Workshop/session on New Communication Technologies for E-health and Socio-Economic Issue
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eHealth application of artificial intelligence, trends in Japanese telecommunications companies

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Some history…

- Healthcare and medicine were one of the first applications, along with natural language understanding, of Artificial Intelligence in the 1960s and 1970s when the so-called expert system became popular (e.g., MYCIN)
- But they did not achieve widespread use, due to:
  - Lack of sufficient computing power, for processing and storage
  - Lack of sufficient large volume of data
  - Lack of digitization (e.g., machine readable health record, MRI)
  - Lack of sufficient supporting technologies (e.g., ultra-high definition video, computer vision, natural language processing)

But now..

- Improvements in computing power resulting in faster data collection and data processing
- Increased volume and availability of health-related data (including text)
- Implementation of electronic health record (EHR) systems
- Development of natural language processing and understanding technology, for large volume
- Improvements in high-definition video and computer vision technology, enabling machines to have better “eyes”
- Growth of genomic sequencing databases

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Fourth Industrial Revolution | Artificial Intelligence and Robotics
Future of Health and Healthcare

7 amazing ways artificial intelligence is used in healthcare

Importance of Sensor, Data and Analysis

- Central to the current trend in AI are:
  - Sensor devices such as camera, microphone, LiDAR, etc.
  - Data, derived from sensor devices, but also from other sources like web-pages, catalogues, EHR, etc. May be structured as well as unstructured
  - Analysis: inspecting, cleansing, transforming and modeling data in order to discover useful information, esp. for decision-making. Machine-learning is an important part of data analysis to predict relations, attributes, etc., of the data.

Types of Data

- Sensor data
  - Video and graphic (images of skin cancer, eye scan, brain scan, etc.)
  - Audio/sound/speech
  - Heat/temperature
- Textual data
  - Typing mistakes, grammatical error
  - documents,
  - EHR, EMR, PHR, etc.
  - Questionnaire
- Numerical data
  - Age, blood pressure, heart rate, etc.
  - Time-series data
  - IQ

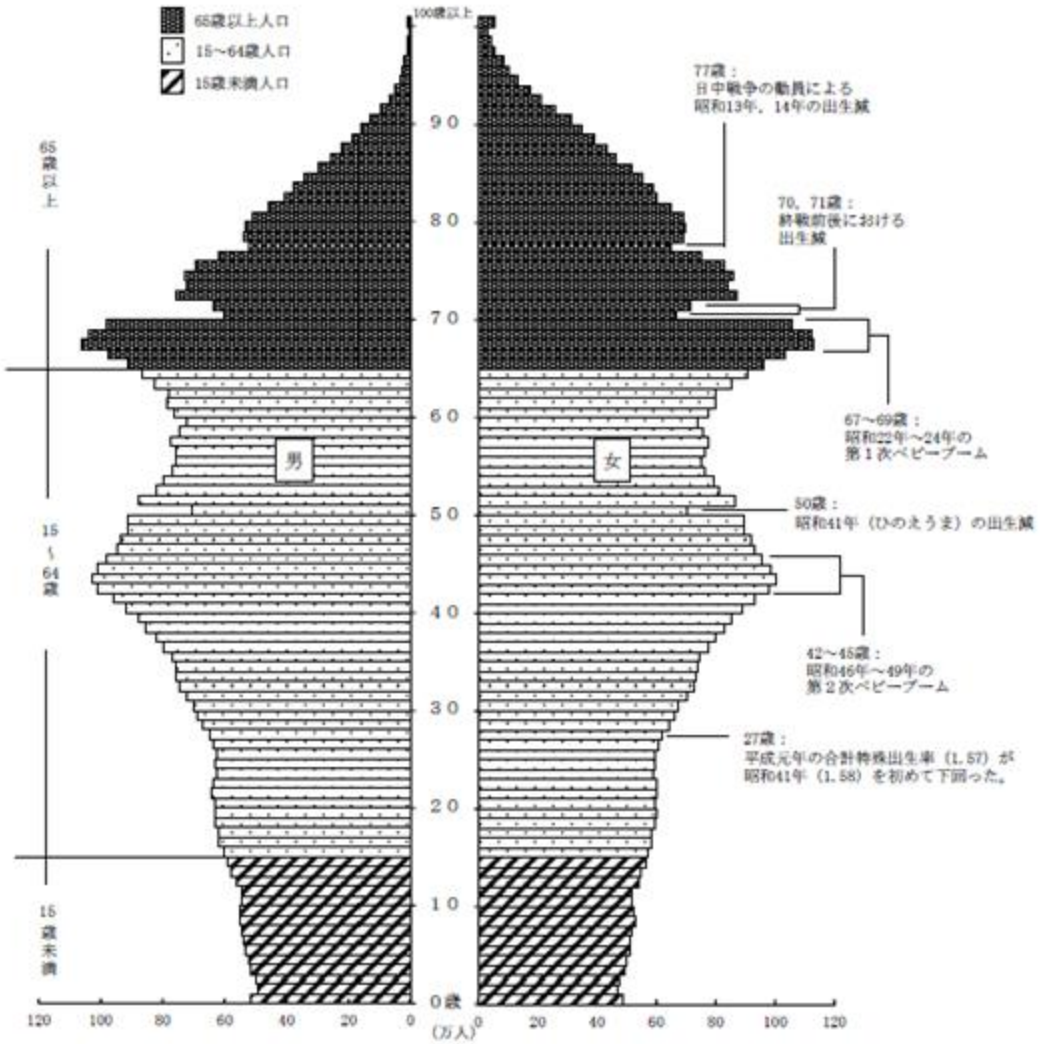
Importance of Imaging in medical/health

- "Some statistics say that up to 80 percent of all medical diagnoses are made or confirmed through **imaging studies**" (Shinjini Kundu)
- Techniques in medical imaging include:
  - Magnetic resonance imaging (MRI)
  - Radiography
  - (Functional) near-infrared spectroscopy (fNIRS)
  - Tomography (e.g., CT)
  - Ultrasound
  - Angiography
  - Photoacoustic imaging
  - ...
- It is clear that imaging data will be one of the key areas where AI can be applied.

Brain Healthcare and AI in Japan

- As an example of using imaging data for healthcare, we introduce here the case of Brain Healthcare Quotient (BHQ) and its use with AI for help improve the QoL (quality of life) of an aging population.

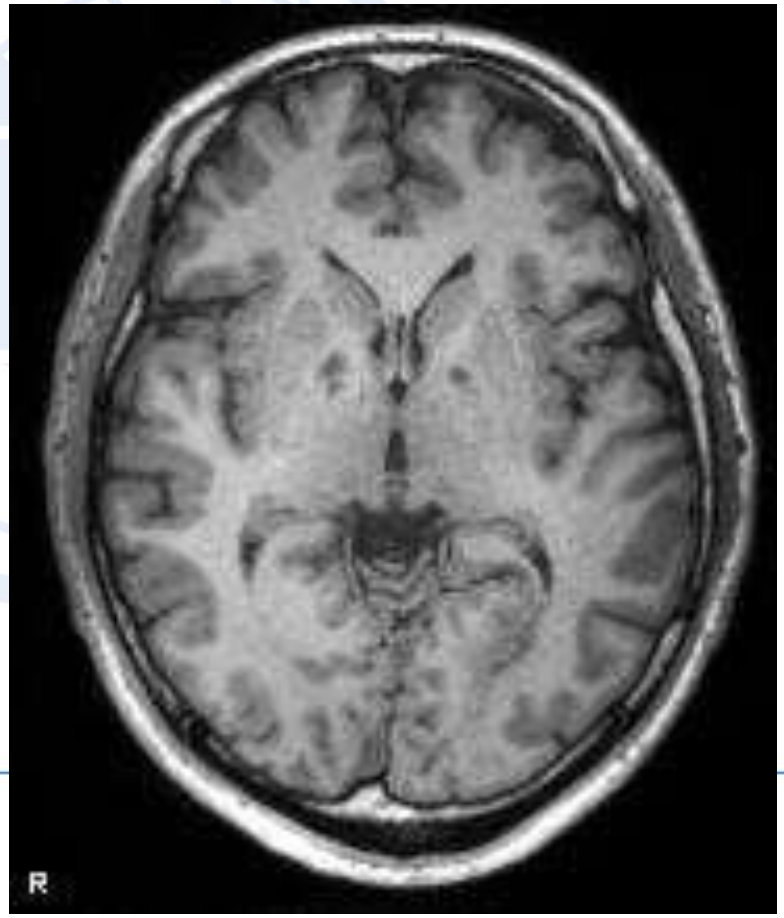
Japan: Aging Society



- The people over the age of 65 accounts for 27.3% of the population of Japan
- **Cognitive diseases** are expected to become the biggest health issue (by 2025, approx. 7 mil. patients expected)
- Detection and other ***preventive measures*** are of immediate need

Brain Image

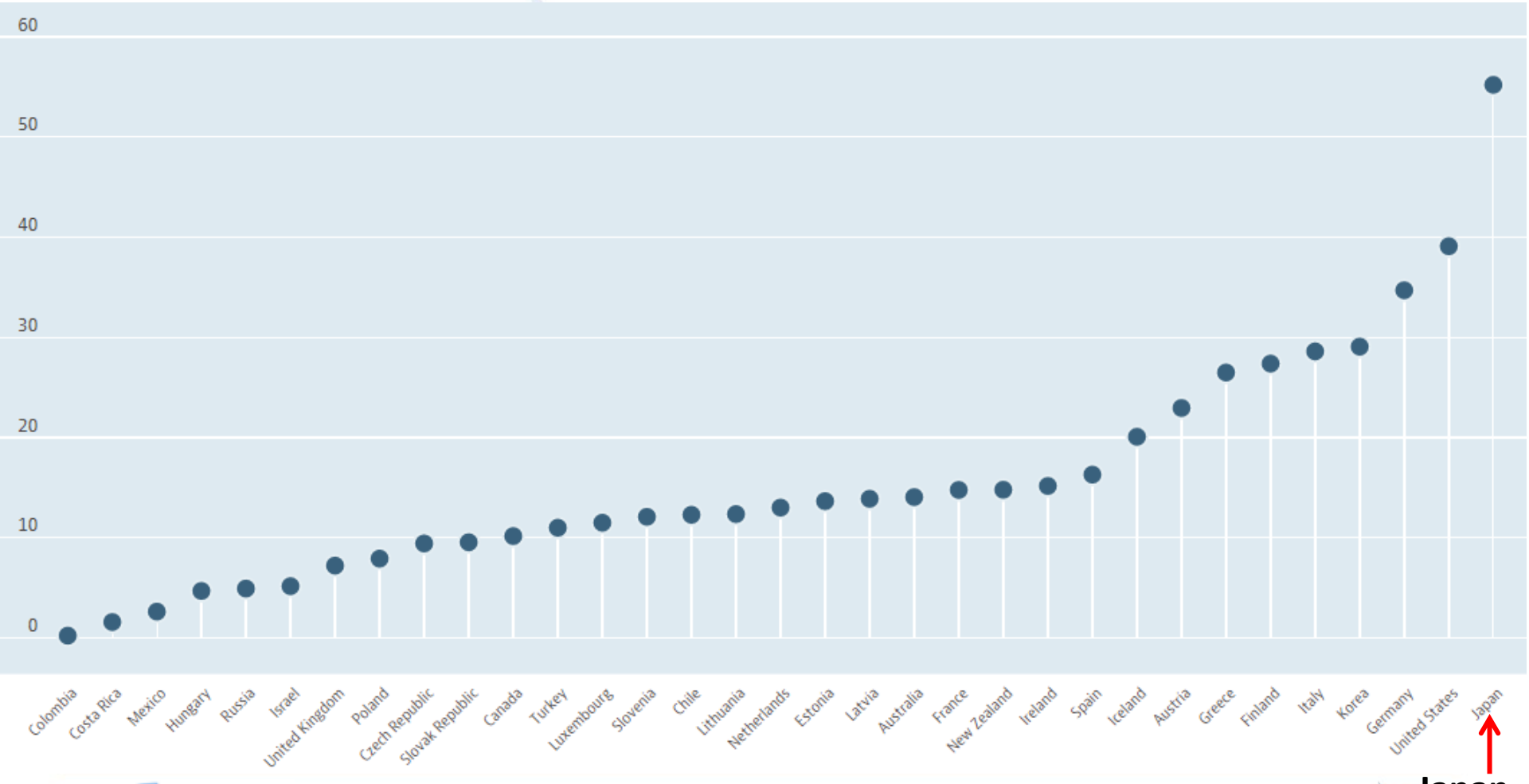
- Brain scanning is the most popular, if not most effective, means to detect abnormality in the brain, including cognitive diseases



MRI

- Magnetic Resonance Imaging (MRI) is now widely available, and commonly utilized to detect various diseases esp. for brain

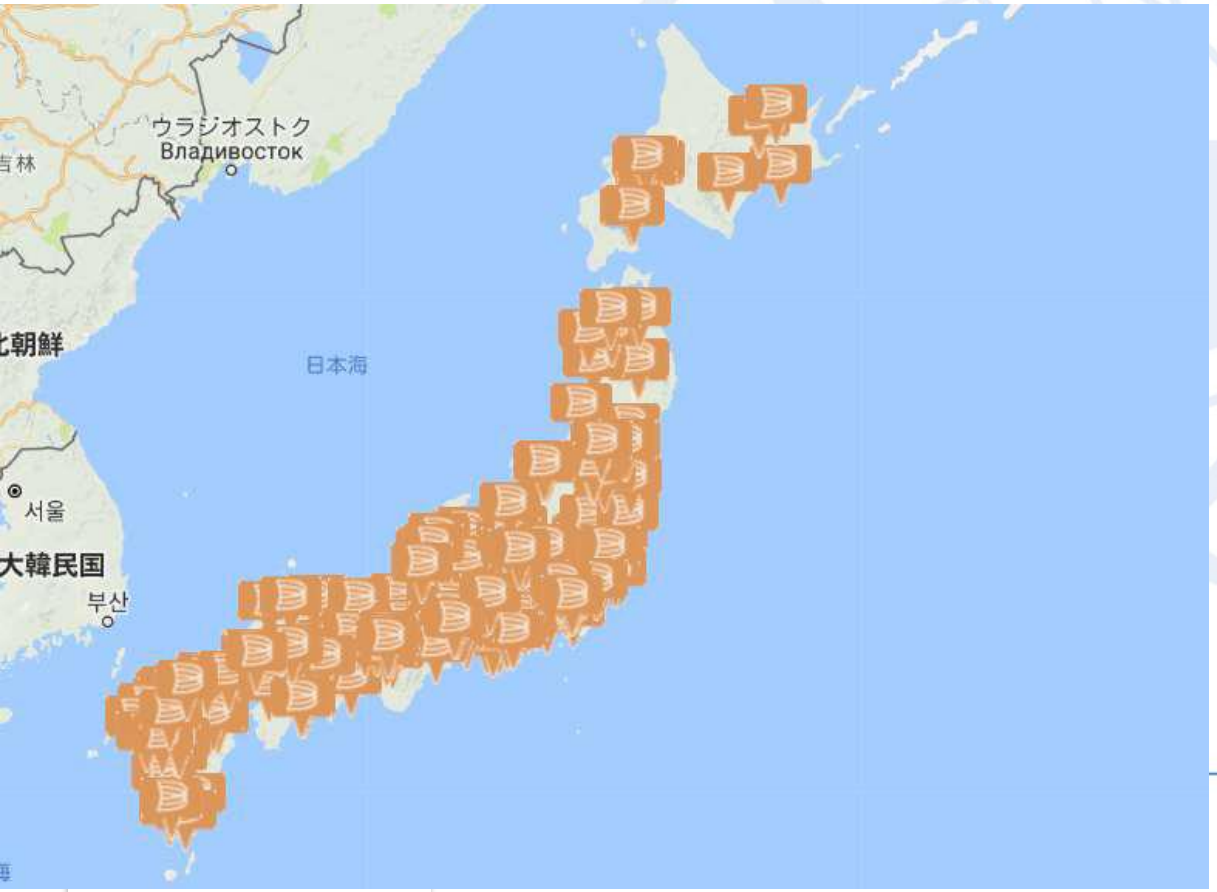
The number of MRI units per million by countries



Brain Dry Dock Examination

- A form of preventive medicine, coined after "human dry dock", where examinations with typical MRIs are conducted to check for brain-related problems.
- About 3.23 million people in Japan get examined annually.
- This means that not only the data about healthy brains, as well as unhealthy ones, can be collected, but they can also be compared over time

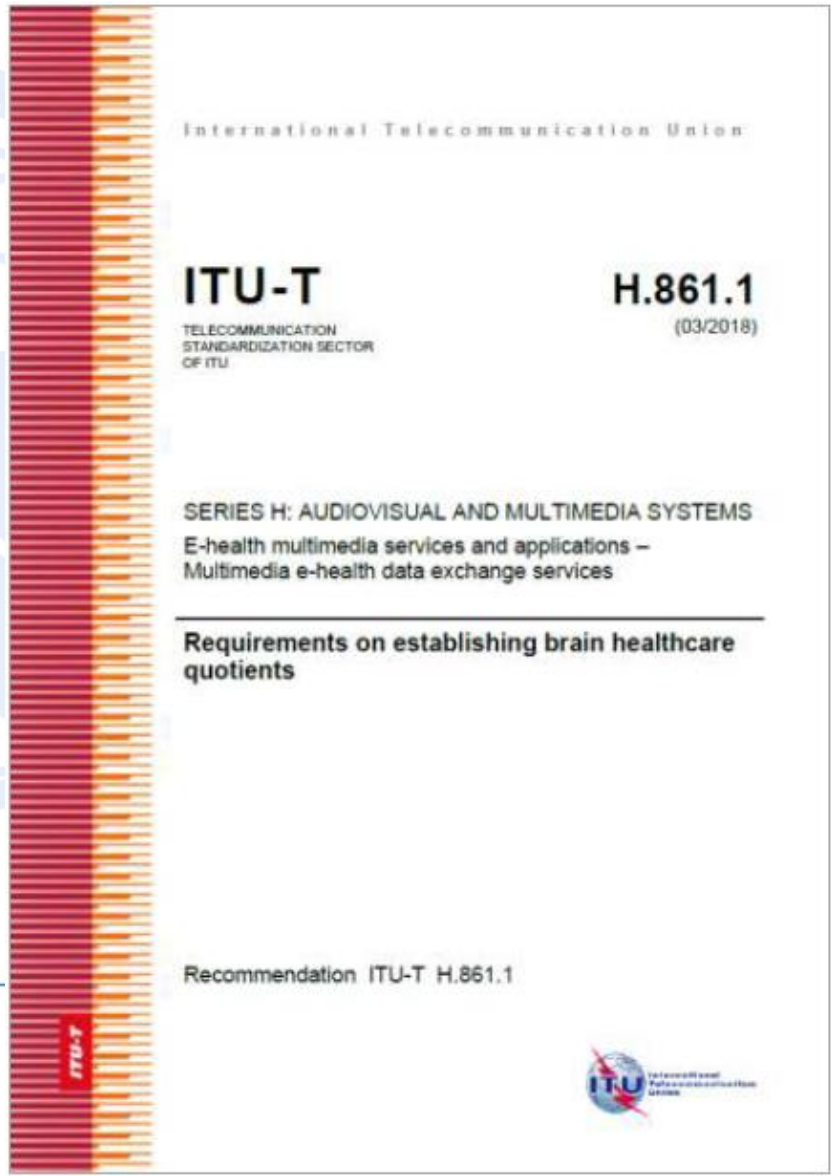
Clinics offering “Brain Dry dock ” exams in Japan



- About 700 medical institutions offer brain dry dock examination all over Japan
- A common “denominator” was needed to compare the data about brain health among these organizations (hospitals, clinics, universities).

Brain Healthcare Quotients (BHQ)

- Against this background, Japanese government funded ImPACT program proposed a new “index” for brain health, called “Brain Healthcare Quotient” based on the calculation on MRI scanning
- This was standardized at ITU-T as ITU-T Rec. 861.1

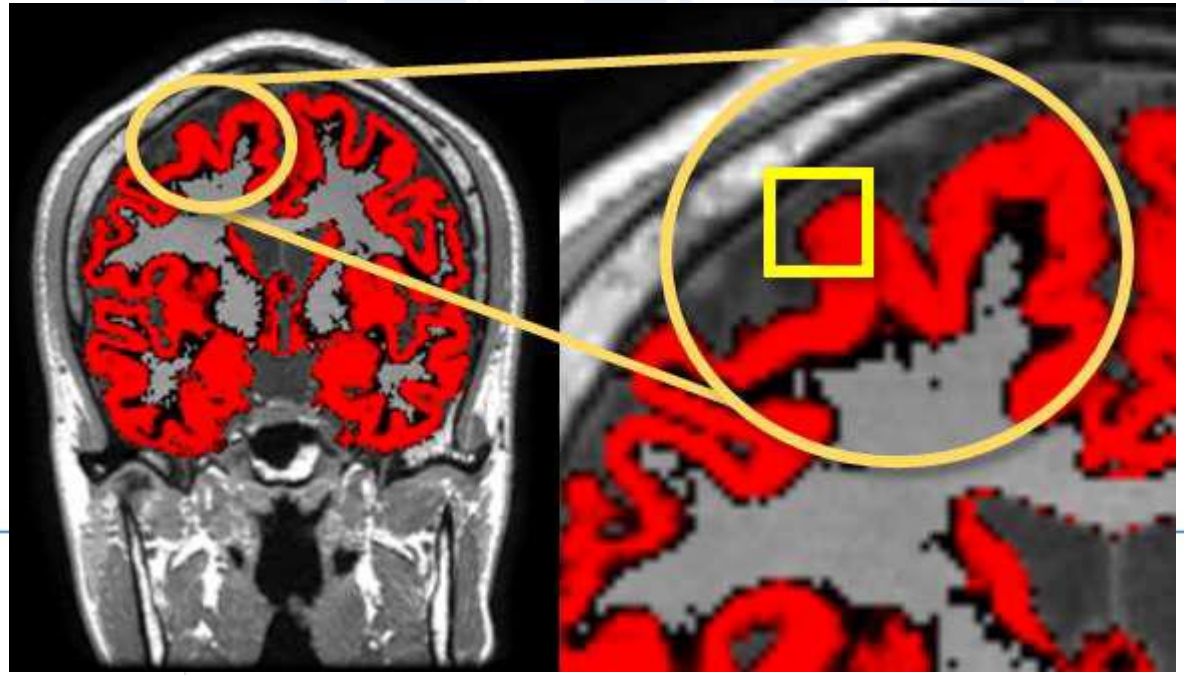


Brain Healthcare Quotients (BHQ)

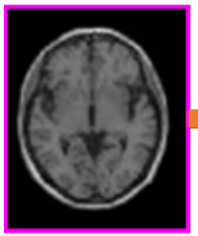
- A numerical indicator representing physical characteristics of the brain that are purported to be indicative of some state of a health related condition
- Currently primarily used to calculate the volume of brain gray matter (GM)
- It has the following characteristics:
  - detect minute changes in the brain of a person in the course of time
  - the exchange of information about the brain in a standardized way
  - on the basis of neuroscience.
  - derived from neuroimaging analysis.
  - built upon an established method to assure its validity
  - employ a standardized score (e.g., mean of population is 100 and 1 standard deviation is 15, so that 95% of population falls within the range of 70-130.).

GM-BHQ

- Evaluates volume of gray matter where a high density of neuronal cells can be found.
- • Gray matter is assessed by VBM (Voxel Based Morphometry)



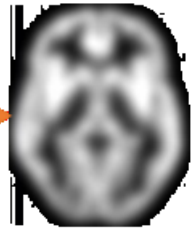
Calculation of BHQ



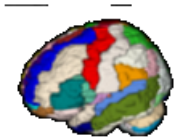
Extract grey matter

Warp to standard space

Smoothing/ proportional scaling



Calculate Z-score based on mean and standard deviation of control.
Then, standardize voxel value by
$100 + 15 \times$ Z-score



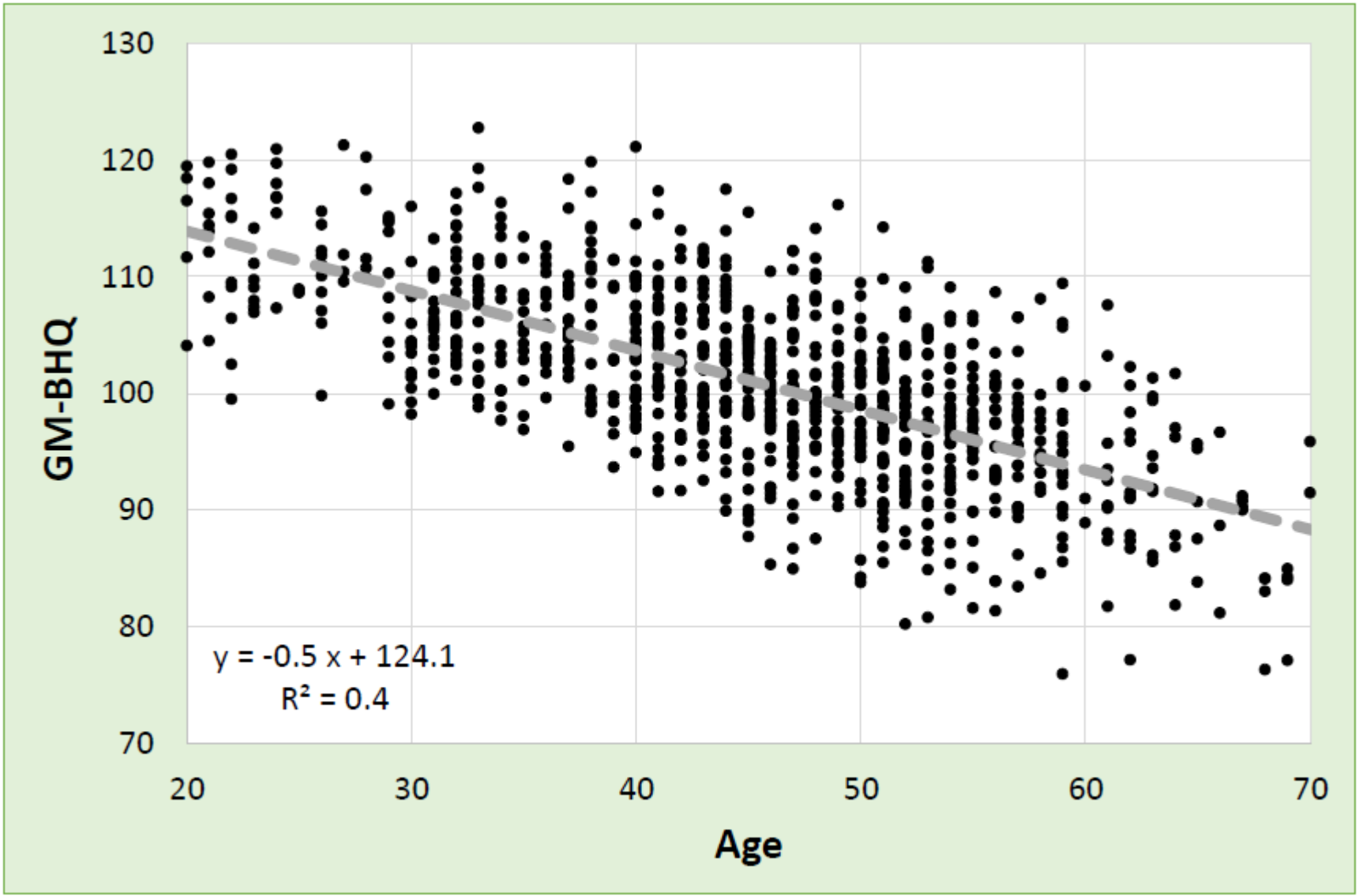
Calculate local BHQ within regions defined by an atlas

	A	B	C	D	E
1	File	AAL_1	AAL_2	AAL_3	AAL_4
2	bhq_pV_M	96.4	86.3	99.9	93.9
3	bhq_pV_M	111.5	109.9	102.3	100.8
4	bhq_pV_M	94.8	96.8	103.4	100.2

Calculate (Global) GM-BHQ by averaging local BHQ

DL	DM	DN
AAL_115	AAL_116	GM-BHQ
115.6	128.(	98.0
92.4	101.5	102.6
110.0	115.2	99.2

Correlation of age and BHQ



Life style and BHQ

Attributes	positive/negative corr
Metabolic Syndrome	+
Inactivity on holidays	--
Activity on weekdays	+
Personal errands on holidays	+

Using AI to estimate BHQ

- These correlations mean that there is a possibility of estimating BHQ by analyzing the life style of a patient.
- With the big database of “brain dry dock” examinees, and associated questionnaires, an AI algorithm can estimate the rough range of BHQ.
- As MRI scanning is still expensive and time-consuming, such an estimate BHQ will make the usefulness of such a process even relevant in the prevention of cognitive diseases, as well as healthy life style
- This project is being undertaken by NTT Data and Kyoto University

Improvement of Endoscopy using UHD and AI

- In Japan, with the advent of ultra high definition broadcasting and video technology, digital imaging in medicine is experiencing a new era of digital medicine
- 8K UHD imaging allows video with a 16-times higher resolution (7680 × 4320 pixels, about 33 million pixels) than the current high-definition (HD) (1920 × 1080 pixels)
- Endoscopic surgery, where surgeons operate by watching a lesion on a video screen with a camera in the body, requires video imaging
- Therefore, UHD video technology is expected to provide better endoscopy
- Aided by AI, such UHD technology will enhance the accuracy of detection of as well as operation on critical conditions such as cancer

Real-time endoscopic diagnosis system using AI

- The system can discover colorectal cancer and precancerous lesions (colon neoplastic polyps) in real time during endoscopic examination. The PC-based system uses AI technology utilizing deep learning for image analysis, high speed processing algorithms, and an advanced image processing device.
- 5,000 endoscopic scan images were provided by the National Cancer Research Center Central to NEC for AI learning.
- Using this AI technique resulted in a cancer detection rate of 98%.

Conclusion

- In (application of AI in) healthcare and medicine, imaging is important as up to 80 percent of all medical diagnoses are made or confirmed through imaging
- MRI, Endoscopy and microscopy are examples of imaging in medicine
- In Japan, due to its aging society, interests are growing in utilizing brain information; BHQ, along with AI, can estimate the health status of one's brain, enabling improvements in life-style
- UHD imaging is changing the way endoscopy and microscopy are done. With the aid of AI, more accurate detection and treatment is possible (real-time)