected in application of IT to health and medical care. The factors can be summarized as follows:

- 1) Performance expectancy; Benefits expected by using technology.
- 2) Effort expectancy; Degree of ease at using technology.
- 3) Social influence; Perception of important others (family and friends) regarding use of technology.
- 4) Facilitating conditions; Resources and support available to perform behavior.
- 5) Hedonic motivation; Pleasure and fun derived from using technology.
- 6) Price value; Trade-off between the perceived benefit and the cost.
- 7) Habit; The extent to which people tend to perform behaviors automatically because of learning.

The authors have been working for the Sensor Network Study Project including application to health and medical care at Japan Techno-Economic Society (JATES) [24], [25], [26]. In the study, necessity to change the current passive social model depending on medicines and surgery after diseases are found to active health creation and disease prevention was appealed by advising health scientists and medical specialists (advisors). Self-improvement activities have been emphasized as key to such a change [27], [28]. Critical importance of continuous and regular sensing was stressed [29]. Effectiveness to know one's physical capacity was reported [30], [31], [32]. Based on the Study, JATES launched proposals to redirect top down policies and strategies as well as bottom up approaches along the direction [28]. Through social experiments in the Project, such sensing was found to offer valuable information for advisors as well as motivation for clients [33], [34].

In order to realize the proposal as business, Health Improvement Net Service LLC, a start-up, was then founded to offer the sensor network service [35], [36]. The main target at present is the artery health. The salt intake meter [37], [38], the blood pressure meter and the activity meter combined with periodical arterial stiffness measurement are offered [39], [40], [41]. Solution for urgent problems by self-improvement has been found to be a strong, killer motivator to move people to habitual actions. Such a motivator would also ensure acceptance and use of information technology.

Although health related instrument manufacturers or sensor device manufactures offer information services, their business model is product centric, positioning the service to support product sales [42], [43]. In contrast, the service of the company features an open platform to benefit both sensor device manufactures and clients and the interactive communication service between advisors and clients.

The service would present a case of IoT (Internet of Things) application; starting from collection of a large scale data through the sensor network, followed by extraction of valuable information by artificial intelligence (AI) and generating impact to the people and the society. Although IoT is expected to greatly improve the quality of the health and medical care [44], the passive social model is generally assumed. The authors' challenge is to extend the service further to change the model itself to active health creation and disease prevention by moving individuals to self-improvement activities. Such a service would help overcoming barriers and difficulties reported by Dr. Kumagai [7] and healthcare nurses [22] described above. How the sensor network technology and associated service has been managed and offered promising findings are to be reported.

## II. JATES SENSOR NETWORK STUDY PROJECT ON HEALTH AND MEDICAL CARE WITH FOLLOWED PROPOSALS AND FINDINGS.

At the JATES Study Project on Health and Medical Care, forefront research works have been surveyed. It has been urged by the advising health scientists and medical specialists (advisors) to study application and management of the sensor network technology to change the current passive social model to active health creation and disease prevention [28]. The advisors are commissioned to Profs. Yoriko Atome of Tokyo University of Agriculture and Technology, Kotaro Yamasue of Yokohama City University, Ryuji Kohno of Yokohama National University and Kiyoshi Itao of Tokyo University of Sciences [25], [26]. The study offered learnings on how to move people to active health creation and disease prevention. It also offered state-of-the-art scientific knowledge and technologies to be reflected in the service.

### A. The proposals of JATES based on the Sensor Network Study Project

The proposal launched by JATES based on the Study is as follows [28].

- 1) Redirection of "health literacy" of the general public.  
The state-of-the-art health science and medical technology including critical importance of self-improvement activities for health need to be penetrated into the general public by top down public policies as well as bottom up movements such as management of the sensor network services.
- 2) Redirection of public policies and industry strategies.  
Redirection of public policies and industry strategies to

enhance creation of new businesses based on management of the sensor network and associated services is necessary to drive the change.

### B. Guiding principles presented by advising health scientists and medical specialists.

For the sensor network service, three guiding principles were presented by the advisors as follows:

- 1) Continuous and regular sensing and sharing of data between clients and advisors [29], [34], [45].  
Continuously and regularly sensed data offer valuable information for advisors as well as clients of the service. The salt intake amount was identified as a key to reduce risks of heart attacks and brain strokes caused by growing arterial stiffness. Measurement of the blood pressure every day (particularly after waking up before breakfast) is recommended and included in the social experiments. It is indispensable for those suffering from high blood pressure, diabetes or chronic kidney diseases. The design of the system including the sensor network and interactive communication has been emphasized as key to effective services.
- 2) Identification of motivation factors to urge individuals to willingly take actions against stresses.  
It has been reported that appropriate stress is indispensable for health, allowing for stress proteins to be activated in all the cells. It becomes a challenge for the sensor network service to move people to willingly take actions against stresses [24], [46].
- 3) Moving individuals to sustained self-improvement activities.  
Moving each individual to self-improvement activities should be the core of the service. It was reported that the linearly scaled health indices are effective for sustained activities through renewals of targets. To measure and know one's physical capacity was also a good motivator and should be incorporated into the service [46], [47].

### C. Stress proteins and their impact through exercises

The recent study on stress proteins reported by Prof. Toru Mizushima [48], [49], and Prof. Yoriko Atomi [46] were eye-opening to the Project members. The fact that the arterial stiffness can be improved by the stress of exercises [46] is encouraging although not yet widely recognized. So, the challenge is how to manage technology to move each to habitual exercises against the pressure of stresses.

The Japanese Ministry of Health, Labor and Welfare announced the guideline of the exercise amount for health improvement [4]. Many epidemiological study reports are stored in a data base at Japan Health Promotion and Fitness Foundation [50]. For example, correlation between the risk of type 2 diabetes and the activity amount measured by dispensed calories was reported by S. P. Helmrich et al [51]. The unit "Ekusasaizu" or "Ex" representing the exercise amount was defined as the exercise intensity in METs [52] multiplied by the time in hours [4], [53]. Prof. Isumi Tabata

explained at the Project meeting about the guideline and how it was developed in the project organized by the Ministry [53]. The guideline was formulated by selecting from the study reports the smallest criteria of the exercise amount that indicated significant difference of risks for outbreak of each kind of diseases [54]. The criteria was recently re-examined and came to the same conclusion [55]. The measure Ex is nearly equivalent to the dispensed calories divided by the weight, allowing translation from studies employing calories as indication of the exercise amount [53]. The criteria of the risk of diabetes and other lifestyle diseases was figured out to be 23 Ex per week [4], [53]. It is expected by the Ministry that the guideline will be widely utilized in top down, population approaches, such as education.

Although many activity meters incorporate measuring capability of walking steps and Ex, there is little sign that the government initiative has been widely utilized. The situation suggests limitation of such a top down, population approach alone. One reason would be that it is an open-end approach without closed loop feedbacks, such as encouragement and recognition from qualified advisors over the Internet. Very few would welcome stresses without feedbacks, and the interactive communication over Internet could be the key.

#### *D. Motivation of students in the educational program at the University of Tokyo*

Prof. Yoriko Atomi disclosed her findings in the education program on health science for the students of the University of Tokyo. Students were amazed to learn their internal functions through observation of heart cells beating even under the microscope [30]. The scientific knowledge apparently aroused their interest in themselves [30]. In the course of exercise on the running machine, the exercise capacity corresponding to the lactic threshold as the maximum healthy exercise amount was measured from the breath count [30]. They could recognize their physical capacity and progress by this threshold [31]. Feedback reports from students showed that many of them became motivated for exercises [30], [32], indicating that the linearly scaled own capacity improvable by exercises would be a good motivator.

#### *E. Motivation for self-improvement in group athletic programs*

Prof. Hiroaki Tanaka of Fukuoka University reported on the athletic exercise programs he was instructing. The maximum oxygen intake ability as the exercise capacity was measured periodically [56], [57]. The “slow jogging” was recommended to easily improve the capacity without physical damages [56], [57]. The capacity increases as the exercise continues. The interesting feature of the program was the special events. For example he organizes a tour to Hawaii once a year to run the full Honolulu Marathon for those who have cleared the marathon level capacity [57]. It is impressive that many members are retired people aged over

60. The report suggests that people can be strongly motivated by competition, comparison and working together when they challenge as a group [57]. It also shows that fun is a good motivator as has been pointed out by V. Vankatesh as “hedonic motivation” [23]. The sensor network service over Internet would bring together many clients spread geographically into the same group, readily offering challenge as a group as well as fun for all.

#### *F. Demonstration of the arterial stiffness measurement and positive responses from JATES members.*

The arterial stiffness is measured with reference to the velocity of the pressure wave propagating through the artery [58]. Shisei Datum, an electronic measuring tool manufacturer, conceived that the arterial stiffness could be calculated from the waveform modulated by the reflection from the central artery at ordinary blood pressure measurement [39]. They made collaborative research with Dr. Komine of AIST (National Institute of Advanced Industrial Science and Technology) and later with Riken. Commercialization was successful allowing for much easier measurement.

The arterial stiffness corresponds to the risk of heart attacks and brain strokes. Recent studies report that it has correlation with the risk of dementia and cognitive impairment [59]. Encouraging is the fact that the stiffness can be improved by control of salt intake and exercise derived stresses to the artery. It can be translated to a linear scale of the average arterial age because the arterial stiffness increases with the age [60], [61]. This linear scale would again offer strong motivation for self-improvement activities. In fact, the JATES members were immensely interested in comparison with their real age at the demonstration by Dr. H. Komine, and they repeated measurement [60], [61].

#### *G. The urine salt content meter to estimate the salt intake amount*

The salt intake measurement was studied at the Yokohama City University by Prof. Osamu Tochikubo and Kotaro Yamasue [37], [38]. The salt intake meter was then commercialized by Kohno ME Research Institute, Inc. as the “Urine Salt Content Meter [62]. The salt intake amount per day is calculated from the salt content of the urine for 8 hours at wake-up. The data can be read by smartphones with the near field communication capability (NFC) or keyed in. It is expected that the regular monitoring would motivate reduction of salt intake from foods. Although this measurement exhibits fairly accurate data compared with other methods and the data are automatically collected via near field communication protocol (NFC), the process may not be as simple as it should be, posing necessity for improvement.

III. SOCIAL EXPERIMENTS FOR THE SENSOR NETWORK SERVICE TO ENHANCE SELF-IMPROVEMENT ACTIVITIES.

A. Scope of the experiment

Social experiments of three months were conducted on volunteer clients using the salt intake meter and the blood pressure meter together with the activity meter that records the exercise amount as the walking steps and Ex [64]. The blood pressure measurement every day was assigned to trace the amount of exercises and salt intake control. The large amount of salt intake surely pushes up the maximum blood pressure or the systolic blood pressure and the exercise surely pulls it down. Those with relatively high blood pressure (the systolic and diastolic blood pressures higher than 135mmHg and 85mmHg respectively, formulated by the Japanese Society of Hypertension [63]) was given special alert regarding the necessity of regular measurement at wake-up before breakfast. The measured data were collected by the center server and the analyzed information was displayed on the web page accessible by the client and the advisors of the service.

The five activity stage model was employed with reference to Chiaki Matsumoto [17] and J. O. Prochaska [18]. The five stages and corresponding person to person intervention reported in the literatures are summarized in Table 1 [17], [18]. It was expected that management of the sensor network and associated services would add further effective intervention as are summarized in the right column of the table.

B. Motivators for self-improvement activities.

Based on the social experiments and the reports at the

study, the following motivating factors or motivators were identified. The factors reported in the previous research works on behavior change and consumer acceptance and use of information technology (UTAUT2) were also reflected [18], [19], [20], [21], [23]:

- 1) Competition and comparison with rivals or those with the same demographic backgrounds [65].
- 2) Target setting on linear scale parameters and renewals with evaluation of improvements [56].
- 3) Scientific explanation for the backgrounds and improvement [30].
- 4) Solutions for urgent problems or troubles by self-improvement activities [66], [68].
- 5) Economic benefit estimation [23], [67].
- 6) Finding fun in exercises themselves and special events [23], [57], [68].
- 7) Participation in group activities for self-improvement [57].
- 8) Advices and encouragement from qualified advisors [69].
- 9) Avoidance of risks [19].
- 10) Self-efficacy (Self-confidence for achieving expect results) [20], [21].
- 11) Social norm or expectation from surrounding people [20], [23].

C. Stage and motivator matrix

Since the activity level of each individual is classified into five stages, and the motivator differs among members and according to the stage, it would greatly help intervention to position each individual in a matrix with reference to the stage and the most effective motivators. The matrix is shown in the table 2.

TABLE1. THE FIVE STAGES OF ACTIVITY LEVEL AND EFFECTIVE INTRVENTION

Stage	Definition	Effective Intervention (Person to Person)	Effective Intervention (Interactive Communication over Internet)
1	No interest	Information that helps development of literacy	Interview and solution for urgent problems by self-improvement activities
2	Interest	Literacy development through in depth information	Information of scientific backgrounds Identification of motivators
3	Intention for Action	Information on successful examples and the feasible program for the client	Trial service for experience and information delivery on initial improvement
4	Actions	Information on progress	Identification of motivators, information of improvement particularly on the linear scale indices and target setting
5	Activity Sustained	Support for continuous improvement	Support for community formation and target renewals on the linear scale indices

TABLE 2. MATRIX OF MOTIVATORS AND STAGES

Motivators	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
1. Competition and comparison with rivals or similar demographics					
2. Target setting on linear scale parameters and target renewals					
3. Scientific explanation for the backgrounds and improvement					
4. Solutions for urgent problems or troubles by self-improvement					
5. Economic benefit estimation					
6. Finding fun in exercises themselves and special events					
7. Participation in group activities for self-improvement					
8. Advices and encouragement from qualified advisors					
9. Avoidance of risks					
10. Self-efficacy or self-confidence for achieving expected results					
11. Social norm or expectation from surrounding people					

It has been reported that even if one begins health improvement activities, or steps up the stage, it is not easy to keep high motivation over a long time, resulting in step down to the previous stages [70], [71]. According to Prof. Tanaka, programs to organize a group and allow for members to compete or compare with each other or work together would be effective [57]. Special events for fun as the group target such as participating the marathon could also work for sustaining or stepping up the stage. Linear scale parameters improvable by efforts have been identified as most effective. Motivators can be identified by interviews or interactive communication over Internet, including a set of questionnaires to clients.

*D. System configuration for the service.*

The schematic system configuration is shown in Fig. 1. The center server is composed of the network service system program, the data base and the artificial intelligence to automatically generate drafts for communications. Sensed data are collected via NFC or key-in by the center server and displayed on the screen of the client. Historical records,

motivators, demographic comparisons and questionnaires are also displayed on the screen. The monthly review with advices and encouragement from the advisor is displayed for the client and the advisor. Effective motivators are identified and offered to the client.

*E. Experimental results.*

Distinct improvement of health indices was observed, demonstrating the effectiveness of continuous and regular sensing and the sensor network service [64]. It was also observed that the measurement had influence on the lifestyle of clients. It has been found that moving clients at primitive stages to habitual actions or to higher stages was very difficult [65]. Finding urgent problems together with solution by self-improvement has been found very effective and works as a strong, killer motivator to move the client most easily. For this purpose, the interview before signing the service contract or during the service is informative. The “habit” was identified as a construct for consumer application and use of information technology in UTAUT2 [23].

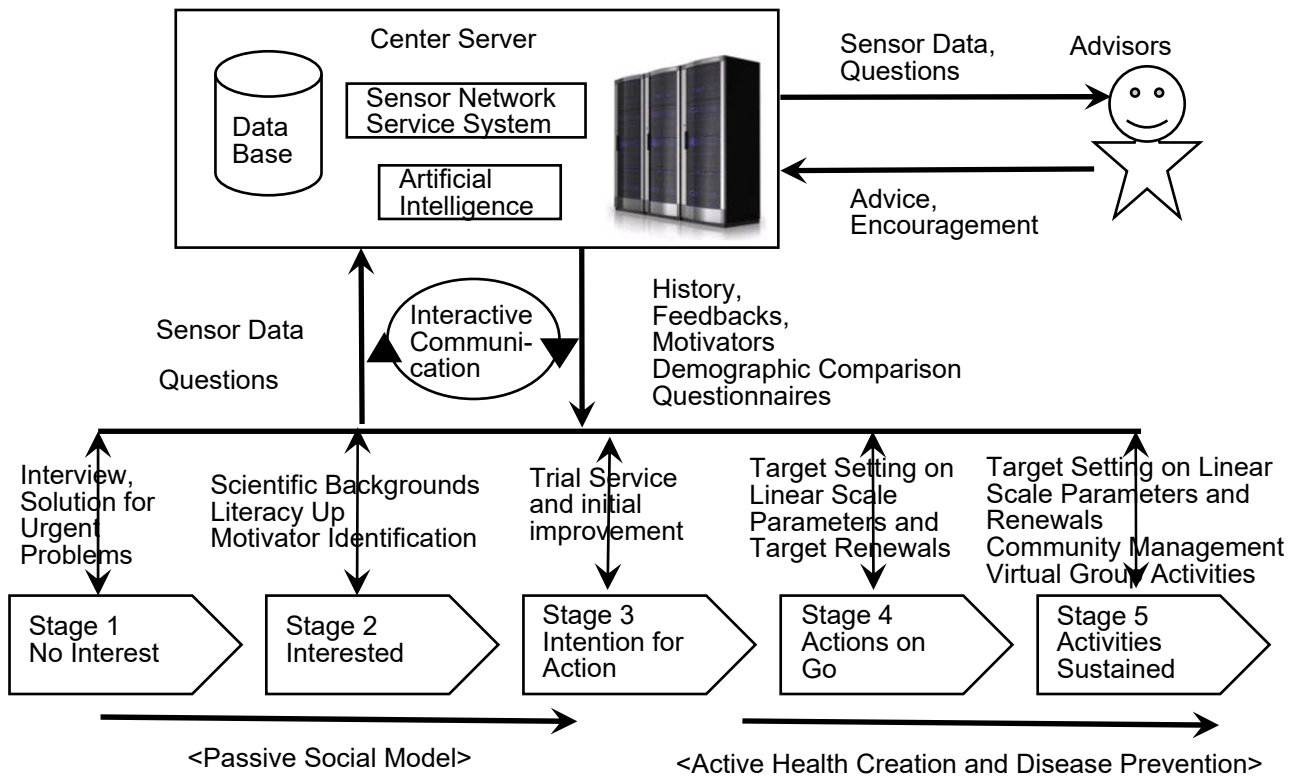


Figure 1. System Configuration Of The Sensor Network Service

IV. CHALLENGE FOR SENSOR NETWORK SERVICE  
AS A PLATFORM BUSINESS BY HEALTH  
IMPROVEMENT NET SERVICE, LLC.

A. *Service structure.*

The system configuration is equal to the one developed for the social experiments. All data and information are securely handled with the Secure Sockets Layer (SSL). Clients are identified only by registered ID to avoid infringement of privacy protection. The system development and management are outsourced to an expert at a reliable organization. It is a closed membership service. A client needs to sign up the service contract, and is registered to the server to allow access to the documents. Very expensive sensor devices, such as the arterial stiffness meter, are installed at the office of the company so that clients may visit periodically for measurement as well as for direct communication.

B. *The features and the service menu offered in the first phase*

The service reflects the three guiding principles presented by the advisors. The basic menu offered in the first phase targets at the arterial stiffness improvement. It consists of the activity meter, the salt intake meter, the blood pressure meter to be measured every day, the arterial stiffness meter once a month and the weight scale once a week or so. The optional menu includes the blood glucose content, the diabetes index measured as HbA1c and the sleep sensing to measure the quality of sleep and breathing while asleep. The sleep sensing for serious problems as sleep apnea syndromes can easily motivate such clients to start habitual measurement and actions as the motivator 4 and 9.

C. *Request for more sensor devices and the future scope*

In order to respond to many requests of sensing and to be prepared to offer solution for urgent problems, search for good sensors is continued for solutions as follows:

- a) Strengthening swallowing functions to prevent pneumonia caused by wrong swallowing.
- b) Skin health measurement to motivate self-improvement activities for the skin age.
- c) Non-invasive glucose sensors to support reduction of glucose content.
- d) Mouth odor elimination with breath sensors and appropriate dental cares.
- e) Autonomic nerve sensors to check mental stability and prevent psychotic depression.
- f) Early detection and solution for Neurosis, Developmental Disorder, Asperger Syndrome, Schizophrenia, the school refusal, sympathetic nerve systems, parasympathetic nerve systems, and etc.

D. *Platform consideration*

The company is ready to incorporate to the platform newly developed sensor devices or even those under

development to be tried by clients. New devices are searched for in the Project meetings, academic conferences and industrial exhibitions. Effective self-improvement activities need to be recommended in order to allow for positive feedback cycles where improvement actions are encouraged by sensing and sensed data encourage actions. Thus the service can be beneficial as a platform for sensor device players as well as the clients.

V. Results and evaluation of the challenge

A. *Remarks from interactive communication.*

Although the service is at an early state, remarks from interactive communication reported below are encouraging as well as promising for realizing the ultimate change of the social model.

- 1) The case of a client stepping up from stage 3 to 5 by motivators 2 and 3.

The characteristic records of Client A are as follows:

- a) Good records of low salt intake around 7 grams, high activity level of more than 10,000 walking steps per day. The arterial stiffness expressed as the arterial age of around 65 much lower than the real age of 74.
- b) The blood pressure is low, with the maximum value of around 100.

The medical specialist suggested to check anemia. Since slight anemia was observed in the health check record, it has been recommended by advisors to improve iron intake through food.

Remarks from the hearing at the interview are as follows:

- a) Challenge for improving the arterial stiffness. The arterial stiffness expressed by the artery age has come down from around 70 to around 65. The targets to bring it down to below 60 within 2016 by further controlling the salt intake and increasing the activity level. The client hopes that the improvement will also work against dementia.
- b) Positive effects of increasing the activity level: The recording of walking steps has encouraged the client to walk instead of using cars or public transportation. The client has noticed improvement in numbness in legs diagnosed as spinal canal stenosis. Another improvement has been the cramp in the feet while asleep. The client has not experienced any since he increased the activity level. A medical doctor suggests that it may be because of the increased amount of muscles in the legs.
- c) The low salt intake as a challenge at home. The low salt content food is not welcomed by the family at home. And yet, as the spouse joins the low salt food, the blood pressure has decreased substantially. Now the spouse does not worry about going to the medical doctor for prescription of the hypotensive medicine that has been of great concern.

This client apparently used to be at the stage 3, and through the service particularly with motivators 2 and 3, progress has been made to step up to the stage 5.

- 2) The case of a client stepping up from stage 4 to 5 by motivators 4 and 9.

Another interview of Client B who used to be at the stage 4 and has come up to the stage 5 has shown that the motivation has been the physical trouble experienced for a long time. The ankle of the heel was injured at a traffic accident a few years ago and caused serious pain when walking. Based on the recommendation of health scientists, exercise such as slow jogging was employed and the exercise amount has been increased gradually with the help of activity meter sensing. The problem has now almost disappeared and the feedback cycle worked well. The motivators have been 4 and 9. The artery age is now around 35 much younger than the real age of 54, and the improvement is immensely encouraging to other clients.

- 3) The case of a client stepping up to habitual actions through working on a serious problem.

The interview of Client C has shown an interesting progress. The salt intake was around 12 grams per day and no improvement was observed for months. The salt control was not welcomed at home because the family apparently likes salty taste food. This client was suffering from the sleep apnea syndrome and the medical doctor recommended to put on a mouthpiece while asleep. During the daytime, he used to suffer from sleepiness which he thought came from the poor sleep quality due to the syndrome. The sleep sensing has been added to the service menu with the sleep meter SL-503 manufactured by Tanita Corporation [72]. The data showed good sleep quality as well as stable breathing thanks to the mouthpiece. So, the client is now confident that the sleepiness comes from different causes, such as full stomach after lunch. The interesting progress has been that the salt intake has shown improvement since then. It is presumed that the regular measurement to check the serious symptom has been accepted by the family and cooperation has also been won for other self-improvement activities such as reduction of salt intake.

- 4) The case of clients at primitive stages.

There are clients at stages 1 and 2, and the company is carefully watching to find key motivators. The interview with Client D has shown such a case. This client neither measured regularly nor engaged in self-improvement activities for a couple of months, followed by another couple of months with no measurement reports. Then there was a phone call that this client had the heart surgery of embedding three stents. At the next interview, this client changed the attitude completely and now is working on track. This would be a case where solution for the serious problem triggered habitual self-improvement actions against stresses.

*B. Evaluation of the challenge to date.*

Although the challenge is at an early stage, it has offered encouraging and promising findings as follows:

- 1) Benefit of the sensor network platform for continuous sensing and interactive communication.

The platform allows for each individual to easily upload the sensed data and be updated about their status together with advices and encouragement from advisors. The platform also serves as a test bed of new sensor devices for manufacturers.

- 2) Effectiveness of continuous and regular sensing and offering motivators.

Continuous and regular sensing with followed interactive communication allows for the servicer and the advisors to understand clients in depth so that effective motivators for each can be identified. Although it is a general perception that it is not easy to move the general public to health improving actions, it has been shown that linearly scaled indices and interactive communication are most effective for urging clients to self-improvement activities and stepping up the activity stages.

- 3) Solution by self-improvement activities for urgent problems as a strong, killer motivator.

It has been shown that the self-improvement solution for urgent problems can be a strong, killer motivator to urge clients, particularly those at primitive stages to habitual actions in spite of the generally perceived difficulty.

- 4) Positive feedback cycle formation to encourage each to step up the stages

Positive feedback cycles have been formed, where motivated actions improve health indices and improvement further motivates actions, allowing for each to step up the stages to a solid track. Linear scale indices have been found most effective to sustain activities by renewals of the target.

- 5) Expectation for the change of the social model to active health creation and disease prevention.

Although the challenge is at an early stage, the findings are promising for the ultimate change of the social model through this bottom up, emergency approach.

VI. DISCUSSIONS AND FUTURE PLANS.

*A. Necessity of stresses and self-improvement activities for health.*

The proposal by JATES is based on the premise that stress works for sustaining or even improving health through activation of stress proteins. The premise is just contrary to the general perception for stress to be avoided. Thus the proposal appeals for the necessity to redirect the literacy of the general public.

*B. Prospect for redirecting the social model to active health creation and disease prevention.*

The pioneering works by Dr. Kumagai for preventive dental care has shown advantages of the approach to reduce



the cost and improve the quality of life. The effort over many years has finally changed the social model even if local. The same approach should also be beneficial in other medical fields. The findings in the social experiments in the Study Project and the early phase of the start-up have aroused expectation for the social model change even if patient efforts would further be required.

*C. Sensor networks and associated information services to move clients to self-improvement activities.*

The proposal urges application and management of the sensor network technology and associated information services to move people to self-improvement activities. Continuous and regular sensing has been found informative to clients as well as advisors. It has also been found that interactive communication over Internet leads to positive feedback cycles of sensed data and improving activities. It has also been found that solution by self-improvement activities for urgent problems moves people to habitual actions. Thus application and management of the sensor network service have been found effective for behavior change perceived difficult.

*D. Differentiated features of the service offered by the start-up.*

Manufacturers of health related instruments or sensor devices offering similar information services would not open their system to competitors for the benefit of clients, whereas an open platform to any device suppliers is offered by the start-up. With the increasing interest in health and medical care, open platform services will emerge. Then collaborative opportunities will be pursued on condition that ultimate change of the social model based on self-improvement activities is aimed for. State-of-the-art scientific knowledge and products coming from the advisors and the study at JATES would be an advantage. Encouragement and recognition by the qualified advisors should also be beneficial to clients.

*E. Development of the algorithm to simulate the economic impacts as well as the benefits in quality of life.*

A substantial portion of the Japanese health insurance is covered by corporate health insurance associations, including member companies of JATES. For the purpose of improving their members' health and reduction of medical expenditures, collaboration with the start-up should be beneficial for both with disclosure of their expenditure data. Thus development of the algorithm to simulate economic impacts would become possible and accelerate expanding the service scale to ultimately move upper layers of society.

*F. The roadmap to changing the passive social model to active health creation and disease prevention*

The roadmap to ultimately changing the social model are envisioned as follows:

1) Accumulation of evidence sufficient to attract

organizations with a large scale of members.

- 2) Reporting to academic conferences as well as symposiums on the findings and achievements.
- 3) Organizing from convinced clients core promoters and opinion leaders for the social model change.
- 4) Collaboration with large organizations to acquire the scale as an influential platformer.
- 5) Focusing on the local government and its residents to change the local social model.
- 6) Expanding the local government network to the national level and beyond.

VII. SUMMARY AND CONCLUDING REMARKS.

Redirection of the literacy of the general public as well as the public policies and industry strategies to change the passive social model depending on medicines and surgery after disease are found to active health creation and disease prevention was proposed by JATES based on the Sensor Network Study Project on Health and Medical Care. Application and management of the sensor network technology and associated services were urged for the purpose. Social experiments to explore the feasibility of the proposal and followed founding of the start-up, Health Improvement Net Service, LLC, to realize the proposals as business has offered promising prospect for the ultimate change of the social model. Although the challenge is at an early stage, there have been encouraging findings for the bottom up, emergency approach utilizing the sensor network and associated services as follows:

- 1) Benefit of the sensor network platform for continuous sensing and interactive communication.

The platform allows for each individual to easily upload the sensed data and be updated about their status together with advices and encouragement from advisors. The platform also serves as a test bed of new sensor devices for manufacturers.

- 2) Effectiveness of continuous and regular sensing and offering motivators.

Continuous and regular sensing with followed interactive communication allows for the servicer and the advisors to understand clients in depth so that effective motivators for each can be identified.

Although it is a general perception that it is not easy to move the general public to health improving actions, it has been shown that linearly scaled indices and interactive communication are most effective for urging clients to self-improvement activities and stepping up the activity stages.

- 3) Solution by self-improvement activities for urgent problems as a strong, killer motivator.

It has been shown that the self-improvement solution for urgent problems can be a strong, killer motivator to urge clients, particularly those at primitive stages to habitual actions in spite of the generally perceived difficulty.

- 4) Positive feedback cycle formation to encourage each to

step up the stages

Formation of positive feedback cycles have been observed, where motivated actions improve health indices and improvement further motivates actions, allowing for each to step up the stages to a solid track. With this respect, linear scale indices have also been found most effective to sustain actions by renewals of the target.

The bottom up, emergency approach will hopefully generate convinced clients to become opinion leaders and influence a large number of population to ultimately move higher levels of society. Based on the accumulated evidence on the effectiveness of the service, collaboration with health insurance associations as well as large organizations are pursued to acquire the scale required for influential platforms to ultimately change the passive social model.

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