

# ICT Technologies and Their Application to the Home Environment in Asian/Oceania Regions: From the View Points of Aging and Home Healthcare

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## Abstract

Almost all countries/regions in the world are now facing the dominant issue of the aging society. In order to observe what happened in the Asian region in terms of change of human resources, we numerically analyze numerical data collected by the author to elucidate the trends and relationships present in ICT migration and expenditure on health.

The analysis of the statistical trends in such items in recent years for the Asian/Oceania region (11 countries) leads to several observations. Changes in estimate Total Expenditure on Health (eTEH) as related to the % rate of elderly people and age dependence of cost on health are estimated using simple expenditure on health (EH) per capita model proposed herein. Numerical evaluations show that even with the constant rate of population, the 65+ increase yields the large increase in eTEH. Therefore, decreasing additional expenditure for 65+ and improving the health of younger people as well are needed to keep TEH constant or to increase it as smaller amount as possible. Relative increase in eTEH for 14 countries (11 Asian/Oceania and 3 others) for 2020 and 2050 are extrapolated from the values collected. Recent research activities conducted in the Information Networking Laboratory of Seikei University, that focus on the vital issue of information transfer enabling to reduce the expenditure especially for elderly, are also introduced together with some detail on foot pressure sensing and thermal information capturing projects.

## I. Introduction\*\*

Most countries/regions are facing the severe problems created by the aging society due to the success of modern public health care policies and evidence-based intervention approaches such as better post-natal care, advances in medical systems, and improved nutrition. This situation has triggered concerns that more people will become sedentary and consume more social resources. The fact is that in the more developed regions,

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all regions of Europe plus Northern America, Australia/New Zealand and Japan, the ratio of people 65 years and older (65+) was 15.3 % in 2005, and will be 26.2 % in 2050 (UNPD 2010). Especially in Japan, the ratio of 65+ was 19.9 % in 2005, 22.6 % in 2010, and will be 37.8 % in 2050. This situation is amazing because more than one third of the population will be 65+ in 2050; the median age will be 55.1.

Information and communication technologies (ICTs), meanwhile, have been playing an important role in daily life even in enterprise offices and private homes. Data transferred using ICT has become indispensable. Everyone uses the data for different purposes every day and on every occasion: for example, WEB content as well as digital TV/radio programs may be used for deciding one's activity, getting updated news, learning, or entertaining. Electric banking or purchasing are also becoming daily events. Email/chat is used for communicating with others, and getting advertisements. Video streaming (uploading) has become a new tool for getting information and is replacing old-fashioned text. The representative key words of ICT are broadband and ubiquitous.

Several governments/organizations have clearly cited the use of ICT in different programs; the European Commission (EU) highlighted that better leveraging of the potential generally provided by ICT for independent living in an aging society represents both a social necessity and an economic opportunity in the framework of the i2010 initiative (EC 2008). Japan released a new health frontier strategy in April 2007 to promote the creation of a society where people can enjoy secure, productive, and healthy life (MHLWJ 2007). This strategy specifically lists the research and development of home medical technologies based on ICT. South Korea declared the IT839 strategy to be a new development strategy for the IT sector in 2004 (Chin 2006). In the IT839 strategy, new key infrastructures such as the broadband convergence network (BcN) and ubiquitous sensor network (USN) are described as providing high-tech services including e-health.

ICT has become so attractive because of the dramatic advances made in technology and the rapid aging of the world. One example of the former is the rapid penetration of FTTx (Fiber-To-The-x; x: home (H), curb (C), building (B)...), especially in Asian regions. In Japan, the number of FTTH users exceeded 30 million in 2010, just 8 years or so after its first deployment. In China, the number of FTTx (B and H) users has increased remarkably; the 2010 projection was more than 46 million. Advanced FTTH with WDM (Wavelength Division Multiplexing) technology, or WDM-PON (Passive Optical Network), has been deployed in South Korea to more than 200,000 subscribers.

The application of ICT to the home is one of the most important issues because individuals will want to or will have to stay longer in their homes than before. In particular, as the elderly stay home more often, the focus of application development will have to shift from just the younger generation to cover all generations, including the elderly.

IEEE held the first trans-disciplinary conference on Distributed Diagnosis and Home Healthcare (D2H2) in 2006; it determined that "Health care is shifting from a central, hospital-based system to a patient-centered system, where patients will be the manager and owner of their health information" (IEEE 2006). While the application of ICT to

the medical or healthcare field is important, applications to other fields in the home are also important because people want their homes to provide comfortable, healthy, safe, convenient and efficient environments.

The latest report released by UNFPA (United Nation Population Fund) underlines that, “while the trend of ageing societies is a cause for celebration, it also presents huge challenges as it requires completely new approaches to health care, retirement, living arrangements and intergenerational relations” (UNPF 2012). “It is obvious that the number of older persons is growing faster than any other age group. Moreover, with one in nine persons (about 10 %) in the world aged 60 years or over, with the latest projection being to increase to one in five ( more than 20 %) by 2050, population ageing is a phenomenon that can no longer be ignored. Therefore, enhancing healthcare is one of the significant challenges that must be tackled by applying new methods/ technologies.”

This paper overviews what has happened in the Asian/Oceania region in terms of ICT migration and expenditure on health by using numerical data collected by the author. The data is subjected to numerical analysis to identify trends and clarify key relationships.

Section II overviews the statistically-derived trends in several basic items including human resources, ICT, and expenditure on health related numbers in recent years for the Asian/Oceania region. Section III highlights changes in total expenditure on health (TEH) estimated to identify the dominant ICT role using simple expenditure on health (EH) per capita model proposed herein. Especially, affects by some value for elderly to the TEH are analyzed. Section IV introduces research activities conducted in the Information Networking Laboratory in Seikei University, focusing on vital information transfer issues. Section V concludes the paper and describes future works.

## **II. Statistics, Some Numbers in Each Country/District**

This section discusses changes in data related to human resources, ICT, and expenditure on health in recent years and projections for 11 countries in Asia/Oceania region, plus some others for reference.

Types of data examined are as follows;

- Total population and the rate of 65+ in the population,
- Number of broadband and mobile subscribers, and
- Expenditure on health and GDP.

The 11 countries/districts that are the focus of this paper are, in alphabetical order (with abbreviations used in figures):

- Australia (Au), China (P.R.C)(Cn), Hong Kong SAR (HK), Indonesia (Id), Japan (Jp), Korea (R.O.K) (Kr), Malaysia (My), Singapore (Sg), Taiwan (R.O.C) (Tw), Thailand (Th), and Vietnam (Vn).

Three others in Europe/North America are also considered for reference. They are;

- Denmark (Dk), Germany (De) and USA (US).

Actual numerical information collected by the author are listed in Tables A1, A2, and A3 in the annex of this paper.

### 1. Human Resource-related Numbers

This subsection analyzes the total population, the rate of 65+ in the population, and median age.

Figure 1 plots the % rate of 65+ for each countries/districts vs. the change in total population for the years 2000, 2010, 2020, and 2050. Detailed values as well as others are listed in Table A1 in the annex of this paper. Values for 2000 are actual ones; the others are estimates.

As is obvious in Fig. 1, each country/district has different attributes. In 2000, total population ranges from about 4 M up to about 1300 M. The larger population group includes Cn, Id, Jp, Th, and Vt with more than 50 M in 2010. Almost all countries/districts have the 65+ rate in 2010 less than 15 % except Jp. However, in 2050, 5 countries/districts have more than 30% and 4 more than 20%. The larger 65+ population group includes Cn, Id, and Jp in 2050.

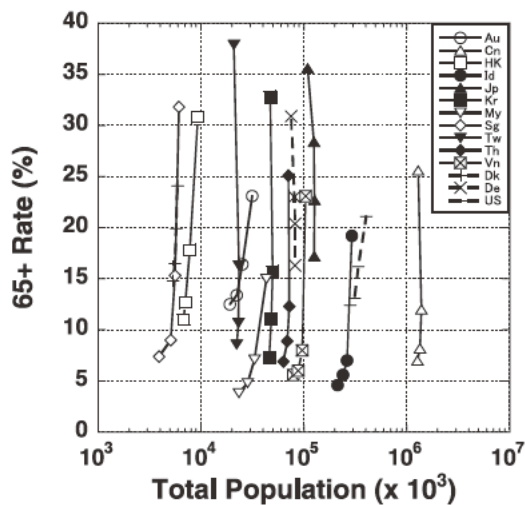


Figure 1. The % Rate of 65+ vs. Total Population over Time.

(Source: Original by the Author)

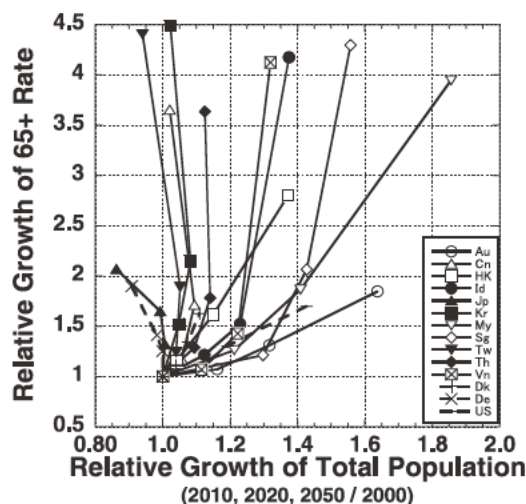


Figure 2. Relative Growth in % Rate of 65+ vs. Relative Growth of Total Population.

Markers Correspond to Values in 2000, 2010, 2020, and 2050.

(Source: Original by the Author)

Figure 2 plots the relative growth rate in the % rate of 65+ vs. the relative growth rate of total population in 2010, 2020, and 2050 (all values normalized against 2000).

Roughly speaking, the 2050 values can be categorized into a 2 x 2 matrix with lower and higher growth rates of the total population (TP), and lower and higher growth rates of 65+ (65+).

- Low TP and low 65+: Jp, (De, Dk),
- Low TP and high 65+: Tw, Cn, Kr, Th,
- High TP and low 65+: Au, (US), and
- High TP and high 65+: Vn, Id, HK, Sg, My.

Another view is given in terms of median age, which is defined as the age that divides the population in two parts of equal size.

Figure 3 plots median age vs. the change in total population for the years of 2000, 2010, 2020, and 2050. Observations in 2050 are;

- The highest group (> 50): Tw, Jp, Kr, Sg, HK,
- Higher group (45 – 50): Cn, Th, Vn, (De),
- Mid group (40 – 45): Id, Au, (Dk, US), and
- Lower group (35 – 40): My.

## 2. ICT-related Numbers

This subsection analyzes the numbers of broadband and mobile subscribers and its relationship with PPP GDP (Gross Domestic Product) per person.

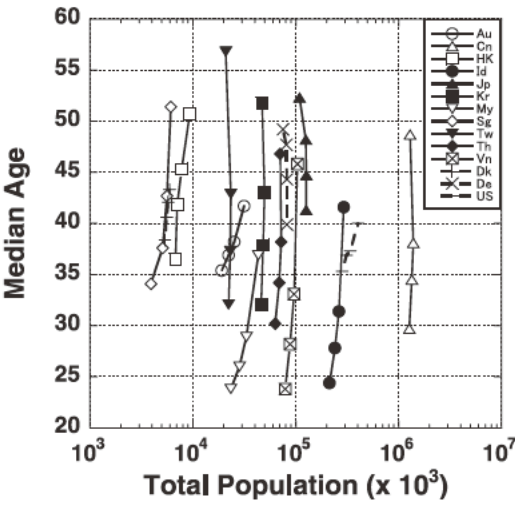


Figure 3. Median Age vs. Total Population over Time  
(Source: Original by the Author)

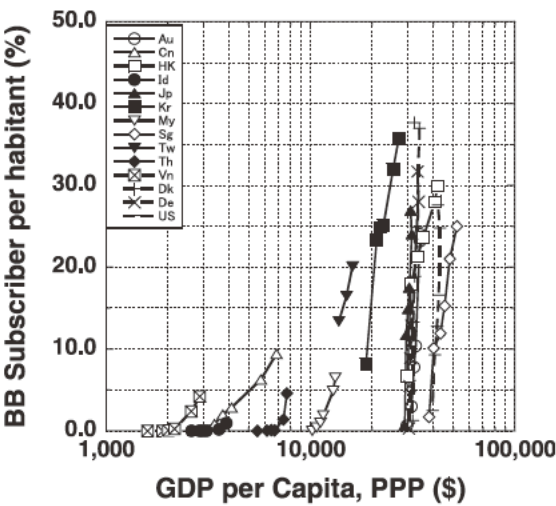


Figure 4. Broadband Subscriber Rate vs. GDP (Markers from Left: 2000, 2003, 2004, 2005, 2008, and 2010).  
(Source: Original by the Author)

Figure 4 depicts the broadband subscriber rate vs. for the years 2000, 2003, 2004, 2005, 2008 and 2010. Detailed values as well as others are listed in Table A2 in the annex of this paper.

Figure 5 depicts the mobile subscriber rate vs. GDP for the same 6 years.

Over the last decade, ICT has dramatically advanced throughout the world. However, its penetration rate is differs with the area and the technology.

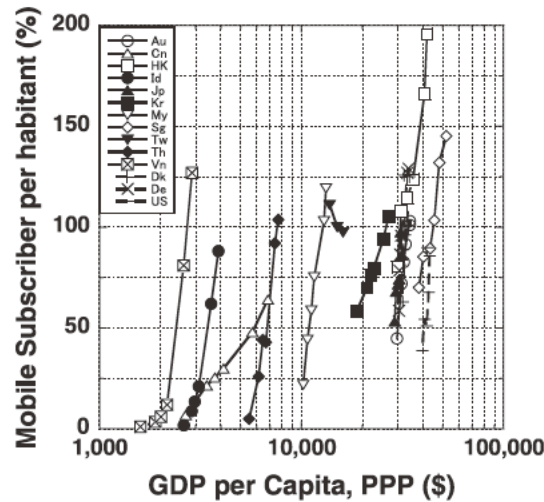


Figure 5. Mobile Subscriber Rate vs. GDP (Markers from Left: 2000, 2003, 2004, 2005, 2008, and 2010).

(Source: Original by the Author)

In Fig. 4, two groups are seen;

- High ( $> 20\%$ ) subscription rate with steep increase. This is chiefly seen with GDP values of more than \$20,000, and
- Low ( $< 10\%$ ) subscription rate with moderate increase; GDP values less than \$20,000.

In Fig. 5, no such grouping is obvious. Almost all countries will have ownership rates of more than 100% meaning there is more than one mobile terminal for each person. It is noted that the growth rate is very steep regardless of the GDP.

One reason for rates higher than 100% is the difference in pricing systems. One telecom carrier offers free download calls, but upload charges are high. Another, in the same country, offers low upload charges. Therefore, some people own two terminals; one dedicated to uploading and the other to downloading.

As seen in Figs. 4 and 5, the recent penetration growth seems to be a linear increase (in log scale for horizontal axis) except for BB with low GDP.

Therefore, the penetration rate ( $R_p$ ) in terms of GDP ( $Gdp$ ) can be described by the following equation;

$$Rp_k = c_k + b_k \log (Gdp_k). \quad (\text{eq. 2-1})$$

where  $c_k$  is a constant value for the  $k$ -th country;  $b_k$  is a constant coefficient.

Numerical analysis with values in 2005, 2008 and 2010 for both BB and mobile subscription rates gives a good correlation between the rate and GDP as depicted in Fig. 6.



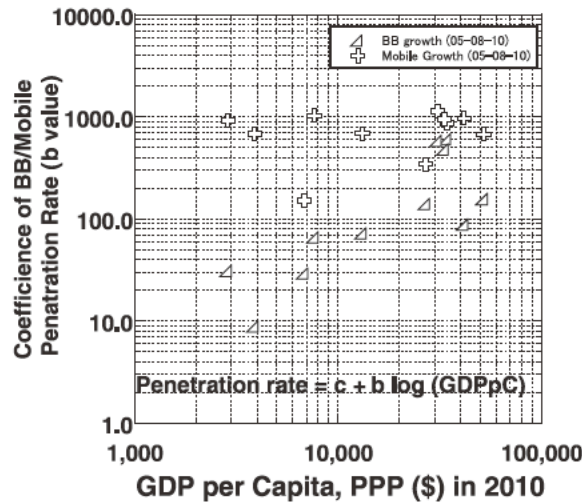


Figure 6.  $b$  Values (Constant Coefficient) vs. GDP.  
(Source: Original by the Author)

Figure 6 shows  $b_k$  values (constant coefficient in eq. 2-1) vs. GDP. As clearly seen in the figure;

- $b_k$  for BB subscription rate increases almost linearly with GDP, and
- $b_k$  for mobile subscription is almost constant regardless of GDP.

This occurs because the BB network needs CAPEX (CAPital EXpenditures) for the network infrastructure including station itself, equipment in the station, and cables between a station and subscribers. Subscriber has to pay some amount of the expenditure by initial and/or monthly fees. Since the mobile network has less cable and cabling costs, its CAPEX is relatively small compared to the BB network. Lower mobile terminal cost and lower monthly fee yields high penetration rates even if GDP is low.

Figure 7 plots the mobile subscriber rate vs. BB subscriber rate for the years of 2000, 2003, 2004, 2005, 2008, and 2010. Figure 8 is similar to that of Fig. 7, but horizontal corresponds to BB subscriber per house in 2010, calculated from the number of households listed in Table A2.

Two groups can be seen in both figures.

- Higher BB subscriber rates per house (> 50 %) and higher mobile subscriber rates (about 100 % or more): Sg, Kr, Au, Tw, Jp, (Dk, US, De) and
- Low BB subscriber rates per house (< 50 %) and higher mobile subscriber rates (about 100 % or more): My, Cn, Th, Vn, Id.



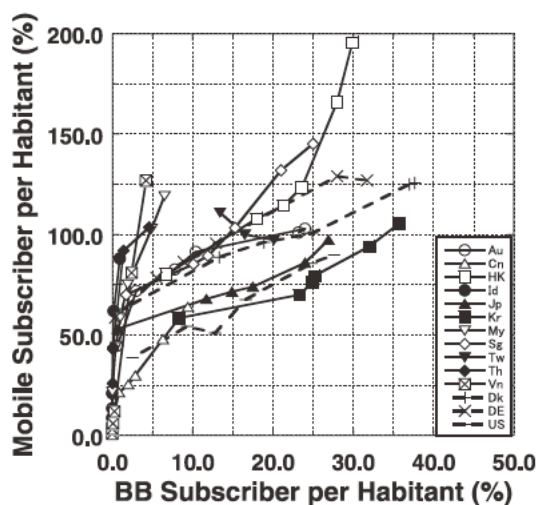


Figure 7. Mobile Subscriber Rate vs. BB Subscriber Rate (Markers from Left: 2000, 2003, 2004, 2005, 2008, and 2010).  
(Source: Original by the Author)

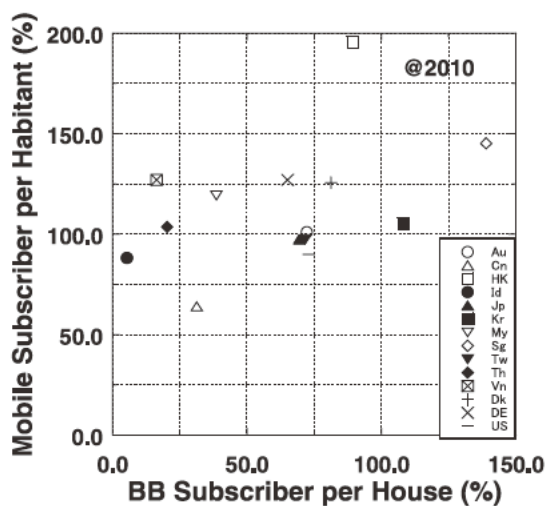


Figure 8. Mobile Subscriber Rate vs. BB Subscriber Rate per House in 2010.  
(Source: Original by the Author)

### 3. Health Expenditure-related Numbers

This subsection analyzes the per person expenditure on health (EH) and its relationship with GDP.

Figure 9 plots EH vs. GDP for the years of 2000, 2003, 2004, 2005, 2008 and 2010. Detailed values as well as others are listed in Table A3 in the annex of this paper.

As seen in Fig. 9, EH seems to increase linearly (in log scale for both horizontal and vertical axis) regardless of GDP value.

Therefore, EH ( $Eh$ ) can be described by the following equation;

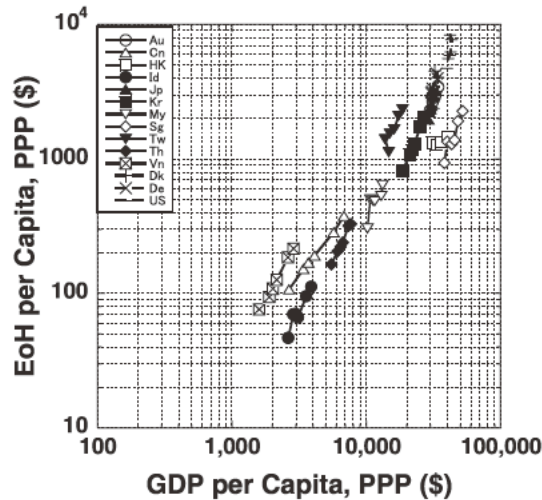


Figure 9. Per Capita Expenditure on Health (EH) vs. GDP (Markers from Left: 2000, 2003, 2004, 2005, 2008, and 2010).

(Source: Original by the Author)

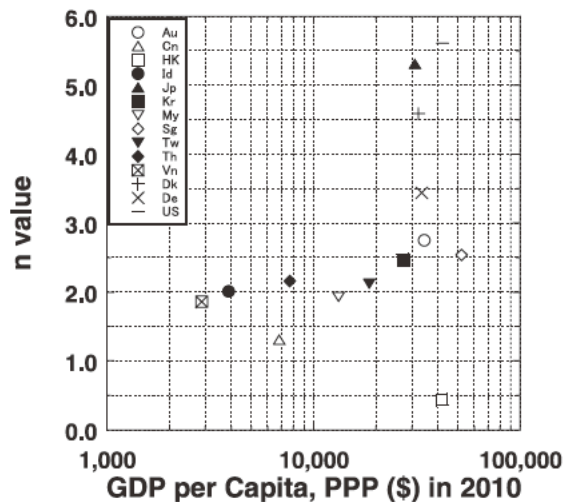


Figure 10. n Value (n-th Power) vs. GDP.

(Source: Original by the Author)

$$Eh = c'_k Gdp_k^n. \quad (\text{eq. 2-2})$$

where  $c'_k$  is a constant value that is country specific.

Numerical analysis with values in 2000, 2003, 2004, 2005, 2008 and 2010 for EH growth gives a good correlation between the rate and GDP as depicted in Fig. 10.

Figure 10 plots  $n$  values (power term in eq. 2-2) vs. GDP. As clearly seen in the figure, two groups can be seen;

- for low GDP (< \$20,000):  $n$  values are almost constant, around 2.0, and
- for high GDP (> \$20,000): they vary widely.

This means that for low GDP, e.g. 10 % growth in GDP yields a 21 % growth in EH ( $1.1^2 = 1.21$ ). For high GDP,  $n$  is much larger and depends on the country.

### III. Estimated Total Expenditure on Health

Even though George Barnard Shaw said “Man does not cease to play because he grows old, he grows old because he ceases to play”, aging itself implies some degradation in human physical performance resulting in sedentary daily living, and/or the necessity of physical care. One such performance degradation is seen in the numerical analysis of world running records; it indicates about 0.7 % decrease per year in age less than around 65 and > 1 % for the elderly (Oguchi 2001).

Current cost for the health related treatment for the 65+ group is about 4 times larger than other generation groups (Nishimura 2011). In aging societies, the trends in total expenditure on health both at present and in the future are critical issues for society.

This section estimates changes of total expenditure on health ( $eTEH$ ) as related to the % rate of elderly people and the age dependence of health cost. In particular, possible solution to reduce the TEH is found out.

#### 1. Estimation model and evaluation

Actual per capita expenditure on health depends on age. Generally speaking, the younger spend the smallest amount except for infants. Age dependent expenditure (per capita) generally has the shape of a bath tub as depicted in Fig. 11. In Japan in 2008, it starts with ¥203 k (thousand) (equivalent to about US\$2,500 if ¥80 = 1US\$) for the age group of 0-4, then goes down to the minimum of ¥64 k for the 15-19 group, and increases towards the end with ¥1,114 k for the 100+ group. Therefore, an exact analysis of the total expenditure on health needs to analyze each age group which seems overly complicated.

In order to clarify the general change in terms of time (year), the definition of  $eTEH$  proposed in this paper is given by the following simple math and the estimation model depicted in Fig. 11;

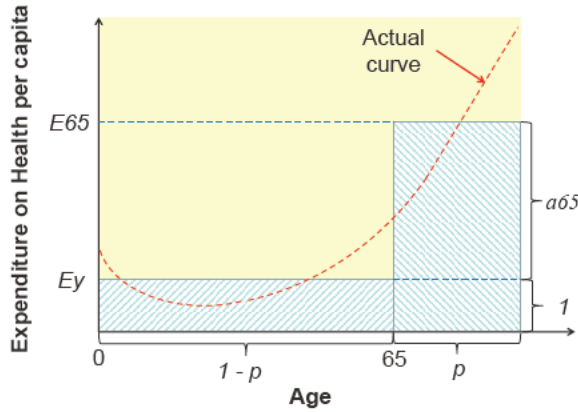


Figure 11. Estimation Model for the Total Expenditure on Health (eTEH).  
(Source: Original by the Author)

$$eTEH = Ey Nt (1 - p65) + E65 Nt p65. \quad (\text{eq. 3-1})$$

where  $Ey$  and  $E65$  correspond to the per capita expenditure for age <65 and 65+, respectively,  $Nt$  is the total population, and  $p65$  is the % rate of 65+ in the total population as depicted in Fig. 11. The  $eTEH$  value is given by adding the two rectangular areas (hatched areas) in Fig. 11.

A further definition is;

$$E65 = (1 + a65) Ey. \quad (\text{eq. 3-2})$$

where  $a65$  corresponds to the additional relative cost for 65+ compared to 65-.

Therefore, eq. 3-1 is rewritten as eq. 3-3;

$$\begin{aligned} eTEH &= Ey Nt (1 - p65) + (1 + a65) Ey Nt p65. \\ &= Ey Nt (1 + a65 p65). \end{aligned} \quad (\text{eq. 3-3})$$

Here, we compare the  $eTEH$  in year 't' to that in 2010; the relative ratio, denoted  $R^t_{2010}$ , is determined by using eq. 3-3 with other values in year 't' and 2010 as follows;

$$R^t_{2010} = \{Ey^t Nt^t (1 + a65^t p65^t)\} / \{Ey_{2010} Nt_{2010} (1 + a65_{2010} p65_{2010})\}. \quad (\text{eq. 3-4})$$

This equation has many parameters, however, it is easily understand that changes in  $Ey$  or  $Nt$  just give the linear change of  $R$ .

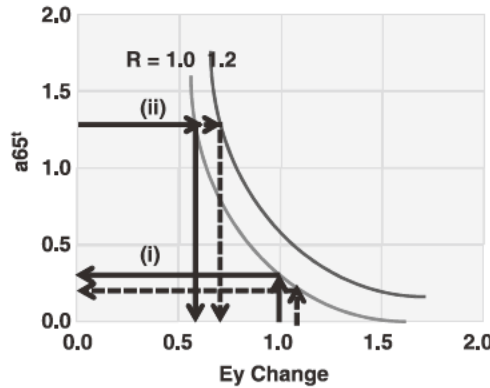


Figure 12. Tradeoff between  $Ey$  Change and  $a65$  Value.  
(Source: Original by the Author)

## 2. Evaluation Results

The following are some numerical estimation yielded for several probable cases;

### Case 1:

Given values,  $p65_{2010}$  and  $p65^t$  and  $Nt$  constant,  $R$  value has a tradeoff relation with  $Ey$  and  $a65$  change.

Figure 12 visualizes the tradeoff between  $Ey$  and  $a65$  change. In the figure, the horizontal axis corresponds to  $Ey$  change, and the vertical to  $a65$  value. Two curves in the figure with  $R = 1.0$  and  $1.2$  correspond to the boundaries delineating the region of the same  $R$  value e.g. 1.0 means the same  $eTEH$ .

For (i) in the figure, if  $Ey$  increases from e.g. 1.0 to 1.1,  $a65$  must decrease from 0.3 to 0.25 to keep  $R = 1.0$ .  $Ey$  increase is possible through the introduction of a new medicine or medical treatment/operation. However,  $a65$  reduction might need new intervention or new approach for healthcare including prognosis/diagnosis.

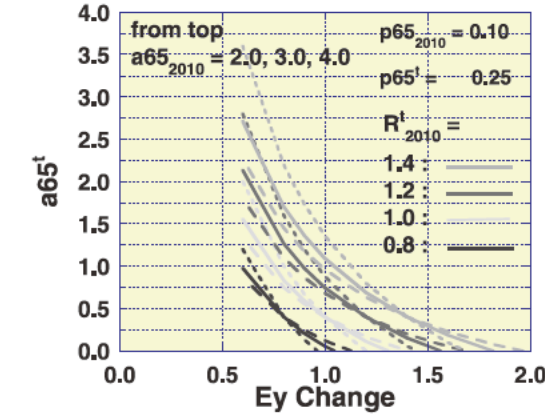
For (ii), even with the same  $a65$  value,  $Ey$  increase will result in an increase in  $R$ , e.g. 1.0 to 1.2.

Even with a constant  $Nt$  value, an increase in  $p65$  triggers a large increase in  $eTEH$ . Therefore, both  $Ey$  and  $a65$  decreases are needed to keep  $eTEH$  constant.

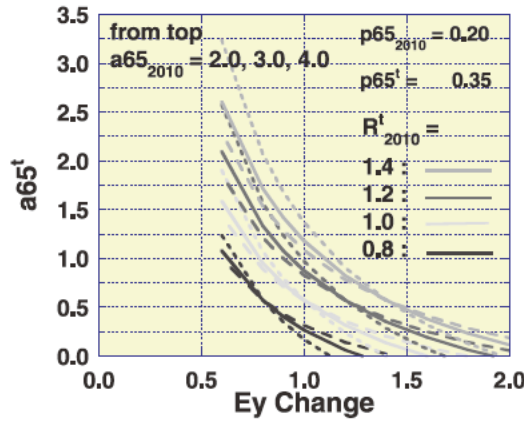
Figures 13 (a) and (b) show the tradeoff between  $Ey$  and  $a65$  change. Here,  $R^t_{2010}$  values are 0.8, 1.0, 1.2 and 1.4, and  $a65_{2010}$  values are 2.0, 3.0, and 4.0. Figure 13(a) uses  $p65_{2010}$  and  $p65^t$  values of 0.10 and 0.25, respectively, and (b) 0.20 and 0.35, respectively. The former is similar to cases of Th and Cn, and the latter of Jp. Here in two figures,  $Nt$  values keep constant. Furthermore, the  $a65_{2008}$  value in Japan in 2008 was 3.32 (Nishimura 2011).

### Case 2:

As described, equation (3-4) has too many parameters to permit easy evaluation. However, an understanding is easily reached by examining some typical values.



(a)  $p65_{2010}$  and  $p65^t$  Values are 0.10 and 0.25.



(b)  $p65_{2010}$  and  $p65^t$  Values are 0.20 and 0.35.

Figure 13. Tradeoff between  $Ey$  and  $a65$  Change. (Source: Original by the Author)

Figures 14 (a) to (n) give the relative increase of the  $eTEH$  for all 14 countries for 2020 and 2050 with several values of  $Nt_{2010}$ ,  $p65_{2010}$ ,  $Nt^t$ , and  $p65^t$  given in Table A1.  $a65_{2010}$  values are 2.0, 3.0, and 4.0, and  $Ey^t/Ey_{2010}=1$  are used in the calculations. If  $Ey^t/Ey_{2010}$  ratio is changed, the result will be to simply multiply by the ratio e.g.  $Ey^t/Ey_{2010}=1.5$ , the result will be 1.5 times larger.

Roughly speaking, with the observation in section II.1.,

- for low TP and low 65+: Jp, (De, Dk); moderate increase,
- for low TP and high 65+: Tw, Cn, Kr, Th; higher increase
- for high TP and low 65+: Au, (US); higher increase and
- for high TP and high 65+: Vn, Id, HK, Sg, My; higher increase.

For example in Japan,  $a65_{2010}$  of 3.0,  $a65^{2020}$  of 4.0, and  $Ey^{2020}/Ey_{2010}=1$  yields 25 % increase of  $eTEH$ . That for 2050 is also 24 % increase even though  $Nt$  decreases by 13 %.

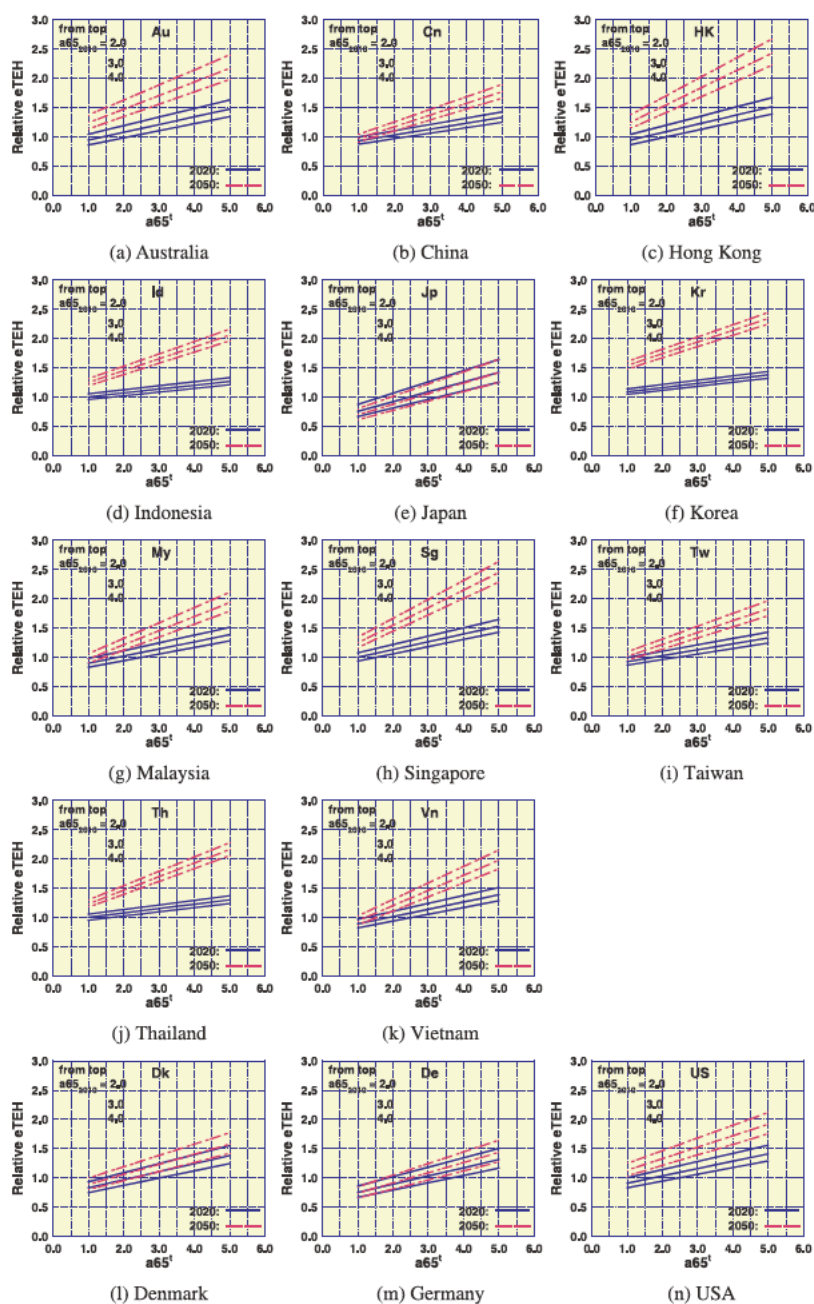


Figure 14. Relative Increase in Total Expenditure on Health (eTEH). (Source: Original by the Author)

The highest group includes HK, Sg, Jp in 2020 and HK, Kr, Sg in 2050.

With the same parameters in Japan, eTEH in HK in 2020 results in 37 % increase and 113 % in 2050.



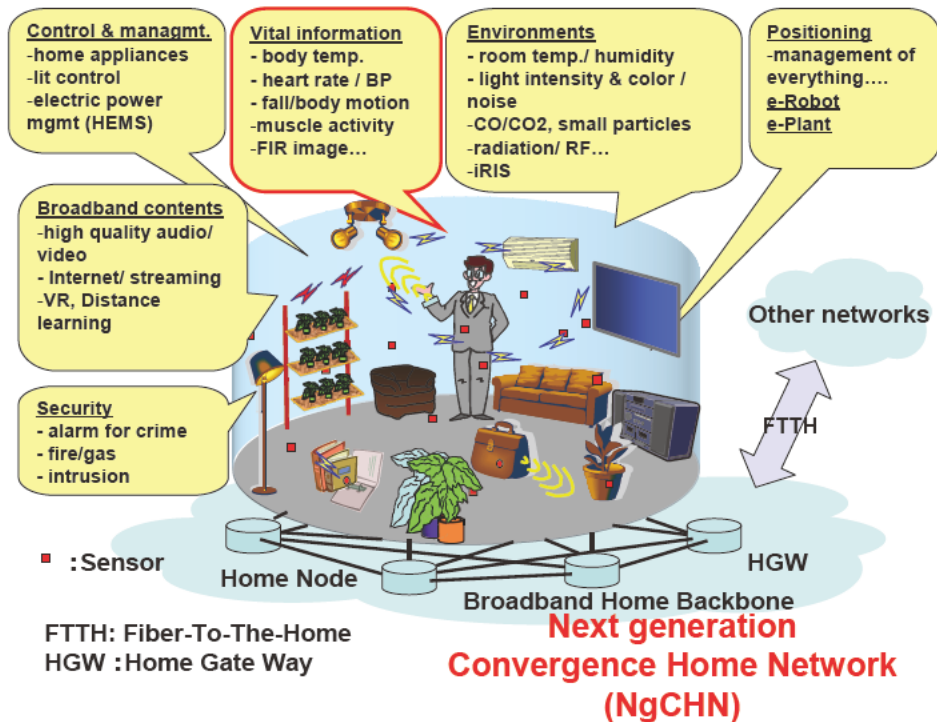


Figure 15. Next generation Convergence Home Network (NgCHN) and its Application Image. (Source: Oguchi2005 modified)

## IV. Latest Research Activities in the Information Networking Laboratory, Seikei University

### 1. NgCHN and its Service Images

The laboratory has been actively targeting the optimum home environment since 2004 by researching several information and communications technologies (ICT). Creating the optimum home environment demands a consideration of how people, especially the elderly, can live comfortable, healthy, safe, efficient and convenient lives. The environment will include a variety of service applications and terminals. Network image and some characteristics are described below.

Figure 15 depicts the next generation convergence home network (NgCHN) image, together with some information / signals transferred through the network (Oguchi 2005, Oguchi 2009). NgCHN consists of the photonic broadband home backbone and edge networks. The photonic home backbone connects to other networks via the HGW (Home Gate Way) through a broadband network e.g. FTTH (Fiber-To-The-Home). Both broadband and ubiquitous technologies are used to support different applications; vital information collection will be the key to enhancing daily life, especially for the elderly. The data should be captured by extremely small and smart devices in order to reduce

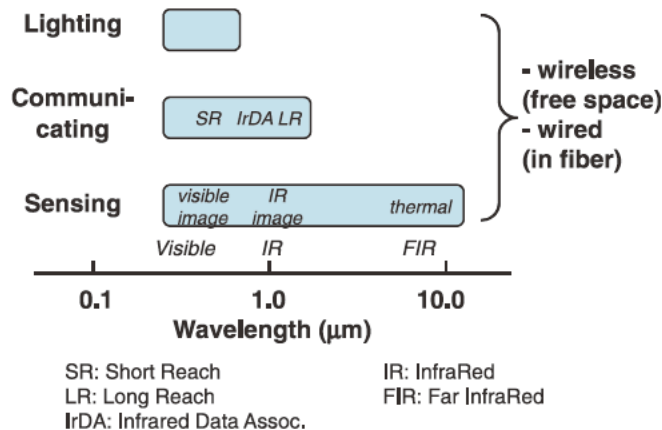


Figure 16. Wavelength Rich Surrounding (WAVERINGS), or iRIS, Concept.

(Source: Original by the Author)

the loads placed on the user and to support service anywhere anytime. Wired/ fixed sensors will also be used for this application and for capturing environmental information to realize comfortable and efficient environments. Position sensing applications that use the RFIC tags attached to all objects are also important in order to recognize object location and the user's context. Security, which includes intrusion, fire, gas etc., is another basic application that may use either wireless or wired sensors. The transfer of high quality audio/video (HD: High Definition / SHD: Super High Definition e.g. 4 K) and Internet content will improve daily life. Control and management of future home appliances connected to the network will also create a much more comfortable daily life. Lighting control in terms of its intensity and color, and home energy (electric power) management are challenging issues. Higher speed applications may connect to the home backbone directly while others pass through wired or wireless links to the home edge networks.

The major point of migration from the existing network to the next generation one is connecting everyday objects and sensors via the Internet Protocol (IP). The existing network, where several terminals (PC, Tel/Fax, CATV etc.) use dedicated networks and the rest do not use any networks, will migrate to the next generation network where virtually all terminals or devices will be IP-networked (recently referred as ToI: Things on the Internet). All can communicate through the convergence network, resulting in the ability to easily create new applications or services efficiently.

Optical technology is the important and major technology for realizing this environment. As depicted in Fig. 16, optical wavelengths are used for sensing, communicating, and lighting regardless wired or wireless with visible to far infrared (non visible) wavelength regions. This framework is named "WAVERINGS: WAVElength RIch surroundINGS" by the author.


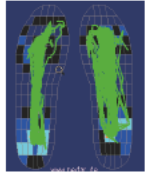
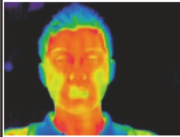
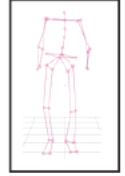
	PJ-V1	PJ-V2	PJ-V3	PJ-V4
Capturing condition	fall detection / fatigue recognition	walking condition after injury / daily, balance	human respiration/ fatigue	body movement while walking/ sports
Sensor(s)	accelerometer, angular velocity (wearable)	foot pressure (wearable, in-sole/ plate)	FIR (Far Infra-Red) image	Motion capture system
On going experiments images				
References	(V1-1) – (V1-7)	(V2-1) – (V2-2)	(V3-1) – (V3-5)	(V4-1) – (V4-5)
	[general] (G1) - (G5) [others] (V5-1) – (V5-3)			

Figure 17. On-going Research Projects Related to Vital Information Transfer.

(Source: Original by the Author)

## 2. Projects outlines

In order to create the next generation convergence home network (NgCHN) and its applications, several issues need to be resolved;

- (1) Several major challenges, each of which corresponds to a sub project;
  - Network issues: fiber-optic broadband backbone and wireless sensor network, and
  - Application issues: data capture, process, analysis, recognition, and feed-back.
- (2) Objectives of the sub project related to vital information are;
  - to clarify the feasibility to capture human condition by sensor (s) in the home,
  - to make a framework of e-healthcare for the home, and
  - to give lessons learned for the next step in smart sensors (e.g. easier to wear; smaller, lighter weight; more intelligent, lower cost...).

Sensor-based research applications are actively on-going in the laboratory. Figure 17 gives an outline of four sub projects, PJ-V1 to PJ-V4. They are related to capturing the human condition by sensor(s) and represent the first step in each field. They include capturing condition, sensor used, experimental image (photo) and related articles so far published or presented in the laboratory. For details please refer to the articles referenced.

### 3. Latest Activities

#### (1) Foot Pressure Sensing

In order to clarify how sensors can be used to assess the rehabilitation status of a person with a leg injury in the home, this trial uses foot pressure sensors (Pedar 2012) to capture foot pressure while walking (Oguchi 2011). Future application image is to assess the status of rehabilitation in the user's home by using very simple but smart sensors. This experiment has been underway for 18 months and is still in progress. This subproject is a collaborative effort with the Office of the Health Center, Seikei University.

Major results are as follows;

The change in scores of pain and fatigue intensities, and walking ability over time showed some improvement in the first two weeks after the subject suffered the injury. Scores of pain and fatigue remained constant thereafter. Score for walking ability improved after 6 weeks, but the subject has not yet to return to a fully healthy state. This means that normal straight walk might be somewhat improved, however, more complex movements, e.g. walking with knee twist, are still difficult.

Peak pressure value for the right and left leg in the terminal stance were obtained from the data set acquired by the pressure sensor. Time periods for 3 cycles for the right and left leg between the initial contact in one cycle of each leg and the third initial contact were also measured and averaged. Peak pressure of the left leg just after the injury was significantly lower than that of the right leg ( $p < 0.01$ ). There was no significant change some 3 weeks after, but some change was evident ( $p < 0.05$ ) 5 weeks later, 7 and 11 weeks later ( $p < 0.01$ ). Time period for 3 cycles on 2 days later was significantly longer than that on other measured some weeks later ( $p < 0.05$ ). This figure indicates that the injury clearly altered walking performance, and some effect remained even one month later.

The center of pressure (COP) was also analyzed visually on the PC. As derived from the movements of the COP, several lines overlap on the foot shape. It was seen that the left leg had a narrower trace than the other immediately after the injury. This means that due to the pain in the knee, the gait was not complete, i.e. not enough rolling of the left foot. About 2 months later after the injury, the traces of the left leg are slightly broader, and similar to that of right leg. However, gait remains asymmetric about one year after the injury indicating that further time is needed for complete recovery.

Even though this experiment is on-going, the following lessons learned have been clarified:

- measuring foot pressure while walking is a feasible way of assessing the status of rehabilitation,
- it is difficult to fully assess the recovery condition from just foot pressure data,
- sensors, or smart or intelligent sensors must be combined to provide a more detailed verification of rehabilitation status,
- smaller and more cost effective sensor systems will be needed to support home

use,

- a simpler graphics-based feedback method is needed, and
- a signal/data processing system with greater capacity e.g. HomeCloud, is needed to handle the massive amounts of data generated.

## **(2) Thermal Images**

It is well known that thermo-imaging by FIR (Far InfraRed) cameras can be used to detect thermally active bodies emitting radiation around 10  $\mu\text{m}$  if the body temperature is about 300 K (= 27 degree C). If an FIR camera is used to capture human thermal information (images), precise measurement of the temperature could give a lot of vital information such as nasal respiration detection, effectiveness of finger massage, and changes in blood flows.

In order to clarify the effectiveness of a finger massage, body temperatures were captured before and during the massage. This subproject is also a collaborative effort with the Office of the Health Center, Seikei University.

A preliminary experiment was conducted with subjects sitting/standing in front of a camera whose parameters were as follows;

- type: NEC/Avio, TH7102MX (NEC/Avio 2012),
- capture wavelength: 8 - 14  $\mu\text{m}$ ,
- thermal resolution: 0.06 degrees,
- size of sensor (active area): 320 x 240 pixels,
- contrast: 256 levels (8 bit), and
- frame rate: 30 frames/sec.

Preliminary results from this experiment show that the massage is effective in terms of temperature increase (blood flow change). This project is still on-going and its results will be presented in another article.

## **V. Conclusion and Future Work**

Recently, almost all countries in the world are facing the problem of the aging society.

In order to observe what happened in the Asian/Oceania region in terms of change of human resources, ICT adoption, and expenditure on health, data collected by the author were subjected to a numerical analysis to identify trends and elucidate key relationships.

Analysis of the trends in several basic items including human resources, ICT, and expenditure on health related numbers in recent years for the Asian/Oceania region (11 countries) yielded the following observations;

Almost all countries/districts have higher rate of 65+ in the population in 2050 even if their rates in 2010 are less than 15 %. Growth of the total population was categorized into high and low (sometimes decrease) areas.

Estimate total expenditure on health (eTEH) evaluated by the simple model proposed herein, indicated its large growth. Major factor was the higher growth rate of 65+. Therefore, some urgent methods/interventions are required for reducing the eTEH or keeping it constant. ICT would play an important role for such purposes.

Numerical analysis of broadband (BB) and mobile subscribers will provide several indications regarding to new applications/services. Area with GDP per capita, PPP less than \$20,000 should accommodate the new application/services on the mobile basis while others on either mobile or BB (fixed) basis. However, new BB mobile, i.e. LTE (Long Term Equipment), may offer new applications/services without any penetration of the BB fixed network e.g. FTTH. Asymmetric pricing system in a mobile carrier for uploading collected data by sensors in a home and downloading feed-backs from medical institution, should also be considered when a new applications/services is released.

Even though the growth rate of EH per capita, PPP is proportional to GDP per capita, PPP with an  $X^2$  relation in area less than \$20,000, the EH amount itself is not so large. Therefore, weighting the applications/services is an important issue to introduce them.

Recent research activities conducted in the Information Networking Laboratory in Seikei University were introduced, focusing on vital issues in information transfer with some detail of foot pressure sensing and thermal information capture and processing projects. These researches are aiming to create the optimum home environment, especially for elderly.

In the future work, further detail will be conducted to clarify what parameter is critical for the eTEH. It will be also conducted to clarify what intervention is the most effective to reduce the additional expenditure on health for elderly. Research activities in other institutions/organizations will be overviewed to identify the major challenges in each project.

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Table A1. Human Resource-related Numbers

Country/District	Total population (k) #1-1 *1-1 Ratio of 65+ (%) #1-2 *1-1 Median age (y) #1-3 *1-1				Number of households #1-4 Year & Source Number of persons per house calculated (@2010)#1-5
	2000	2010	2020	2050	
Australia	19,164 12.5 35.4	22,268 13.4 36.9	25,241 16.4 38.2	31,385 23.1 41.7	7,144 @06*1-3 3.12
China	1,269,117 7.0 29.7	1,341,335 8.2 34.5	1,387,792 12.0 38.1	1,295,604 25.6 48.7	401,517 @10*1-2 3.34
Hong Kong	6,783 11.0 36.5	7,053 12.7 41.8	7,803 17.8 45.3	9,305 30.8 50.7	2,358 @11*1-5 2.99
Indonesia	213,395 4.6 24.4	239,871 5.6 27.8	262,569 7.0 31.4	293,456 19.2 41.6	39,695 @90*1-6 6.06
Japan	125,720 17.2 41.3	126,536 22.7 44.7	124,804 28.4 48.2	108,549 35.6 52.3	49,063 @05*1-3 2.58
Korea (South)	45,988 7.3 32.1	48,184 11.1 37.9	49,810 15.7 43.0	47,050 32.8 51.8	15,887 @05*1-3 3.03
Malaysia	23,415 3.8 23.8	28,401 4.8 26.0	32,986 7.1 28.9	43,455 15.0 36.9	4,778 @00*1-3 5.94
Singapore	3,919 7.4 34.1	5,086 9.0 37.6	5,597 15.3 42.7	6,106 31.8 51.4	915 @00*1-3 5.56
Taiwan *1-8, 1-9	22,277 8.6 32.1	23,162 10.7 37.3	23,437 16.3 42.9	20,935 37.9 56.8	6,496 @00*1-4 3.57
Thailand	63,155 6.9 30.2	69,122 8.9 34.2	72,091 12.3 38.2	71,037 25.1 46.8	15,661 @00*1-7 4.41
Vietnam	78,758 5.6 23.8	87,848 6.0 28.2	96,355 8.0 33.1	103,962 23.1 45.8	22,444 @09*1-3 3.91
Canada	30,667 12.6 36.8	34,017 14.1 39.9	37,163 18.1 41.6	43,642 24.9 44.0	12,437 @06*1-2 2.74
Denmark	5,340 14.8 38.4	5,550 16.5 40.6	5,736 19.9 42.1	5,920 24.1 43.3	2,573 @10*1-2 2.16
France	59,048 16.1 37.7	62,787 16.8 39.9	65,874 20.3 41.3	72,442 24.9 42.7	25,253 @05*1-2 2.49
Germany	82,349 16.3 39.9	82,302 20.4 44.3	80,988 23.0 47.7	74,781 30.9 49.2	40,076 @08*1-2 2.05
Italy	56,986 18.3 40.2	60,551 20.4 43.2	61,290 22.8 46.8	59,158 32.7 49.6	23,848 @08*1-2 2.54
Spain	40288 16.9 37.6	46077 17.0 40.1	48661 19.0 44.1	51354 32.6 48.9	16741 @08*1-2 2.75
UK	58,874 15.8 37.7	62,036 16.6 39.8	65,802 18.7 40.4	72,817 23.6 42.9	26,024 @10*1-2 2.38
USA	282,496 12.4 35.3	310,384 13.1 36.9	337,102 16.2 37.3	403,101 21.1 40.0	117,538 @10*1-2 2.64

(Data collected from several sources is listed by the author)

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#### Terms and definition:

##### #1-1: Population

De facto population in a country, area or region as of 1 July of the year indicated. Figures are presented in thousands.

##### #1-2: Population aged 65 or over (Ratio of)

De facto population as of 1 July of the year indicated and in the age group indicated and the percentage it represents with respect to the total population. Population data are presented in thousands.

##### #1-3: Median age

Age that divides the population in two parts of equal size.

##### #1-4: A private household

either: (a) One person household consisting of a person living alone in a separate housing unit or who occupies, as a lodger, a separate room (or rooms) of a housing unit but does not join with any of the other occupants of the housing unit to form part of a multi-person household OR (b) Multi-person household consisting of a group of two or more persons who combine to occupy the whole or part of a housing unit and to provide themselves with food and possibly other essentials for living. The group may be composed of related persons only or of unrelated persons or of a combination of both. The group may also pool their income.

##### #1-5: Number of person per house calculated

The number is calculated by Total population in 2010 / the number of households in the referred year.

Table A2. ICT Related Numbers

Country/ District	Broadband (BB) Subscriber per habitant (%)#2-1 Mobile Subscriber per habitant (%)#2-2 GDP per capita, PPP (constant 2005 International US\$)#2-3*2-4						Number of households Year & Source Number of persons per house calculated (@2010)
	2000*2-4	2003*2-1	2004*2-2	2005*2-3	2008*2-4	2010*2-4	
Australia	0.63@01 44.7 29,663	2.99 72 31,277	7.8 82.6 32,201	10.4 91.4 32,719	24 103 34,406	23.2 101 34,411	7,144 @06*1-3 3.12
China	0.0018 6.7 2,667	0.84 21.5 3,398	2.0 25.5 3,718	2.85 29.9 4,115	6.3 48 5,712	9.4 64 6,816	401,517 @10*1-2 3.34
Hong Kong	6.7 80.3 29,785	18 107.9 31,093	21.3 114.5 33,464	23.6 123.5 35,678	28 166 40,579	29.9 195.6 41,713	2,358 @11*1-5 2.99
Indonesia	0.0019 1.7 2,623	0.02 8.74 2,863	0.0 13.48 2,970	0.02 21.06 3,102	0.18 62 3,570	0.95 88.1 3,885	39,695 @90*1-6 6.06
Japan	0.67 53.1 28,889	11.7 67.9 29,369	14.9 71.6 30,053	17.5 74 30,441	24 86 31,323	26.9 97.4 30,965	49,063 @05*1-3 2.58
Korea (South)	8.2 58.3 18,730	23.3 70.1 21,071	24.9 76.1 21,961	25.2 79.4 22,783	32 94 25,338	35.7 105.4 27,067	15,887 @05** 3.03
Malaysia	0 21.9 10,209	0.44 44.2 10,690	1.0 58.74 11,178	1.9 75.17 11,544	4.9 103 12,942	6.5 119.2 13,214	4,778 @00*1-3 5.94
Singapore	1.7 70.1 38,063	10.1 85.3 40,134	11.9 89.5 43,265	15.3 103.4 45,374	21 132 48,140	25 145.2 52,167	915 @00*1-3 5.56
Taiwan *2-5	N/A N/A 14,704	13.4 111 13,773	16.5 100 15,012	20.1 97.4 16,051	N/A N/A 17,399	N/A N/A 18,588	6,496 @00*1-3 3.57
Thailand	0 4.8 5,497	0.03 26.04 6,122	0.1 44.12 6,443	0.07 42.98 6,675	1.4 92 7,378	4.6 103.6 7,673	15,661 @00*1-7 4.41
Vietnam	0@01 1.0 1,597	0.011 3.4 1,893	0.064 6 2,016	0.25 12 2,161	2.4 81 2,611	4.2 127 2,875	22,444 @09*1-3 3.91
Canada	4.6 28.5 32,446	14.7 41.7 33,640	17.7 47.2 34,344	20.8 51.4 35,033	30 66 35,948	29.8 70.7 35,223	12,437 @06*1-2 2.74
Denmark	1.3 63.0 31,653	13.3 88.72 31,843	18.9 96.1 32,490	24.9 100.71 33,193	37 125 34,123	37.7 125.8 32,235	2,573 @10*1-2 2.16
France	0.33 49.2 28,210	5.6 69.6 28,630	11.2 73.7 29,143	15.6 79.4 29,453	28 93 30,272	33.9 100.6 29,483	25,253 @05*1-2 2.49
Germany	0.32 58.5 30,298	5.5 78.5 30,524	8.9 86.4 30,885	12.9 95.8 31,115	28 129 33,829	31.7 127.0 33,414	40,076 @08*1-2 2.05
Italy	0.2 74.1 27,717	4 101.8 28,022	8.2 109.4 28,227	11.7 124.3 28,280	19 151 28,454	21.6 149.6 27,081	23,848 @08*1-2 2.54
Spain	0.19 60.2 25,147	5.21 91.6 26,459	8.4 93.9 26,882	11.7 96.8 27,392	20.0 109.9 28,353	22.9 112.0 26,968	16,741 @08*1-2 2.75
UK	0.05 73.8 29,056	3.13 84.1 31,493	10.5 102.8 32,260	16 102.1 32,737	28.2 125.2 33,718	30.8 130.8 32,474	26,024 @10* 2.38
USA	2.5 38.8 39,545	9.3 54.3 40,604	12.8 51 41,630	16.6 67.6 42,516	24.8 85.7 43,070	27.6 89.9 42,078	117,538 @10*1-2 2.64

(Data collected from several sources is listed by the author)

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- \*2-5: Council for Economic Planning and Development, "Taiwan Statistical Data Book 2011", July 2011.  
<http://www.cepd.gov.tw> (accessed on March 2012).

Terms and definition:

#2-1: Broadband (BB) Subscriber

Fixed broadband Internet subscribers are the number of broadband subscribers with a digital subscriber line, cable modem, or other high-speed technology. BB subscriber per habitant equals the number per 100 persons, also in %.

#2-2: Mobile Subscriber

Mobile subscribers are the number of subscribers. Mobile subscriber per habitant equals the number per 100 persons, also in %.

#2-3: GDP per capita, PPP (constant 2005 international \$)

GDP per capita based on purchasing power parity (PPP). PPP GDP is gross domestic product converted to international dollars using purchasing power parity rates. An international dollar has the same purchasing power over GDP as the U.S. dollar has in the United States. GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant 2005 international dollars.

Table A3. Expenditure on Health and GDP

Country / District	Expenditure on Health (EoH) per Capita, PPP (\$) *3-1 GDP per Capita, PPP (\$) #2-3*2-4 Ratio of EoHpC / GDPpC (%)					
	2000	2003	2004	2005	2008	2010
Australia	2,266 29,663 7.64	2,665 31,277 8.52	2,870 32,201 8.91	2,980 32,719 9.11	3,409 34,406 9.91	3,441 34,411 10.00
China	107 2,667 4.01	152 3,398 4.47	170 3,719 4.57	191 4,115 4.65	285 5,712 4.99	379 6,816 5.56
Hong Kong *3-2 3-3	N/A 29,785 N/A	1,316 31,094 4.23	1,287 33,464 3.85	1,326 35,678 3.72	1,464 40,579 3.61	N/A 41,713 N/A
Indonesia	47 2,623 1.78	70 2,863 2.44	71 2,970 2.38	66 3,102 2.13	95 3,570 2.67	112 3,885 2.88
Japan	1,969 28,889 6.82	2,224 29,369 7.57	2,336 30,053 7.77	2,474 30,441 8.13	2,878 31,323 9.19	3,204 30,965 10.35
Korea	824 18,730 4.40	1,086 21,071 5.15	1,166 21,961 5.31	1,305 22,783 5.73	1,736 25,339 6.85	2,023 27,067 7.47
Malaysia	304 10,209 2.98	502 10,690 4.70	492 11,178 4.41	487 11,544 4.21	533 12,942 4.12	641 13,214 4.85
Singapore	937 38,063 2.46	1,348 40,134 3.36	1,291 43,265 2.99	1,379 45,374 3.04	1,911 48,160 3.97	2,273 52,167 4.36
Taiwan *3-4 *3-5	1,126 14,704 7.66	1,403 13,773 10.19	1,551 15,012 10.33	1,667 16,051 10.39	2,094 17,399 12.04	2,335 18,588 12.56
Thailand	165 5,497 2.99	206 6,122 3.36	222 6,443 3.44	240 6,675 3.59	318 7,378 4.31	330 7,673 4.30
Vietnam	76 1,597 4.76	94 1,893 4.95	108 2,016 5.38	126 2,161 5.85	186 2,611 7.11	215 2,875 7.49
Canada	2,519 32,447 7.76	3,319 33,640 9.87	3,275 34,344 9.54	3,288 35,033 9.39	3,996 35,948 11.12	4,404 35,223 12.50
Denmark	2,377 31,653 7.51	2,825 31,843 8.87	3,047 32,490 9.38	3,146 33,193 9.48	4,031 34,123 11.81	4,537 32,235 14.07
France	2,535 28,210 8.99	2,972 28,630 10.38	3,097 29,143 10.63	3,294 29,453 11.18	3,801 30,272 12.56	4,021 29,483 13.64
Germany	2,667 30,298 8.80	3,083 30,524 10.10	3,162 30,885 10.24	3,355 31,115 10.78	3,963 33,829 11.71	4,332 33,414 12.97
Italy	2,063 27,717 7.44	2,253 28,022 8.04	2,360 28,227 8.36	2,412 28,280 8.53	3,009 28,454 10.58	3,022 27,081 11.16
Spain	1,529 25,147 6.08	2,001 26,459 7.56	2,109 26,882 7.84	2,249 27,392 8.21	2,971 28,353 10.48	3,027 26,968 11.23
United Kingdom	1,833 29,056 6.31	2,318 31,493 7.36	2,540 32,260 7.87	2,694 32,738 8.23	3,234 33,718 9.59	3,480 32,474 10.71
United States	4,703 39,545 11.89	5,588 40,604 13.76	5,911 41,630 14.20	6,259 42,516 14.72	7,720 43,070 17.92	8,362 42,079 19.87

(Data collected from several sources is listed by the author)

- \*3-1: The World databank, "World Bank Data World Development Indicators & Global Development Finance", <http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=2> (accessed on March 2012).
- \*3-2: Department of Health, "Health facts of Hong Kong, 2011 Edition", [http://www.dh.gov.hk/textonly/english/statistics/statistics\\_hs/statistics\\_hs.html](http://www.dh.gov.hk/textonly/english/statistics/statistics_hs/statistics_hs.html) (accessed on March 2012).
- \*3-3: 1HK\$=0.1284US\$
- \*3-4: Council for Economic Planning and Development, "Taiwan Statistical Data Book 2011", <http://www.cepd.gov.tw/encontent/m1.aspx?sNo=0015743> (accessed on July 2011).
- \*3-5: Department of Health, ROC, "Statistics National Health Expenditure 2010", [http://www.doh.gov.tw/EN2006/DM/DM2.aspx?now\\_fod\\_list\\_no=12117&class\\_no=390&level\\_no=2](http://www.doh.gov.tw/EN2006/DM/DM2.aspx?now_fod_list_no=12117&class_no=390&level_no=2) (accessed on Nov. 2010).

## Annex A4: List of Latest Activities in the Laboratory

## [General]

- (G1) Oguchi, K. 2009-1. "Content Transfer and Supporting Technologies in a Home Environment over Next Generation Convergence Home Network: From Vital Information Transfer to Broadband Content Transfer", *IDCTA*, Vol.3, No.3, pp.124-135.
- (G2) Oguchi, K. et al. 2009-2. "Vital Information Transfer and Supporting Technology in a Home Environment", *Proc. isabel2009*.
- (G3) Oguchi, K. 2009-3. "Information Transfer and Supporting Technology in the Smart Home Environment", *Proc. IBASH2009*.
- (G4) Oguchi, K. et al. 2007. "Vital Information Sensing System Technologies and Experiments in the Next Generation Convergence Home Network", *Proc. ISMICT2007*.
- (G5) Oguchi, K. et al. 2006. "Vital Information Sensing in the Next Generation Convergence Home Network", *Proc. ISSS-MDBS2006*.

## [Fall detection]

- (V1-1) Enomoto, Y. et al. 2011. "Fall Detection Method for Elderly People with Wearable Sensor", *Proc. icampam2011*.
- (V1-2) Enomoto, Y. et al. 2010. "Novel Fall Detection Method with a Wearable Hybrid-type Sensor", *Proc. ICBME2010*.
- (V1-3) Endo, H. 2010. "Fall Detection System Using Template Approach", *Proc. ICBME2010*.
- (V1-4) Enomoto, Y. et al. 2009-1. "Processing Acceleration Sensor Data to Detect Falls", *Proc. SAA2009*.
- (V1-5) Enomoto, Y. et al. 2009-2. "Data Processing for Fall Detection Using an Acceleration Sensor", *Proc. ICCCS2009*.
- (V1-6) Endo, H. et al. 2009. "Fall Detection Method Based on Acceleration Sensor", *Proc. ISBB2009*.
- (V1-7) Okazaki, Y. et al. 2008. "Foot-Wear Depended Acceleration Measurements of a Fall Prevention System Based on a Wearable Sensor", *Proc. ICAMPAM2008*.

## [Foot pressure]

- (V2-1) Oguchi, K. et al., 2011. "Feasibility of Assessing Rehabilitation Status by Using Foot Pressure Sensor While Walking", *Proc. ICBPE2011*.
- (V2-2) Okazaki, Y. et al, 2006. "Using Sole Pressure Signals to Analyze Walking Posture", *Proc. ICBPE2006*.

## [Respiration by FIR image]

- (V3-1) Hanawa, D. et al. 2011. "Nasal Breathing Detection by Using Far-Infrared Imaging in a Home Healthcare System (in Japanese)", *Trans. IEICE*, Vol.J94-D, No.1, pp.260-263.
- (V3-2) Hanawa, D. et al. 2010. "Automation of Non-intrusive Nasal Breathing Detection by Using Far-Infrared Imaging", *Proc. uHealthcare2010*.
- (V3-3) Koide, T. et al. 2009-1. "Breathing Detection by Far Infrared (FIR) Imaging in



a Home Healthcare System”, *Proc. IBASH2009*.

(V3-4) Koide, T. et al. 2009-2. “Breathing Detection by Far Infrared (FIR) Imaging in a Home Health Care System”, *Proc. ISBB2009*.

(V3-5) Koide, T. et al. 2009-3. “Breathing Detection by Far Infrared (FIR) Imaging in a Home Healthcare System”, *Proc. ISMICT2009*.

[Body movements]

(V4-1) Terada, S. et al. 2011. “Gait Authentication Using a Wearable Sensor”, *Proc. ICBPE2011*.

(V4-2) Endo, H. et al. 2009. “Gait analysis on stairs using a template method”, *Proc. SAA2009*.

(V4-3) Okazaki, Y. et al. 2006. “Using Sole Pressure Signals to Analyze Walking Posture”, *Proc. ICBPE2006*.

(V4-4) Yoshida, N. et al. 2005. “Analysis of Gait Utilizing Simple Wearable Sensors, and its Applicability to a Visualizing System”, *Proc. ICBME2005*.

(V4-5) Mochizuki, T. et al. 2005. “Visualization of Human Body Motion Using Simple Wearable Tool and TVML”, *Proc. ICBME2005*.

[Others]

(V5-1) Oguchi, K. et al. 2011. “Basic Experimental Study on Visibility Dependence on the Signal Sign Pattern for Low Vision People”, *Proc. TSP2011*.

(V5-2) Terada, S. et al. 2010. “User Localization by a Wearable Sensor”, *Proc. ICBME2010*.

(V5-3) Oguchi, K. et al. 2008. “Heart Rate during Sleep Measured by a Wearable Sensor and its Relationship with One’s Behavior during the Day”, *Proc. u-Healthcare2008*.