CT dosimetric calculator

- Development of WAZA-ARIv2 system -

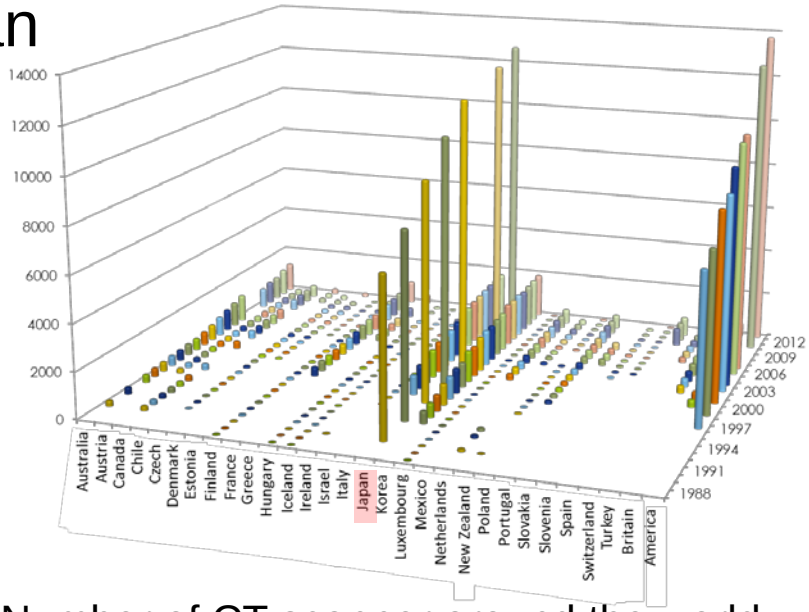
Yusuke Koba[1)], Shinnosuke Matsumoto[1)], Yoshihiro Nakada[1)], Keiichi Akahane[1)], Reiko Kanda[1)], Koji Ono[2)], Kaoru Sato[3)], Fumiaki Takahashi[3)], Michiaki Kai[4)]

1) National Institute of Radiological Sciences
2) Tokyo Healthcare University
3) Japan Atomic Energy Agency
4) Oita University of Nursing and Health Sciences

Introduction

- X ray CT(Computed Tomography)
  - Recently, very popular as helpful diagnostics
  - High exposure dose as compared with simple roentgenography
  - The IAEA has recently called for enhanced Radiation Protection of Patients(RPoP). https://rpop.iaea.org/RPoP/RPoP/Content/index.htm

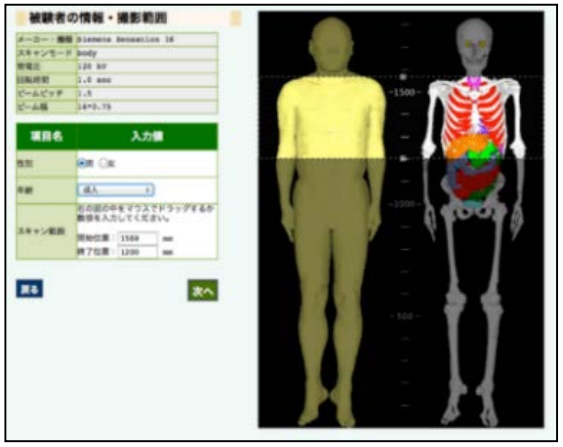
- Number of CT scanner in Japan
  - About 13,000 scanners
  - The largest over the world
  - And the number of CT scanners per million population is about 101, this is by far the largest.
    * USA: 32 / million



Number of CT scanner around the world
(ref. OECD Health Statistics 2014)

WAZA-ARI system

- WAZA-ARI is the web-based open system for CT dose calculator, which has been developed by Oita University of Nursing and Health Sciences and the Japan Atomic Energy Agency (JAEA).
- WAZA-ARI system was installed on a web server of National Institute of Radiological Sciences (NIRS) of Japan, and released as a trial version in December 2012.



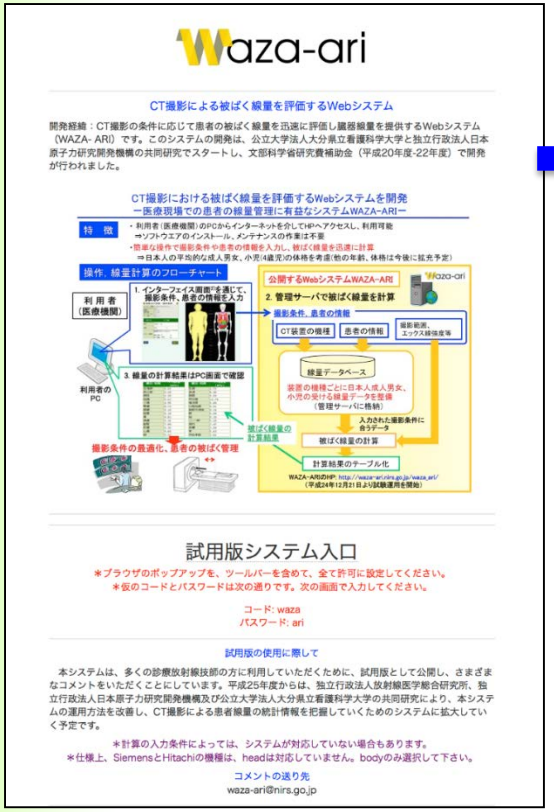
What's WAZA-ARI?

- 「WAZA-ARI」

  Waza-ari (Japanese: 技あり) is the second highest score a fighter can achieve in a Japanese martial arts ippon or waza-ari contest, usually judo, karate or jujutsu.
- In judo, a waza-ari is awarded after an action in which the opponent is thrown with control and accuracy (Wikipedia)
- Not acronym nor anagram, but just a name in this system

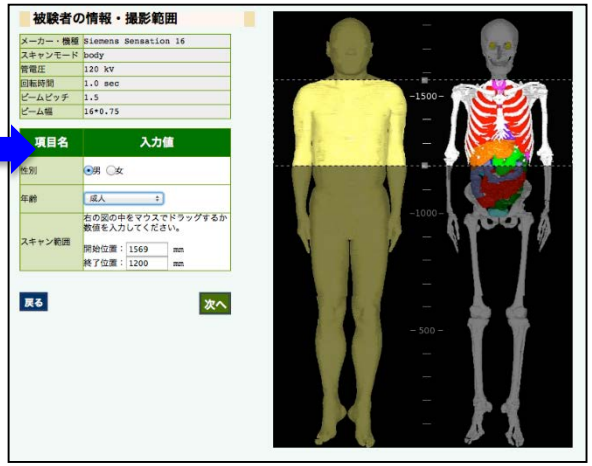
WAZA-ARI (version 1)

This version was a trial version.



Homepage

Free login

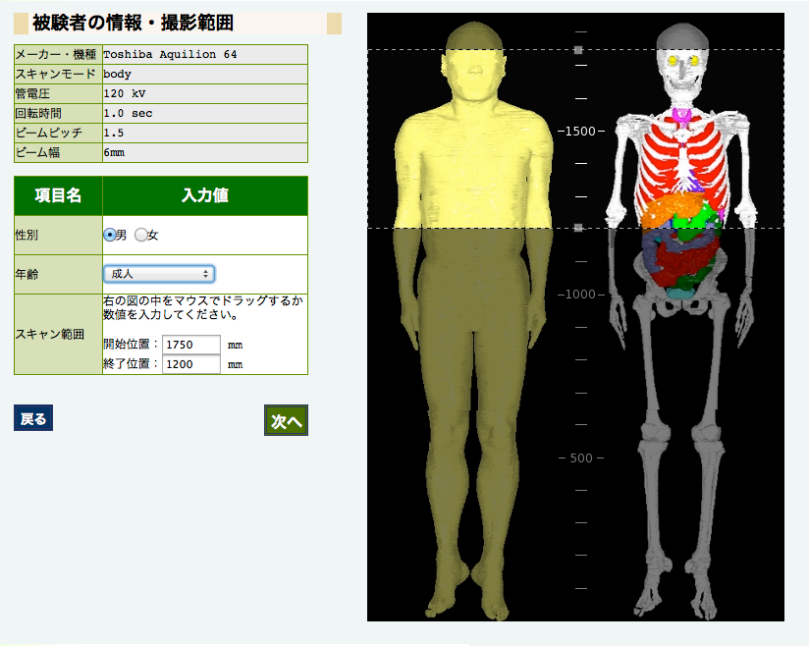


Input condition

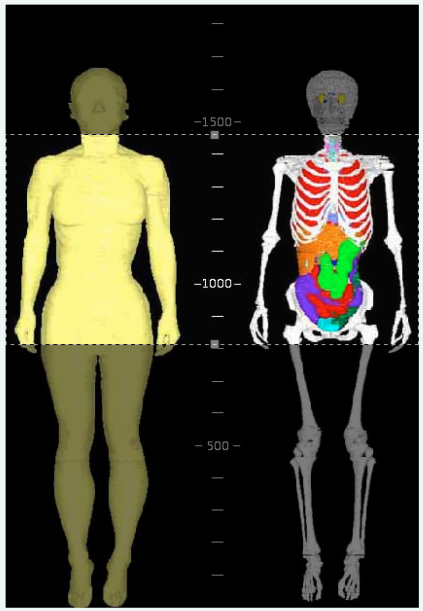
Calculation result

- No user registration
- 3 phantoms
- Few CT model
- 120 kV only
- Japanese only

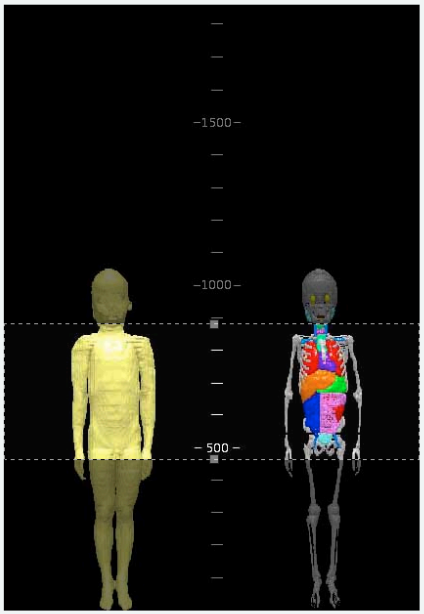
Selectable phantoms in WAZA-ARI



Adult male

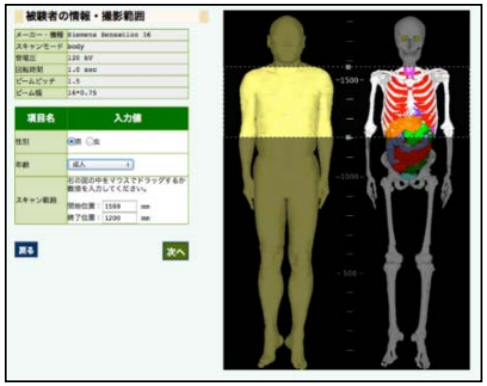


Adult female



4 years old girl

Points to be improved in WAZA-ARI



Points to be improved in WAZA-ARI system

- No user registration
  - ✓Utilization situation was not understand
  - ✓It was unavailable to survey exposure dose in Japan
- No consideration of body type
  - ✓children or fat person or thin person
- Available exposure conditions were few
  - ✓9 CT models
  - ✓Tube voltage : 120 kV only

Purpose of improvement of WAZA-ARIv2

- Dose-distribution survey of CT exposure in Japan
  - To check the exposure levels of the CT examination in each medical facility
  - To provide the information for the optimization of exposure conditions

→ Database function of storing the calculation results in each facility

- Consideration of patient's age and body type
  - Age: infants / preschool children / school children / adolescent / adult ?
  - Body type: thin / normal / fat ?

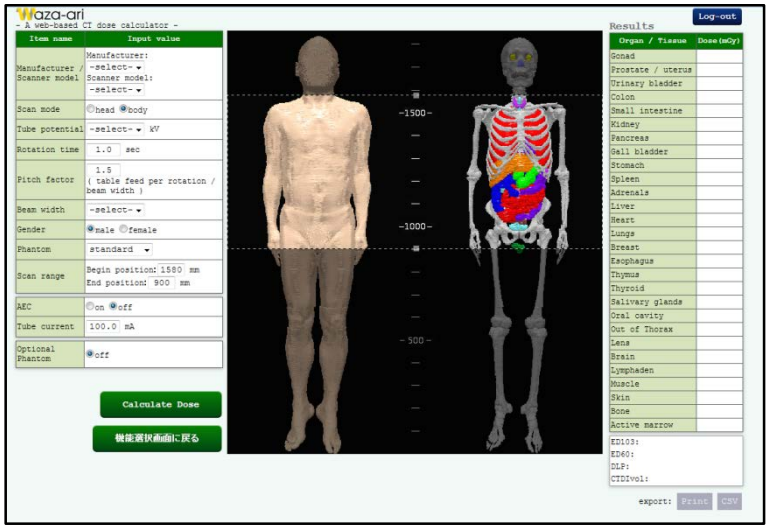
→ Dose calculation using children and thin/fat phantoms

- Increase selectable CT models and exposure condition

Development of WAZA-ARIv2

System open: Jan 30, 2015

URL: https://waza-ari.nirs.qst.go.jp/



Features

- Organ dose calculator by CT exposure
- Web-based system (*require user registration, free)
- 18 phantoms: 0, 1, 5, 10, 15 years old boys and girls
  4 body type of male and female adults
- 31 scanner models: measure models in Japan
  (GE, Siemens, Toshiba, Hitachi)
  → about 60% share of number of CT scanner installed in Japan
- Optional function: dose calculation for AEC(Auto Exposure Control)
- Database and statistics function
- Language: Japanese and English (*Manual: Japanese only yet)

Comparison of CT exposure dose calculation tools

	WAZA-ARIv2	ImPACT	CT-Expo	ImpactDose	VirtualDose
phantoms					
Calculation type	Voxel	MIRD	MIRD	MIRD and Voxel	Voxel
Race (adult)	Japanese (Mongoloid)	Caucasoid	Caucasoid	Caucasoid	Caucasoid
Age	0,1,5,10,15 y.o., adult	Using the coefficient	Using the coefficient	0,1,5,10,15 y.o., adult	0,1,5,10,15 y.o., adult
Body type (adult)	○ standard thin, fat(2 type)	×	×	×	○ standard, fat(5 type), pregnant(3 type)
number of types	18	1	4	12+2	25
AEC	○	×	×	○	○
Usage fee	free	pay (MC dataset)	pay	pay	pay
Platform	WEB browser	Excel	Excel / iPhone app.	PC	WEB browser
CT model matching	○	○	×	×	?
Database and statistics function	○	×	×	×	×
Developer or Distributor	NIRS, JAEA, Oita NHS univ. (Japan)	ImPACT group (England)	Sascrad (Germany)	CT Imaging (Germany)	Virtual Phantoms Inc. (USA)

Dose-calculation procedure in WAZA-ARIv2

Developers

Measure

Source Model

Calculation of organ dose of each slice

Users

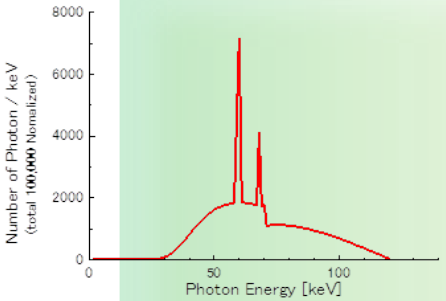
In WAZA-ARIv2 system

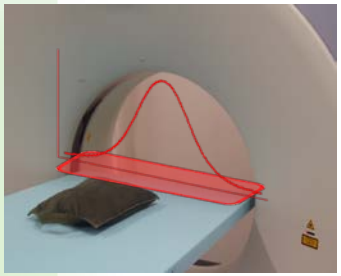
Dose calculation by exposure condition

Registration of results

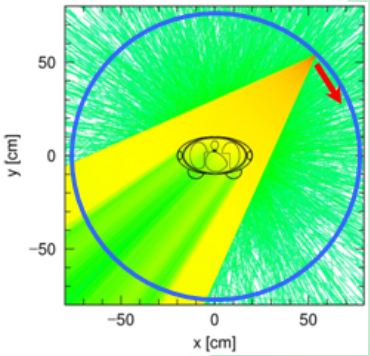
Evaluation of dose distribution

HVL



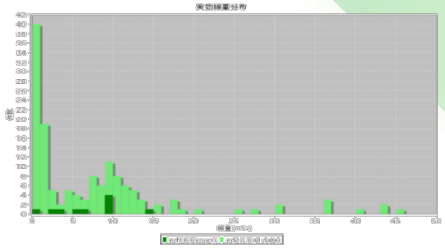


Lateral profile



Monte Carlo Calculation using PHITS

Setting of exposure condition in WAZA-ARIv2 system



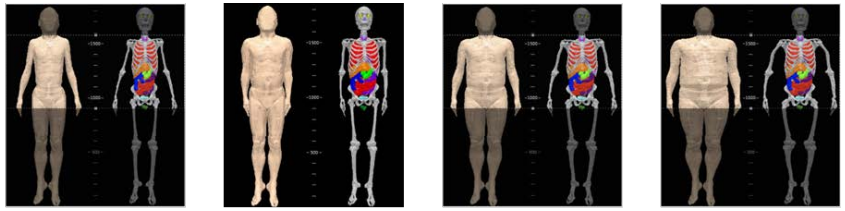
Statistics information of registered data in WAZA-ARIv2 server

Voxel Phantoms

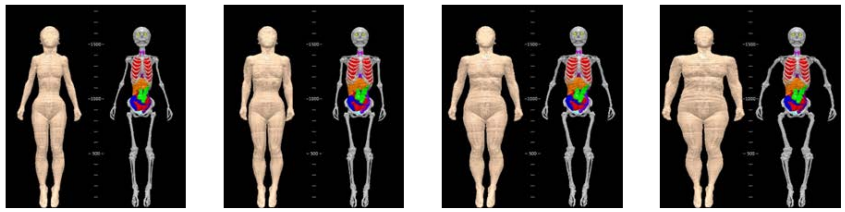
- Adult phantoms[1)]
  - developed by JAEA
  - 4 types
    - Thin type(-2σ)
    - Standard type
    - Fat type(+2σ)
    - Fat type(+5σ)

  *σ: standard deviation based on statistics data in Japan

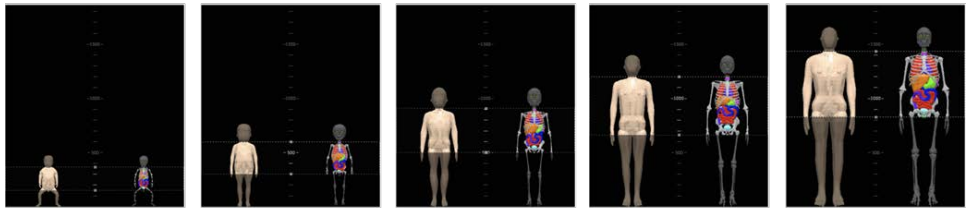
- Child phantoms[2,3)]
  - developed by University of Florida
  - 5 types
    - 0, 1, 5, 10, 15 years old



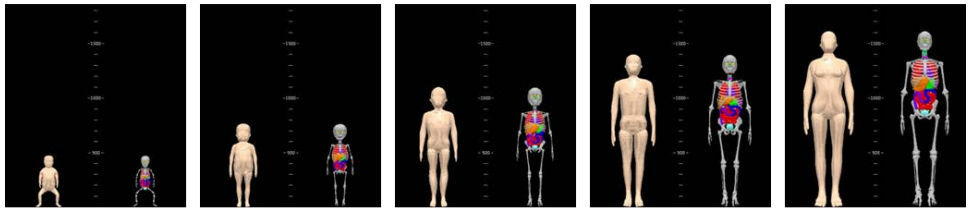
Adult male: thin(-2σ), standard, fat(+2σ and +5σ)



Adult female: thin(-2σ), standard, fat(+2σ and +5σ)



Child male: 0, 1, 5, 10, 15 years old



Child female: 0, 1, 5, 10, 15 years old

ref. 1) K. Sato, et al., Radiat. Prot. Dosim. Vol. 123, No. 3, 337-344, 2007.
2) C. Lee, et al., Phys. Med. Biol. 52, 3309-3333, 2007.
3) C Lee, D Lodwick, et al., Phys. Med. Biol. 55, 339-363, 2010.

Utilization of WAZA-ARIv2

WAZA-ARIv2 HP
https://waza-ari.nirs.qst.go.jp/

System Log-in

User Registration

- Multi-Platform
  PC, Tablet, Smart phone, etc.
- Language: Japanese or English
  (dependence of language setting of browser)

Main Menu

- Calculation of the X-ray CT exposures
- Calculation of dose with data in a csv file
- Register your conditions
- Register your user model
- History of your calculations
- Dose distributions
- Registration of the data of X-ray CT examinations
- Change the password

Dose calculation

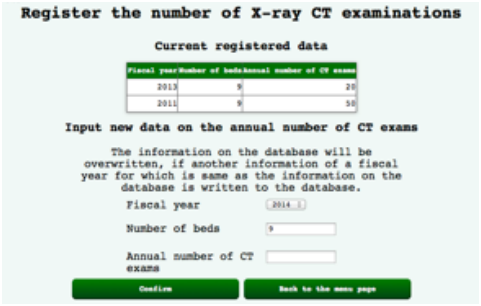
Optional function

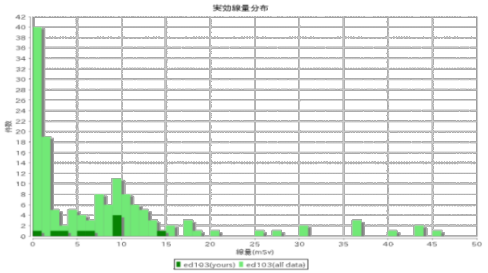
History of results

Dose distribution

User's facility Info.

password

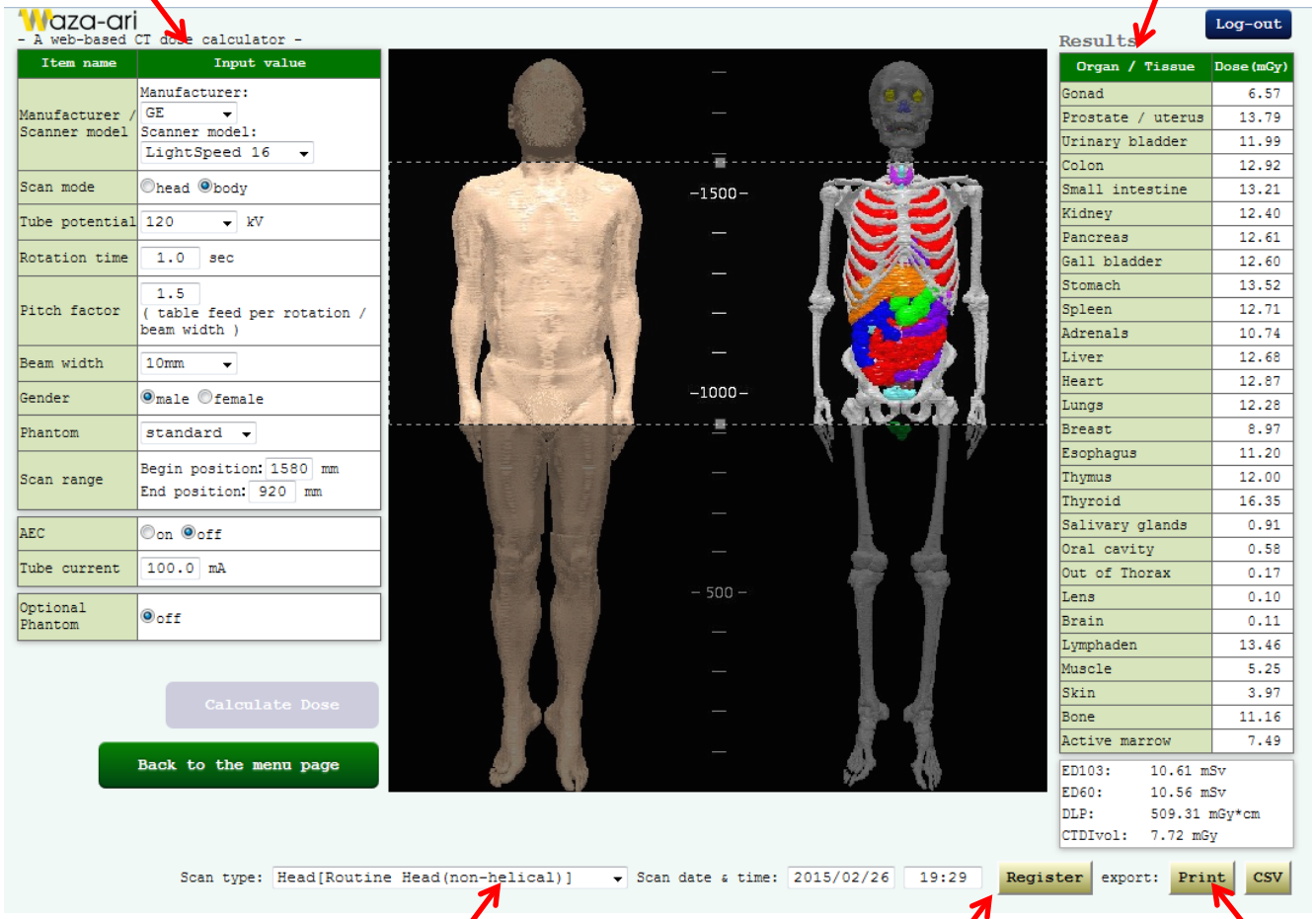




Dose Calculation Window

Exposure Condition Settings

Calculation Result of Organ Dose



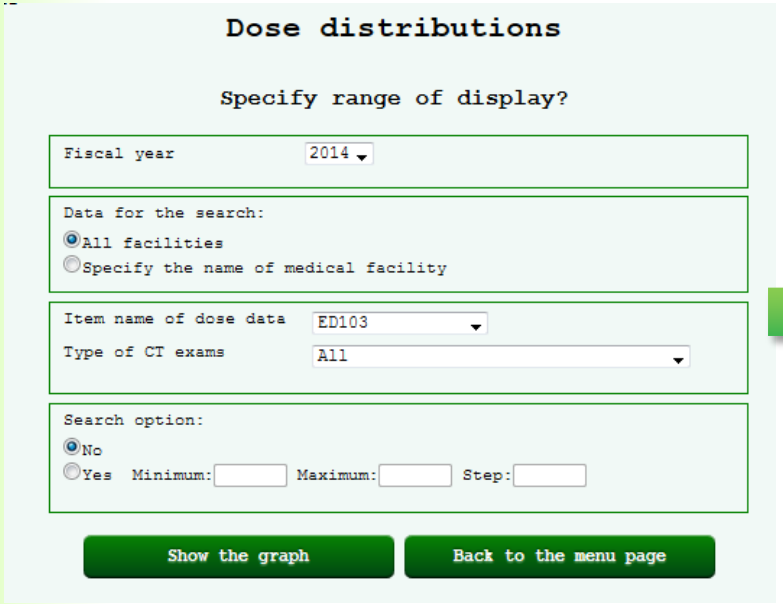
Scan Type and Scan date & time

Register

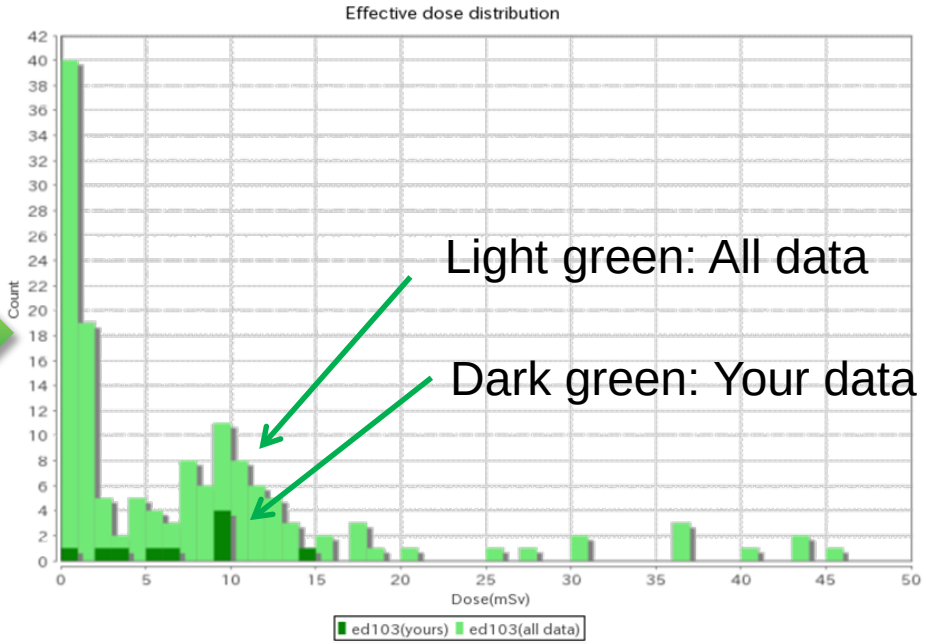
Result export (print or csv)

Dose Distributions

- Users can evaluate each data registered in the database.
- By this database function, users can see the whole dose distributions and check the exposure levels of X-ray CT examinations in their medical facilities.



search condition setting



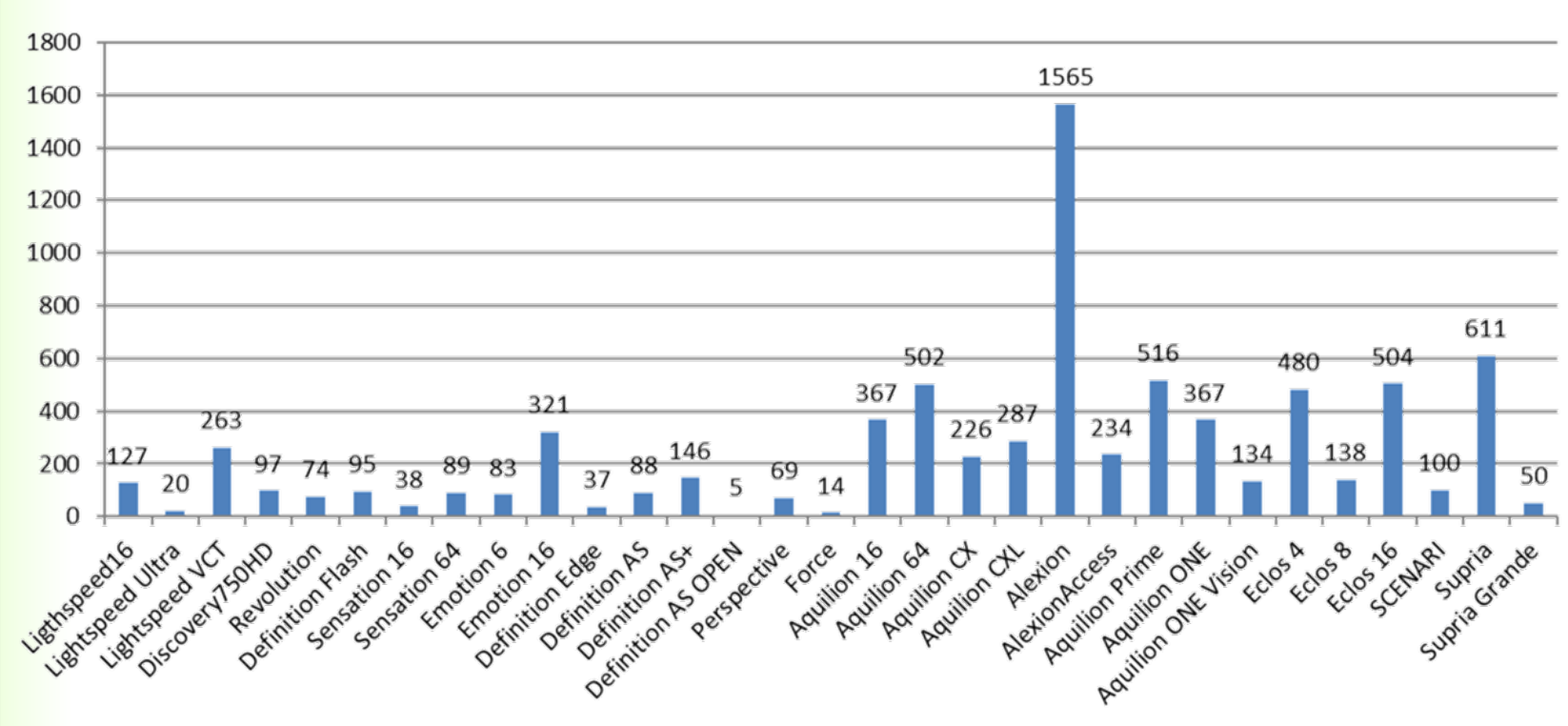
Selectable CT model / Tube voltage

Black: WAZA-ARI (v1), Red: WAZA-ARIv2 (Oct. 2017)

△: calculating or in preparation

Manufacturer	モデル名	80 kV	100/110 kV	120/130 kV	135/140 kV
GE	LightSpeed 16/Ultra	○	△	○	
	LightSpeed VCT	○		○	
	Discovery CT750HD	○	○	○	△
	Revolution	○	○	○	△
Siemens	Sensation 16	△		○	
	Sensation 64	○	△	○	△
	Emotion 6/16			○	-
	Perspective			○	
	Definition Flash/Edge/AS	○	○	○	
	Force	○	○	○	
Toshiba	Aquilion 16/64/CX/CXL	○	△	○	△
	Alexion -/Access Edition	○		○	
	Aquilion Prime	○	△	○	
	Aquilion ONE(TSX301)	○	△	○	△
Hitachi	Eclos 4/8/16	-	△	○	
	Scenaria	○	△	○	△
	Supria -/Advance/Grande/Grande Advance/Grande Premium	○	△	○	△

Japanese Share of selectable CT model in WAZA-ARI v2

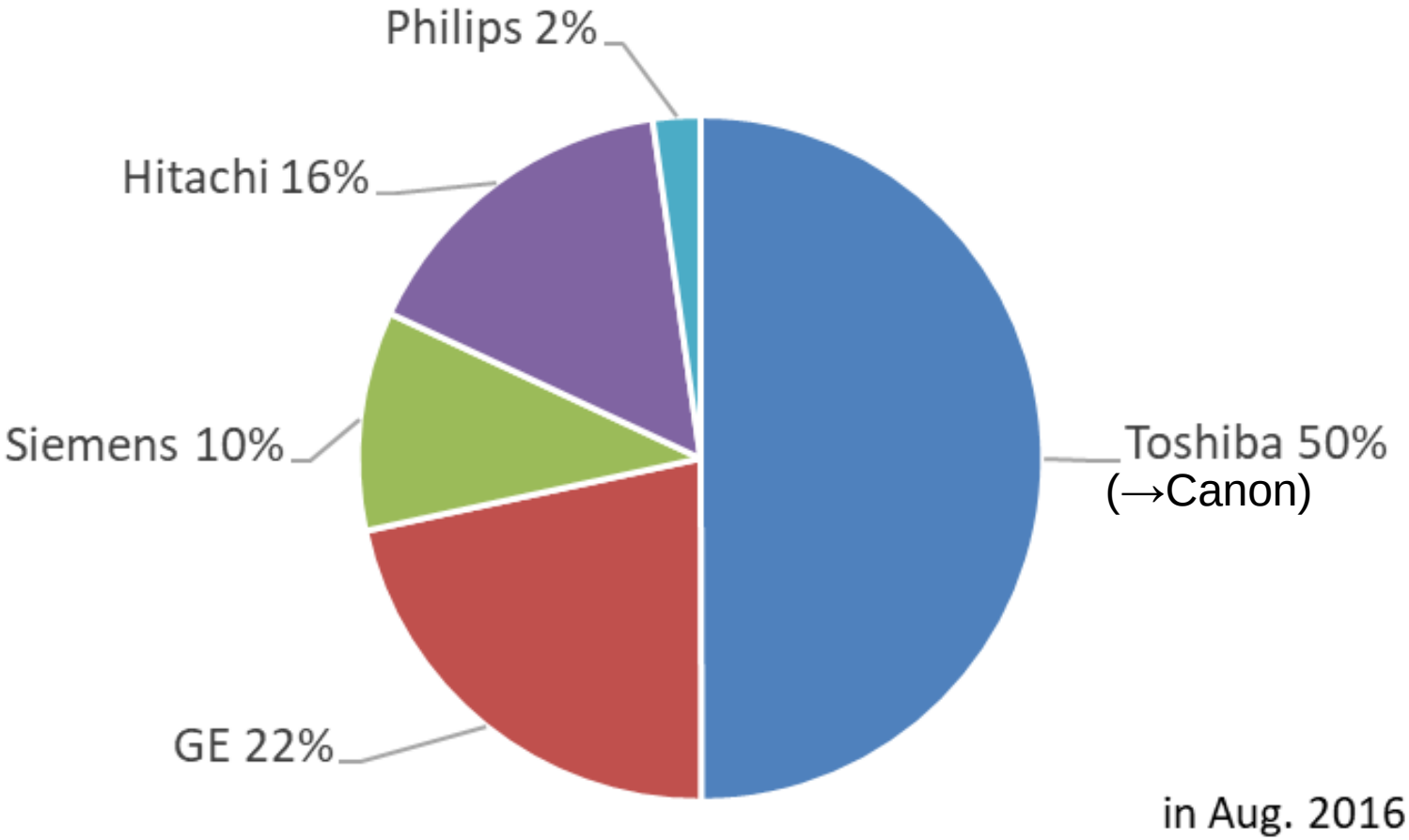


Number of each CT model installed in Japan

Total number of scanner installed in Japan: 12,826
Total number of each selectable model in WAZA-ARI: 7,647 (60%)

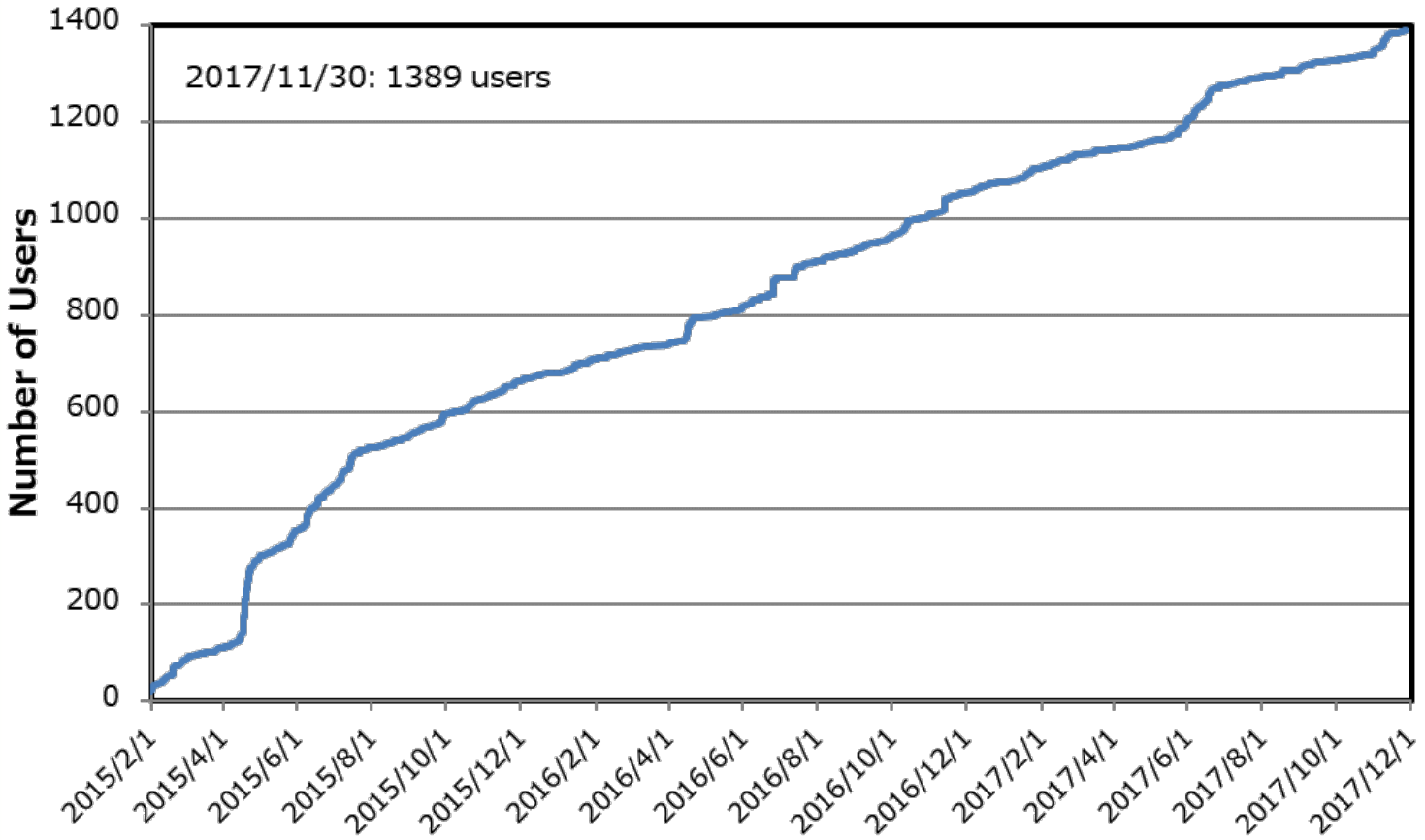
Ref. Data book of medical devices & systems (Japanese 医療機器システム白書) (at August 1. 2016)

CT scanner shares in Japan



Ref. Data book of medical devices & systems (Japanese 医療機器システム白書) (at August 1. 2016)

Number of Registered Users



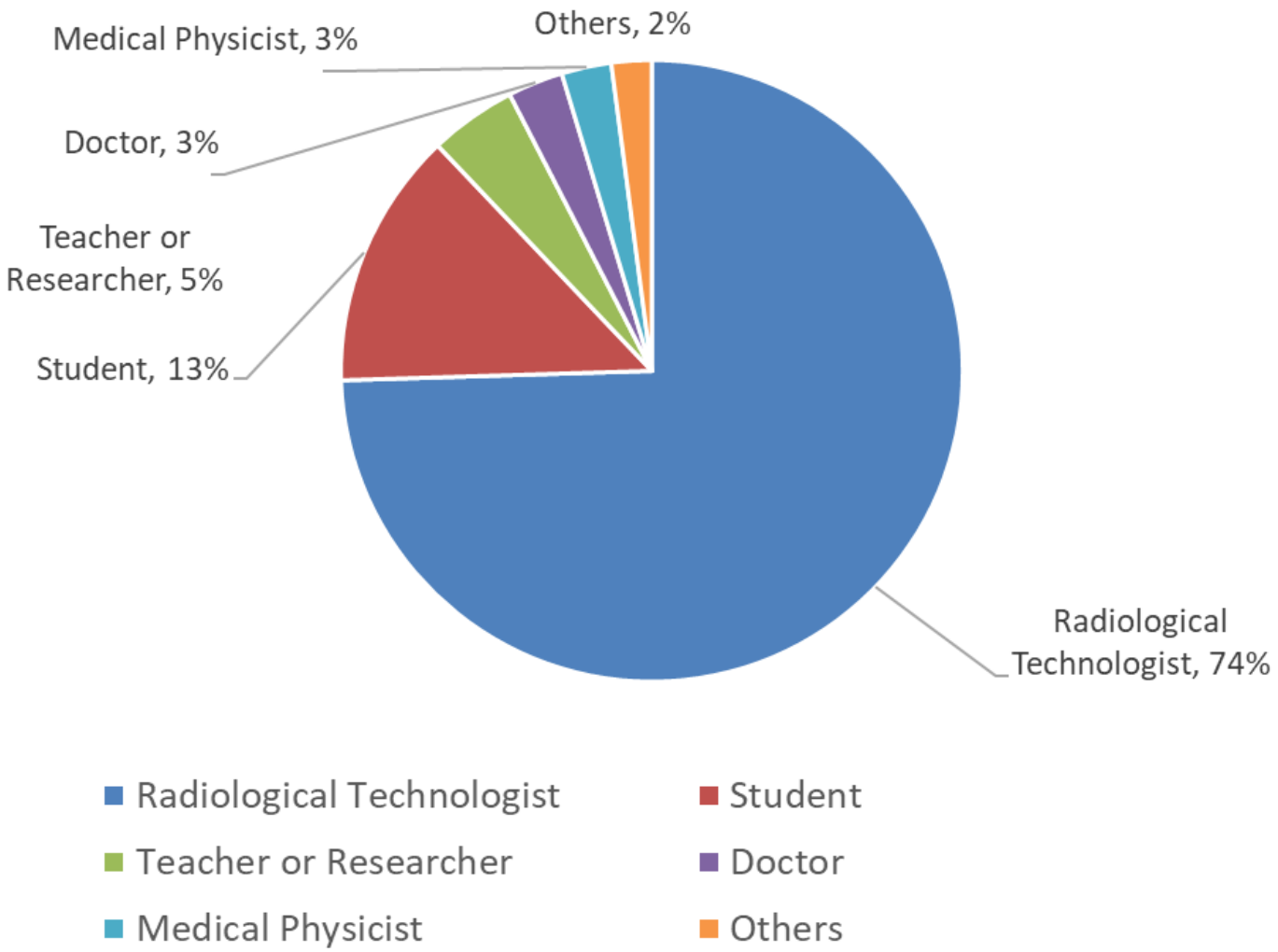
Registered Users : 1389 (Nov. 2017)

- Japanese 1359 users
- Others 30 users

Number of facilities: 881

Number of data: 12,159

Occupation of Users



Summary

- WAZA-ARIv2 was developed by researchers of Oita University of Nursing and Health Sciences, Japan Atomic Energy Agency and National Institute of Radiological Sciences.
- We added a database function of storing the calculation results in each facility for dose-distribution survey of CT exposure in Japan.
- In consideration of patient's age and body type, the child and thin/fat phantoms was used in dose calculation.
- In order to use WAZA-ARIv2 system, you access the WAZA-ARIv2 HP (https://waza-ari.nirs.qst.go.jp/), and need to register as a users.
- Currently over one thousand user are registered on WAZA-ARIv2 system.
- WAZA-ARIv2 system is useful for various research and education.