34th Annual International Conference of the IEEE EMBS
San Diego, California USA, 28 August - 1 September, 2012

Tailor-made Preventive Medicine Integrating Amino Acid Checkup and its Application toward Disaster-stricken Areas

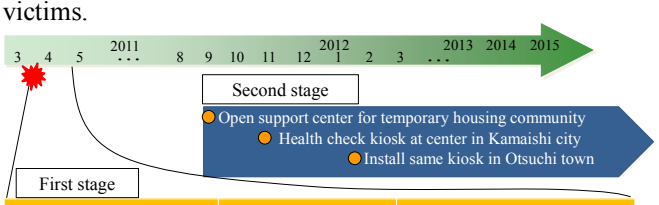
Masahiro Kuroda[1] and Osamu Tochikubo[2]

***Abstract* – ICT technologies for healthcare are useful in myriad locations for people with lifestyle-related illnesses and health irregularities. When symptoms turn into actual illnesses, it is difficult for them to be managed, and this situation is relevant for managing the health of victims after large-scale disasters; it is important to keep people healthy to prevent them from acquiring illness. This paper proposes a system of personalized preventive medicine for individuals to maintain their health and receive evidence-based feedback. We introduce general medical checkups, ubiquitous sensing, and plasma amino acid analysis as the system's core components. We evaluate these elements and discuss their applicability toward the disaster-stricken Tohoku area of Japan. This is an initial evaluation, but some functions are being used in the area. There are gaps between research results and actually deployable technologies, but it is important to use and improve the quality of life of victims who are ultimately forced to live in temporary housing for more than five years.**

I. Introduction

The earthquake off the Pacific coast of Japan's Tohoku region on March 11, 2011 was the largest in the country's recorded history and triggered a massive tsunami that left huge numbers of victims in its wake.

There are two stages for aiding people in the affected areas. The first stage of recovery is for providing rescue and medical treatment immediately after the disaster, as per the Basic Act on Disaster Control Measures [1]. This emergency response covers Phase 0-2 (Fig. 1). The second stage, which is positioned beyond Phase 2, seeks to restore everyday life for victims.



Phase 0 Initial emergency response (within 24 hours)	Phase 1 Urgent measures (within 72 hours)	Phase 2 Temporary measures (4-30 days)
Cut lifeline utilities	Confusion by evacuees increases	Increased incidence of constipation
Increase of evacuees	Increase in injured	Increase of chronic fatigue and poor physical condition

Reference - http://www.kenko-niigata.com/21/shishin/sonotakeikaku/saigaijieiyoupdf/5_gaiyouhyouP9_10.pdf

Fig. 1. Disaster recovery stages

The second stage begins when temporary housing communities are established, and comes about six months after the disaster. In this disaster, in just minutes victims lost family members, houses, and jobs by the tsunami, but not large number of external injuries were observed because the arrival time of tsunami came late after the quake and evacuees could survive with no injuries. More than 300,000 people were forced into distress and long-term evacuations were enforced. The resulting change of people's lives also calls for health support suited to individuals since many of these people were essentially healthy before the disaster and each comes from a unique family environment. Since the second stage of recovery will likely last more than five years, it is expected that using a system of physical and psychological checkups under the management of life support advisers (LSAs) and health support systems, along with ICT technologies, can restore a certain level of daily life. Indeed this is a unique disaster-response situation.

In this paper, we propose a system of preventive medicine for individuals to maintain their health that provides evidential data on vital sensing and amino acids. Three components are explained herein: general medical checkups, ubiquitous sensing, and plasma amino acid analysis. A subset of the medical checkup is implemented in temporary housing communities as a preparatory step for providing the preventive medicine. We then evaluate ubiquitous sensors to measure mental stress and sleep quality, and discuss plasma amino acid analysis and its application in the disaster-stricken area. The paper concludes with our plan for preventive medicine supported by medical/healthcare personnel.

II. Tailor-made Preventive Medicine

The tailor-made preventive medicine consists of general medical checkups, ubiquitous sensing, and plasma amino acid analysis, and is intended for individual healthcare management. It integrates two forms of evidential data: vital sensing and amino acid analysis. Individuals build their own health feedback system with health food supply and/or supplements to prevent lifestyle-related illnesses (Fig. 2).

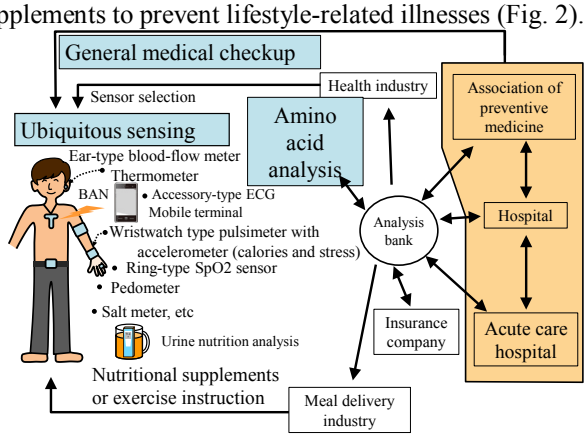


Fig. 2. Tailor-made preventive medicine

[1]M. Kuroda is with the National Institute of Information and Communications Technology, 4-2-1 Nukui-Kitamachi, Koganei, Tokyo 184-8795 Japan (e-mail: marsh@nict.go.jp)

[2]O. Tochikubo is with the Graduate School of Medicine, Yokohama City University, 3-9 Fukuura, Kanazawa-ku, Yokohama, 236-004, Japan (e-mail: tocchi@med.yokohama-cu.ac.jp)

Preventive medicine has attracted attention because lifestyle-related irregularities can lead to advanced illnesses such as diabetes, hypertension, and hyperlipemia. A comprehensive physical examination is a detailed inspection of many areas and can identify abnormalities. Detailed examination in addition to the general checkup can be useful for discovering early sign of illness.

Dietary supplements such as vitamins, minerals, and herbs can enhance the human diet and some play an important role in health and can function as alternative medicine.

A. General Medical Checkup

Residents of Japan must periodically undergo a physical examination as mandated by the Industrial Safety and Health Law [2] for companies and the School Health and Safety Act [3] for schools (Fig. 3). Equipment used for examinations depends on the examinee's requests, and can be transported by an examination bus. Mass medical examinations, including those at medical facilities, are conducted in a well-structured environment with medical personnel managing the procedure. These examinations, called general medical checkups, are useful for screening and are run with instructions that are easy for examinees to follow. They currently use offline equipment and paper-based examination results.

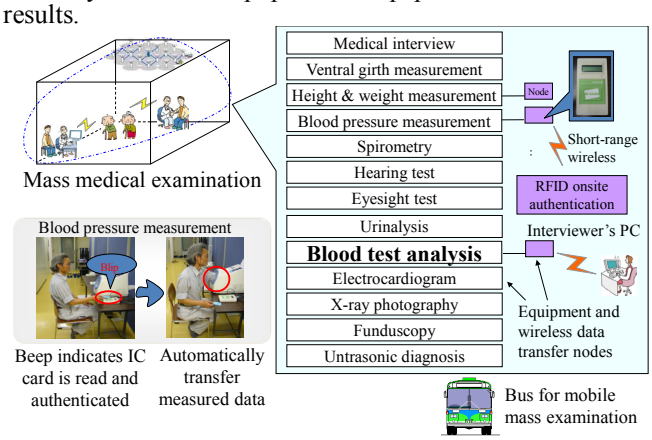


Fig. 3. Experimental self-checkup system and components

We have designed an experimental medical-checkup system, called UMe-1, which uses short-range wireless communication (Pre IEEE8021.5.6 standard) with standard AES128-CBC encryption between equipment and a data collector on the interviewer's PC. We defined protocols and data formats suitable for a power-efficient wireless communication environment using battery-operated devices and satisfying the Pharmaceutical Affairs Law [4]. The system is expected to be used for self-performed health checkups in a mobile environment, such as temporary housing communities.

B. Ubiquitous sensing

Ubiquitous sensing is achieved via a body area network (BAN) consisting of non-invasive sensors and a coordinator. A BAN is a short-range wireless network based on the IEEE802.15.6 [5] specification, which is the first BAN standard dedicated to medical and healthcare uses.

We have proposed a BAN requiring less traffic from the coordinator to sensors to reduce the receive-wait state in the sensor RF and which permits plug-in of sensors, such as an SpO2, at the setup or a later time. These ensure order in the data coming from sensors using a beaconless time synchronization mechanism, and protect wireless communications from eavesdroppers and attacks [6]. The interface is defined on IEEE802.15.6 by the Quality-of-Life Sensing Network (QoL-SN) association [7].

There are many non-invasive sensors, as shown in Fig. 2. A BAN consisting of a wristwatch-type pulsimeter with an accelerometer and pedometer using a BAN coordinator, such as on an iPhone, is useful for daytime evaluation of stress as it relates to preventive medicine (Fig. 4(a)). The pulsimeter is not currently configured in a BAN. At night, we can use a breath sensor to identify heartbeats and breathing and analyze the heart rate (HR). Fig. 4(b) shows the configuration of a BAN consisting of a breath sensor and a small ring-type SpO2 sensor used at night. Sensors can be worn during the daytime, but they can be difficult to use at night if they interfere with sleeping. The breath sensor is positioned under a bed sheet and imperceptible to the user at night. Stress analysis using two types of sensors is appropriate for 24-hour uses.

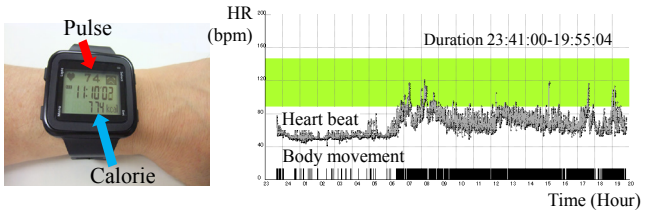


Fig. 4(a). Wristwatch-type pulsimeter with accelerometer

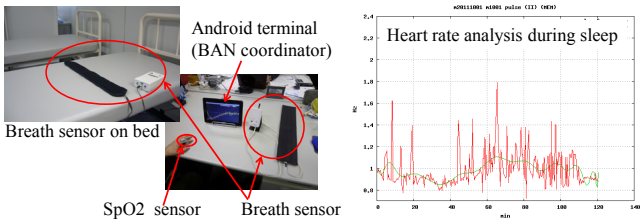


Fig. 4(b). Breath and SpO2 sensors during sleep

We evaluated mental and physical stress and sleep quality (Fig. 5). Both forms of stress are evaluated via mean heart rate (HR) compared with the user's base HR. Mental stress appears when the user is sleeping, and the HR/baseHR ratio > 1.55 is set for the stress and the red part 92.88 minutes is high mental stress duration. The blue part shows high physical stress. The mental stress evaluation is especially useful for preventing psychological illnesses. It is generally approved that calories are calculated from heartbeats.

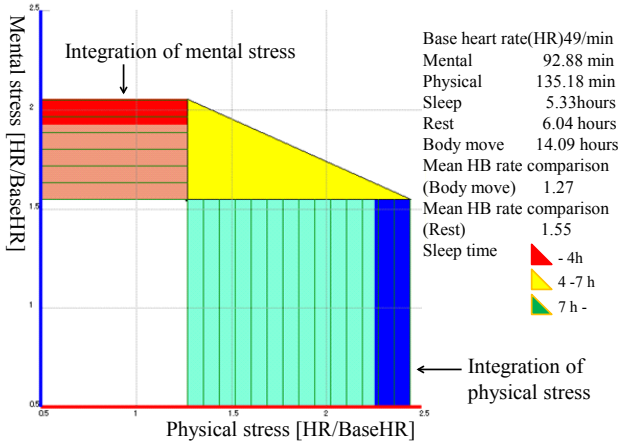


Fig. 5. Mental and physical stress and sleep evaluation

One of factors underlying mental health is insomnia, and amino acids are used to ease this condition. When people wake up, optical stimulus controls the suprachiasmatic nucleus and pineal body that are above where the left and right optic nerves cross paths. At night, the control is released and melatonin is induced from the pineal body. Aging sharply decreases the secretion of melatonin [8]. Since melatonin is compounded in the body from tryptophan, an essential amino acid, a supply of melatonin or tryptophan alleviates insomnia.

C. *Plasma Amino Acid Analysis*

The amino index was developed to provide a score for more clearly distinguishing diseases and health conditions by combining the number of plasma amino acid concentrations [9]. The index shows the imbalance of amino acids and each disease group is separated by choosing a combination of amino acids. Extending this method, health conditions and diseases are identified through multivariate analysis of selected amino acids [10]. By using analysis based on the sensing results, users are guided in taking supplements or exercising (Fig. 6).

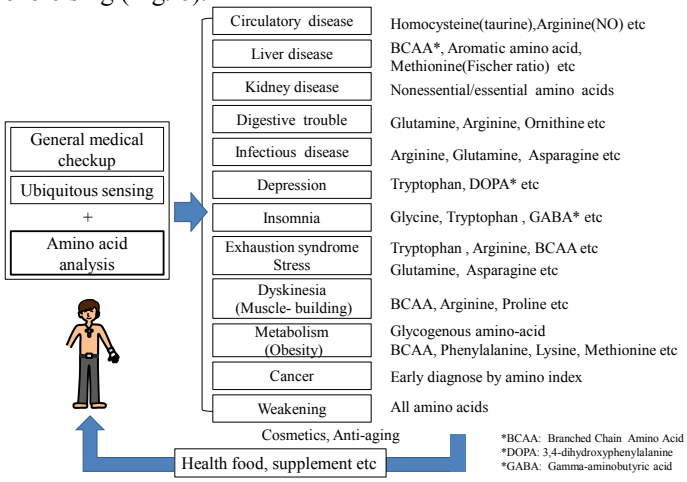


Fig. 6. Amino acid examination and feedback system

A great deal of research has examined the relationships between disease and amino acids, but still there are few studies and long-term results have yet not been acquired.

We evaluated the relationship between plasma amino acids and obesity (88 samples), which is one of the main factors (along with salt and stress) associated with lifestyle-related illnesses. We use three groups; a group who do not need diet (normal), a group who succeed in diet under doctor instructions (good-diet), and a group who failed in diet under doctor instructions (bad-diet) to measure the differences in amino acid concentration. The bad-diet group has significant imbalance in essential amino acids compared to the normal and good-diet group. The bad-diet group also loses its balance in amino acids, especially essential amino acids: Histidine (His), Arginine (Arg), Tryptophan (Trp), Tyrosine (Tyr), Methionine (Met), Lysine (Lys), Threonine (Thr) (Figs. 7(a), (b), (c)). These unbalances may be a main factor behind difficulty in losing weight. This is an initial evaluation and further research is underway.

III. Application to Disaster-Stricken Area

More than 300,000 people are living in temporary housing and metal stress is the most prevalent health issue. Many people have lost their jobs and houses, which means they have nothing to do but stay in their narrow rooms, and they sometimes eat adequate but not well-balanced foods. A system of examining sleep patterns and stress can be important in this situation for preventing lifestyle irregularity from escalating into lifestyle-related illness (Fig. 8).

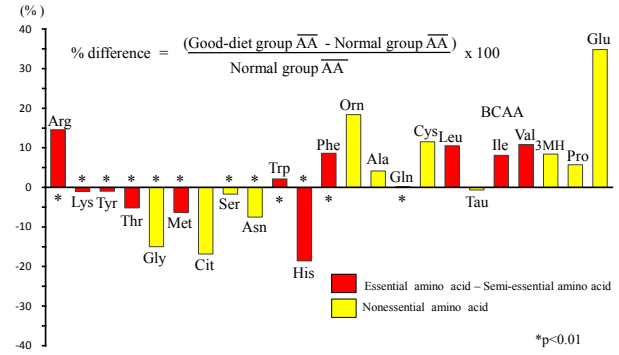


Fig. 7(a). Difference between normal and good-diet groups

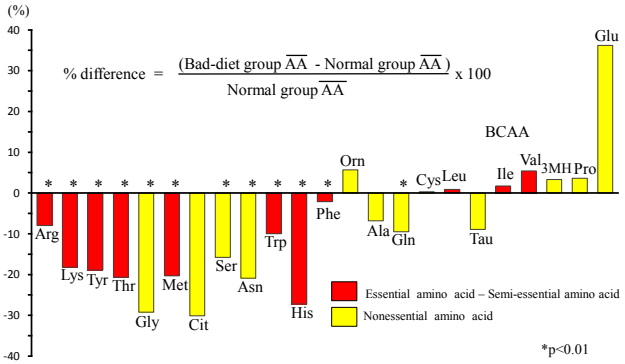


Fig. 7(b). Difference between normal and bad-diet groups

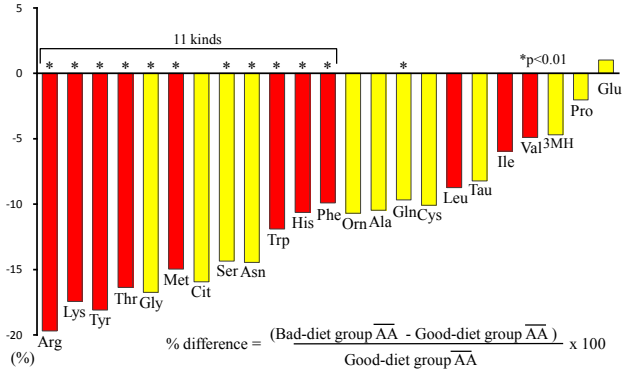


Fig. 7(c). Difference between good-diet and bad-diet groups

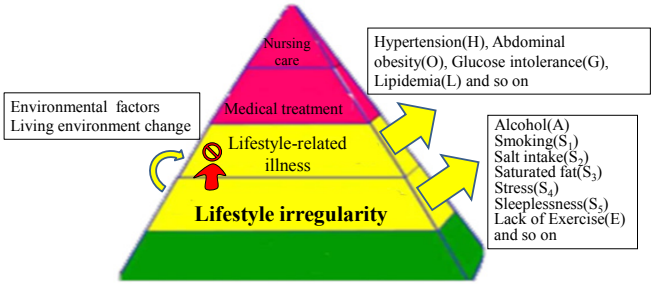


Fig. 8. Lifestyle irregularity and illness

A. *Environment of Temporary Housing Community*

Following the Great East Japan Earthquake, more than 13,000 units of temporary housing have been built in Iwate prefecture. We began work on our ICT deployment from the second stage of disaster recovery (Fig. 1). Temporary housing is constructed in tsunami-safe and isolated areas between mountains, which were uninhabited before the tsunami, and also scattered along the bases of mountains. We first installed a health checkup kiosk at support centers in Kamaishi City and Otsuchi Town.

Fig. 9. Area and temporary housing six months after disaster

As the views in Fig. 9 imply, limited communications are available. Local governments provide a TV set for each temporary housing unit to provide the residents with broadcast information. Other means of communication may be available. The following conditions were also considered.

1) Very cold winters
2) Limited space in the support center and individual units
3) People living in makeshift housing incur emotional stress

B. *Kaera version 0 System*

ICT technologies are an important tool for providing care that is imperceptible to the user and BANs need to be installed in each house that do not violate the users' privacy.

The Kaera version 0 system is a subset of the UMe-1 system, an experimental basic medical checkup that measures blood pressure, weight, and height.

An examinee first receives an IC card for local user identification and independently takes measurements on each instrument as the data is collected wirelessly in a PC at the support center (Fig. 10). At any time the user can print out records and use them as a reference in consulting a doctor.

The system deployed only three medical instruments because of space limitations, but these are popular instruments familiar to most people. Such devices are good candidates for the initial deployment.

The next step is to install ubiquitous sensors such as the wristwatch-type pulsimeters and breath sensors. These require in each housing unit a BAN configuration that is based on the health condition, in order to gather data and upload it via a television to the support center. Amino acid analysis is then conducted by combining with the general medical checkup under the management of a local organization for Preventive Medicine that operates periodic general health checkups in the area. Monthly checkups are planned in the case of the disaster-stricken area. We expect that each person receives measured feedback from the BAN and monthly health checkups with the amino acid examination and, then, provide amino acid supplements when imbalance in amino acid is found.

A sense of trust needs to be established among the victims and consensus needs to be built among the medical association, city office, social welfare service corporations, and other related parties in the area before installing services, since various organizations manage the temporary housing. The Kaera system establishes a framework for providing personalized preventive medicine in the area and is expected to extend to personalized preventive medicine.

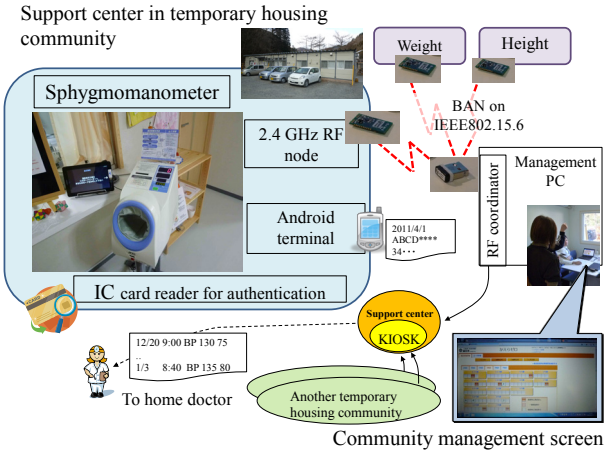


Fig. 10. Kaera version 0 system and its use

IV. Conclusion and Future Work

This paper proposed a system of personalized preventive medicine for individuals to maintain their health using evidence from vital sensing and amino acid data, and is particularly targeted at mental stress in a disaster-stricken area. We briefly discussed three components – general medical checkups, ubiquitous sensing, and plasma amino acid analysis – and implemented a subset of the checkup kiosk in temporary housing communities. Non-invasive sensors were evaluated for measuring stress and sleep quality, and we discussed implementation of plasma amino acid analysis and its applications related to insomnia.

We will continue to work on evaluating functions related to preventive medicine and progressively apply them in real life for rebuilding and rehabilitating disaster-stricken areas.

Acknowledgments

We would like to thank Takeyuki Nagato and Taiki Mori of Caunets Corporation for contributing voluntary Kaera software development.

References

[1] http://law.e-gov.go.jp/htmldata/S36/S36HO223.html (In Japanese)
[2] http://unpan1.un.org/intradoc/groups/public/documents/APCITY/UNPAN009437.pdf
[3] http://www.japaneselawtranslation.go.jp/law/detail_main?re=01&vm=&id=1736 (Japanese)
[4] http://law.e-gov.go.jp/htmldata/S35/S35HO145.html (Japanese)
[5] http://www.ieee802.org/15/pub/TG6.html
[6] M. Kuroda, Y. Tamura, R. Kohno, and O. Tochikubo, "Empirical Evaluation of Zero-admin Authentication for Vital Sensors in Body Area Networks," pp. 2349-2352, IEEE EMBC 2008, Aug. 2008.
[7] http://www.qolsn.org
[8] F. Waldhauser, B. Ehrhart, and E. Forster, "Clinical aspects of the melatonin action: impact of development, aging, and puberty, involvement of melatonin in psychiatric disease and importance of neuroimmunoendocrine interactions," *Experientia*, pp. 671-81, 49(8), 1993.
[9] Y. Noguchi, Q. W. Zhang, T. Sugimoto, et al, "Network analysis of plasma and tissue amino acids and the generation of an amino index for potential diagnostic use," *Am J Clin Nutr* 83, pp. 513S-519S, 2006.
[10] O. Tochikubo, E. Miyajima, K. Okabe, et al, "Improvement of multiple coronary risk factors in obese hypertensive by reduction of inter-abdominal visceral fat," *Jpn Heart J* 3516; pp. 715-725, 1994.