report

Use of Finger Vein Authentication for Population-based Surveys in Developing Countries

OVERVIEW: A Health and Demographic Surveillance System (HDSS) is a longitudinal population data collection process for public health research in rural or marginal regions of developing countries in Africa and Asia. The lack of a residential registration system in such regions makes it impossible to calculate basic demographic information, like populations or births and deaths. Instead of the official registration system, the HDSS registers people and provides basic information for public health research and disease control programs, such as infectious disease control. However, because people in such regions sometimes change their names for reasons that relate to the local customs and culture, the system faces the problem of how to identify individuals definitely. Additionally, people in these regions are often not conscious of dates, and this makes it difficult to use date of birth for identification of individuals. In response to this challenge, an HDSS being worked on by the Institute of Tropical Medicine, Nagasaki University and the Research Institute for Humanity and Nature, Kyoto, has adopted Hitachi's finger vein authentication technology. This has made a major contribution to the research by dramatically improving the accuracy of personal identification, preventing people from registering more than once, for example. This outcome also indicates the potential for extending and enhancing not only healthcare but the full range of public services in developing countries. This article looks at further applications for finger vein authentication and upcoming business developments.

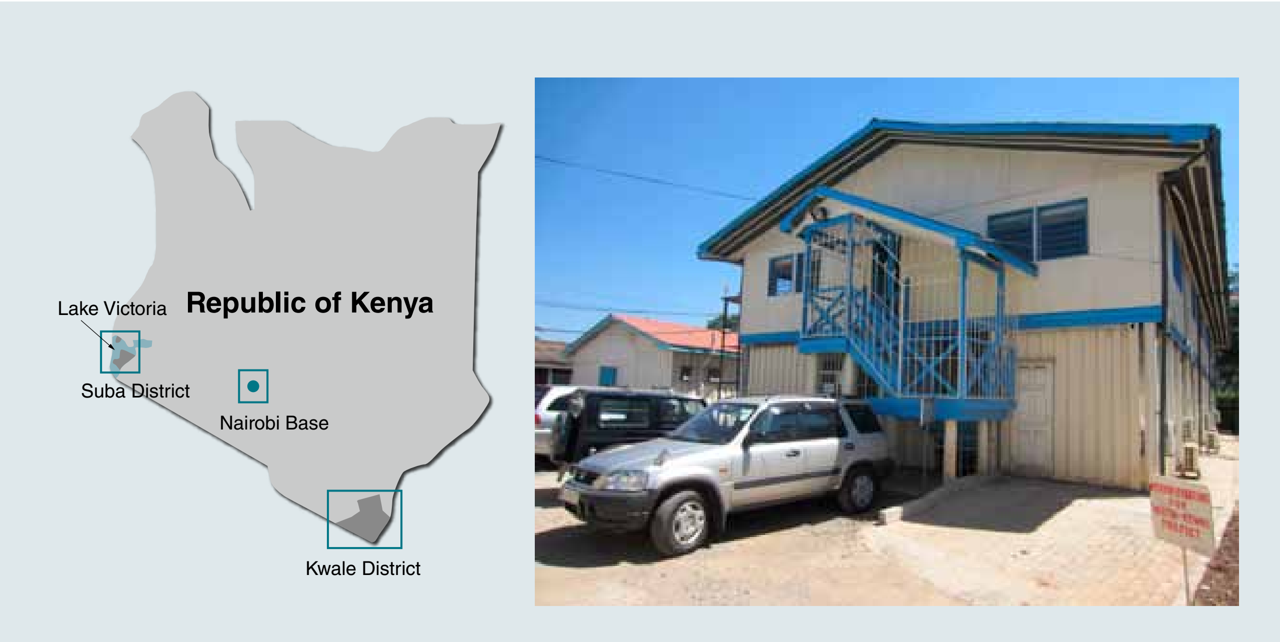
HEALTHCARE WORK IN KENYA BY INSTITUTE OF TROPICAL MEDICINE, NAGASAKI UNIVERSITY

NAGASAKI University was founded based on the Igaku Denshusho (Medical Training Institute), Japan's first ever modern, western-style hospital (established in 1857). It has a long history of working at the forefront of medicine, including the establishment in 1942 of the East Asia Research Institute of Endemics within the university. After the successful eradication of endemic diseases in Japan (such as malaria, filariasis, and schistosomiasis) in its early years, the focus of its activities in the post-war era shifted overseas. In 1967, it was renamed the "Institute of Tropical Medicine" and has devoted its efforts since then to health promotion and the prevention of tropical diseases in developing countries, working in conjunction with the School of Medicine. In particular, from the early 1960s up until 1975, the institute was actively involved in combating tropical diseases, sending medical teams to the Republic of Kenya as part of a healthcare collaboration project by the Overseas Technology Cooperation Agency (OTCA), the forerunner of the current Japan International Cooperation Agency (JICA).

Despite such initiatives, the number of people with infectious diseases such as malaria, pneumonia, and tuberculosis still showed no sign of declining. Given this situation, the institute recognized the need to strike at the underlying causes of disease.

In 1979, Nagasaki University and JICA, in collaboration with the Kenya Medical Research Institute (KEMRI), which had only just formed at the time, embarked on a project researching measures against infection diseases. In 1985, facilities were established at KEMRI headquarters (laboratory and administration, etc.) with financial aid from Japan. They were used for research and control activities

Professor Kazuhiko Moji, Research Institute for Humanity and Nature Inter-university Research Institute Corporation, National Institutes for the Humanities, Japan.



Operational sites of the Institute of Tropical Medicine in the Republic of Kenya and its base in the capital, Nairobi.

against infectious diseases (such as viruses, bacteria, protozoa, and parasites) with researchers and staff members from the Kenyan government. In 2005, the Institute of Tropical Medicine established an overseas research station at KEMRI funded by a special grant for education and research from the Ministry of Education, Culture, Sports, Science and Technology Japan. The institute has established two research bases for field surveys, one in the Suba District of Nyanza Province on the shores of Lake Victoria in western Kenya where malaria is endemic, and another in the Kwale District of Coast Province, which is located on the Indian Ocean and surrounded by savannah.

ECOHEALTH PROJECT

The EcoHealth Project (Environmental Change and Infectious Diseases in Tropical Asia), which involves surveys and research in which staff from the Institute of Tropical Medicine, Nagasaki University also participated, is being run by the Research Institute for Humanity and Nature (RIHN), Inter-University Research Institute Corporation, National Institutes for the Humanities, Japan. Project Leader Professor Kazuhiko Moji explains the nature and significance of the project as follows.

"This project is concerned with environmental change and infectious diseases in the tropical monsoon regions of Asia. It treats infectious disease as part of people's way of life and the environment in which they live, and attempts to document and analyze this situation in an integrated and cross-disciplinary manner. The 20th century is seen as an era in which people acquired health along with economic progress, particularly in developed countries. Health in the 21st century, in contrast, rather than being proportional to wealth, is something that needs to be achieved alongside a reduction in the load on the global environment. This project aims to look into what form healthcare should take in this new era."

For example, clonorchiasis (liver fluke infection) is one of the infectious diseases that afflict the tropical monsoon regions of Asia. The disease is caught by eating the raw flesh of freshwater carp, and while it is

Personnel involved in EcoHealth Project (Environmental Change and Infectious Diseases in Tropical Asia) (From left: Jiang HongWei, researcher; Bumpei Tojo, researcher; and Professor Moji of RIHN; Professor Satoshi Kaneko, Institute of Tropical Medicine, Nagasaki University; and Professor Makoto Ito, Aichi Medical University).

not immediately life-threatening, the infection can, if it persists over time, lead to liver cirrhosis. Infectious diseases like this one arise from local factors, in other words the ecosystem and the way people live. This intimate relationship with the natural environment and cultural and economic practices (which are distinctive of specific locations) makes such diseases hard to eradicate.

"Accordingly, rather than relying on drugs or other medical procedures as in the past, our aim was to find solutions that would be tailored to the social systems in each community. In the case of liver fluke infection, for example, if surveys can tell us the season in which the fish are dangerous to eat, we would be able to deploy this information in education programs. We then want to go on and consider these in terms of the problem at the national level or at the level of the regional environment so that it can lead us to a comprehensive solution." (Professor Kazuhiko Moji)

HEALTH AND DEMOGRAPHIC SURVEILLANCE SYSTEM (HDSS)

The Health and Demographic Surveillance System (HDSS) has attracted attention for its use in the study of methods for dealing with infectious diseases in developing countries.

Intended for use in regions that lack adequate measures for keeping track of the static and dynamic aspects of their demographics, such as not having a register of births and deaths or a residential registration system, an HDSS provides a method for registering everyone who lives in the region to allow the systematic and ongoing tracking of changes in residency. First proposed by Professor John Gordon, an epidemiologist at Harvard University, it has proven an extremely effective tool for the provision of health and healthcare information in the sort of regions described above, and are being adopted in a variety of developing countries in Africa, Asia, and Central and South America. In practice, an HDSS involves visiting each household about once every one to three months to survey everyone living there, including information about marriages, births, deaths, or relocations. This sort of patient investigation is essential to the fight against infectious disease.

Professor Satoshi Kaneko, Institute of Tropical Medicine, Nagasaki University.

During his time at Nagasaki University, Professor Moji was involved in the small-scale use of an HDSS in studies of maternal and child health and in research into infectious disease pathogens in the 1980s and 1990s. Unfortunately, these initiatives were fraught with problems.

"The surveys were recorded in paper notebooks making it difficult to avoid entering information incorrectly or registering people more than once. It meant searching and cross-checking were very time consuming. Also, because operating a proper HDSS was expensive and labor-intensive, we were not able to expand its scope. In the end, all we seemed to achieve was an increase in the volume of paper survey forms." (Professor Moji)

USE OF INFORMATION TECHNOLOGY IN HDSS, AND THE CHALLENGES THIS POSES

Once Nagasaki University had set up its research bases in Kenya, it embarked on two HDSS research projects, one at each of the bases and each involving 50,000 people (100,000 in total). This increase in scale demanded a step up in the efficiency of survey and research work.

While this was going on, Professor Satoshi Kaneko moved to the Institute of Tropical Medicine, Nagasaki University to work on system development with a focus on HDSS site selection and information technology (IT).

"At that time, I had been working at the National Cancer Center on a cancer surveillance program development in Japan. This consisted of the "Regional Cancer Registry," a prefecture-based registration system, and the "Hospital Cancer Registry," a hospital-based cancer registry used to calculate incident case numbers

and survivals of cancer patients. Based on my experience of that system development, my aim was to also make full use of IT systems in the establishment of an HDSS in Kenya. A paper-based system for surveying 100,000 people, for example, would require 100,000 pieces of paper. Repeat the survey four times a year over 10 years and the total will reach 4 million. Not only would you need to obtain somewhere large enough to store all this paper, it would not be easy to retrieve information. Accordingly, we dispensed with paper for the survey and instead adopted IT, including personal digital assistants (PDAs) and the global positioning system (GPS). This significantly reduced the workload, time, and cost associated with the survey."
(Professor Satoshi Kaneko)

Nevertheless, a number of problems arose, one in particular being the difficulty of using names to identify and consolidate duplicate data. Underlying this problem were differences in people's concepts of name and address and the particular circumstances in each region.

"For example, there are people with more than one name and people who frequently change name due to superstition. There is also the cultural practice of not wanting to let strangers discover your name. Added to these are people with more than one address and itinerant people who move frequently from place to place. Along with the complexities of family structure in areas where polygamy is practiced, there also exist customs of giving children the same name and cultural taboos against counting the number of children. Uncertainty about date of birth is common and some respondents I met even claimed to be 400 years old. In other words, using residency information like name and address to identify individuals is very problematic."
(Professor Moji)

HDSS research without use of IT systems requires a large storage area for paper records.

While they tried issuing identification (ID) cards to overcome this situation, these were frequently lost. There were also past examples of research institutions from other countries using fingerprint-based biometric authentication in HDSS, but the accuracy of identification was a problem as fingerprints can become worn down.

ADOPTION OF FINGER VEIN AUTHENTICATION

"This left me wondering whether there was a better method. The way I became aware of Hitachi's finger vein authentication was when I visited an automated teller machine (ATM) while I was back visiting Japan from Kenya. It immediately struck me that this was something we could use. Learning that Associate Professor Yoshifumi Ueshige at the Information Media Center of Nagasaki University was conducting research into the use of biometric authentication for the personnel records of researchers at the university, I asked him to help me with the work. Associate Professor Ueshige then introduced me to Professor Yoichi Seto of the Advanced Institute of Industrial Technology, a leader in the field of biometric authentication research (and previously a researcher at Hitachi, Ltd.), and this led ultimately to my being able to contact the relevant people at Hitachi and ask for their cooperation and assistance."
(Professor Kaneko)

They went on, in March 2012, to trial the use of finger vein authentication in a survey tracking 500 people in Kenya. Whereas the reception process in past surveys invariably became very crowded, the ability to identify people simply by having them place their finger on a scanner dramatically improved the efficiency of the survey.

Another trial of the use of finger vein authentication took place in July 2012 in a survey of forest environments and malaria infections conducted in the Sepon District of Savannakhet Province in the south of the Lao People's Democratic Republic as part of the EcoHealth Project. The survey included everyone aged six or over (approximately 4,000 people) and operated an HDSS in collaboration with the Lao Ministry of Health's National Institute of Public Health and the Savannakhet Provincial Health Department.

Finger vein authentication was also used in a health survey, including fecal examination, that was conducted in December 2012 for approximately 500 junior and senior high school students in Lahanam in

Hitachi finger vein authentication system. The system is used for personal identification at bank ATMs.

the Songkhone District of Savannakhet Province. The use of finger vein authentication succeeded in boosting the accuracy with which survey participants could be identified and matched to their fecal samples.

In addition to Laos, the RIHN also plans to conduct similar work in China, the People's Republic of Bangladesh, and other countries in the tropical monsoon regions of Asia.

"Based on the results of these demonstrations, I believe finger vein authentication will be useful for many different types of record-keeping, such as vaccine inoculation records, changes in antibodies, or the provision of anti-mosquito bed nets for malaria prevention."
(Professor Moji)

"Our aim is to make extensive use of finger vein authentication in HDSS in the future, and to link it to other data sources such as hospital records or information from a geographic information system (GIS). We want to help deliver comprehensive healthcare through the comprehensive collection and analysis of data across entire communities."
(Professor Kaneko)

Shigenori Kaneko (Senior Engineer at the Global Product Department, Security & Smart ID Solutions Division, Information & Telecommunication Systems Company, Hitachi, Ltd.) who was involved in the technical development of the finger vein authentication system, described the product issues that have been highlighted by the demonstrations as follows.

"The survey participants include infants. Identification problems sometimes occur with small children because it is difficult for them to insert their fingers far enough into the scanner, or because their finger vein patterns change as they grow. Also, because these sorts of surveys are often conducted outdoors, there is a need to improve identification accuracy under conditions of strong sunlight. While these sorts of issues were not anticipated, the product being

Demonstrations in the Lao People's Democratic Republic were conducted in Savannakhet Province in the country's south.

Use of finger vein authentication in surveys in Kenya (left) and Laos (right).

EcoHealth Project Sub-Leader Futoshi Nishimoto working on a survey (researcher, RIHN).

originally intended for office use, we want to utilize these discoveries in future product development and to improve the ways in which the system can be used. We are also finding other unexpected conclusions and pointers from these new initiatives that use finger vein authentication."

POTENTIAL OF BIOMETRIC AUTHENTICATION

Professor Moji sees three major benefits that the use of biometrics for personal identification offers to future healthcare. He describes these as follows.

"The first is providing centralized access to personal information such as your medical history or hospital attendance records. This should help reduce cases of patients having to repeat their stories at different hospital visits or undergo the same tests multiple times. It also offers benefits for healthcare administration by simplifying the tracking of what treatments each patient requires and what care they should be receiving. The third benefit is that, because it facilitates the use of IT for data storage, it supports the application of big data to the monitoring of people's health."

That is, it makes it possible to obtain new knowledge from areas that have not been looked at in the past, such as determining how the environment influences people's health by comparing people's data against monitoring information on environmental change to identify any correlations. Analyzing big data on personal health and using this information appropriately has the potential to bring about major changes in how society functions.

Meanwhile, biometric authentication technology also has the potential to make enhancements across the full range of public systems. In India, for example, a project currently underway is establishing a database of biometric information for the entire population of about 1.2 billion. This involves recording not only fingerprints but also iris (the thin membrane that regulates the quantity of light entering the eye) and facial photographs, and tying this biometric information to each person's national ID. It is anticipated that emerging and developing countries will proceed with more initiatives like this in the future, and that they will help extend a wide range of different public services, such as census taking, patient registration by medical institutions, and the design and implementation of healthcare systems.

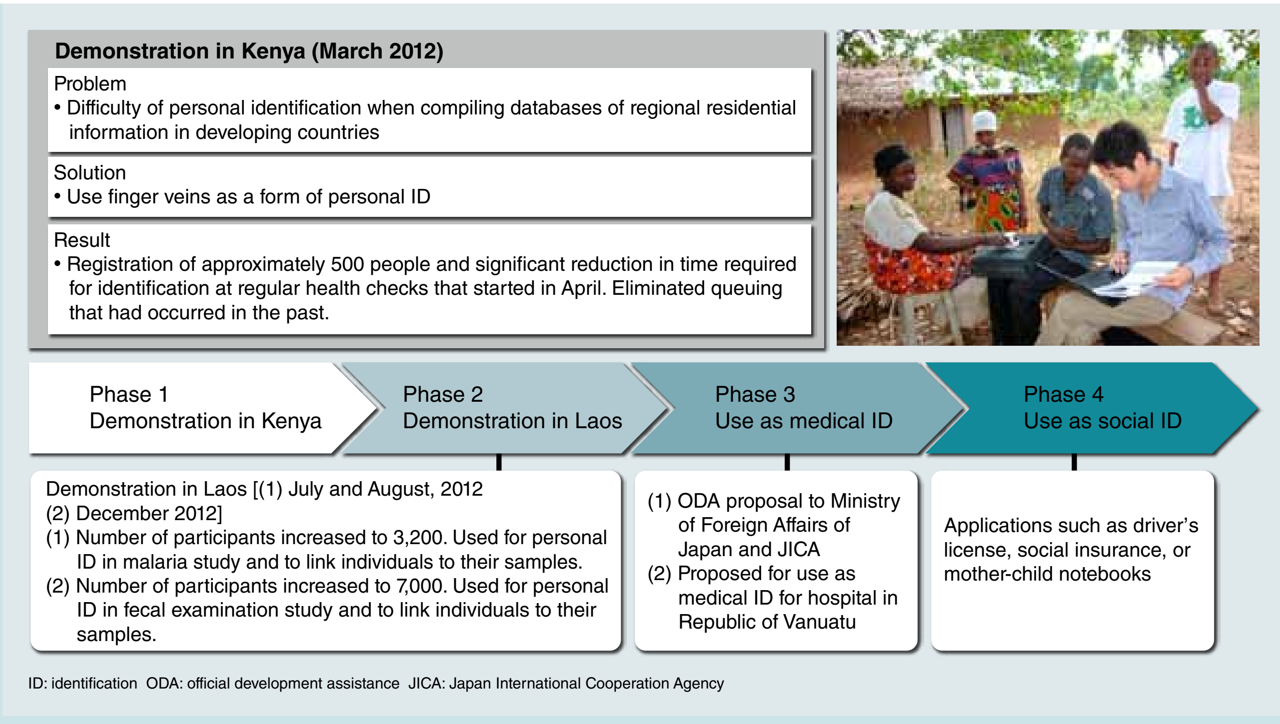
"It may be that developing countries will be able to establish their own superior systems that leapfrog the social infrastructure that developed countries have built up over many years. In the case of Laos and Bangladesh, close to the entire population has mobile phone coverage. To the extent that they have avoided over-regulation, their IT environments are in some ways better than Japan's. If advanced techniques can be made to work successfully in such places, it is not unrealistic to expect systems from developing countries to be imported back to developed countries in the future." (Professor Kaneko)

Developed world technology that undergoes a process of evolution in developing countries—what is needed for this to occur is a flexible remaking of uniquely Japanese systems that have undergone their own isolated "Galapagos-style" evolution. In regard to this, Yasushi Ikeda (General Manager of the Solution Sales Group, No. 2 Sales Department, Sales Management & Accounting Division, Information & Telecommunication Systems Company, Hitachi, Ltd.), who is involved in promoting new applications for finger vein authentication, explains their motivation as follows.

Shigenori Kaneko, Senior Engineer at the Global Product Department, Security & Smart ID Solutions Division, Information & Telecommunication Systems Company, Hitachi, Ltd. (left) and Yasushi Ikeda, General Manager of the Solution Sales Group, No. 2 Sales Department, Sales Management & Accounting Division, Information & Telecommunication Systems Company, Hitachi, Ltd. (right).

"Hitachi's finger vein authentication was originally developed for security applications where it needed to satisfy very stringent requirements. On the other hand, the main objectives in developing countries are things like ID management and personal IDs, and the ways in which the technology is used and the environments in which it must operate are many and varied. It seems likely that we will need to change the specifications in the future to suit different uses. Meanwhile, when it comes to collecting a diverse range of information and then linking it together, there are the problems of how to handle big data and how to utilize cloud computing. Not only are these questions with which Hitachi is currently wrestling, they are also our areas of expertise, and therefore we see scope for making further contributions in the future."

In the long-term view, the implementation of public systems that draw on know-how in biometric authentication systems, big data, and the use of the cloud can be thought of as infrastructure exports in the software sense. It is clear that this will play an important core role in future business activities in developed as well as developing countries.



Overview of past work and future strategies.