

CT dosimetric calculator

- Development of WAZA-ARIV2 system -

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3) Japan Atomic Energy Agency

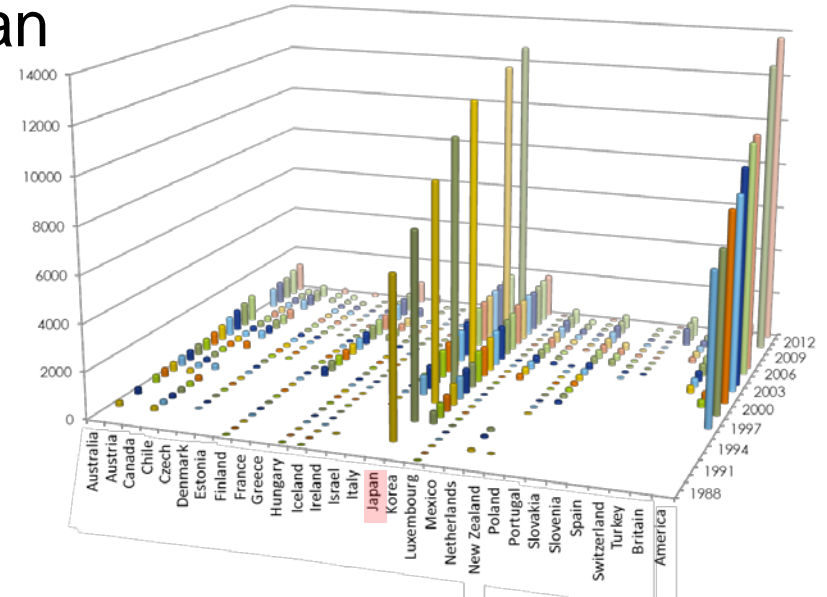
4) Oita University of Nursing and Health Sciences

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.

Waza-ari

CT撮影による被ばく線量を評価するWebシステム

開発経緯：CT撮影の条件に応じて患者の被ばく線量を迅速に評価し線量値を提供するWebシステム (WAZA-ARI) です。このシステムの開発は、公立大学法人大分県立看護科学大学と独立行政法人日本原子力研究開発機構の共同研究でスタートし、文部科学省研究費補助金（平成20年度-22年度）で開発が行われました。

CT撮影における被ばく線量を評価するWebシステムを開発
～医療現場での患者の線量管理に有益なシステムWAZA-ARI～

特徴

- ・利用者（医療機関）のPCからインターネットを通してWebアクセスし、利用可能
- ・ソフトウェアのインストール、メンテナンスの作業は不要
- ・Webブラウザで撮影条件や患者の情報を入力し、被ばく線量を迅速に計算
- ・日本人の平均的な体型を、年齢・性別・臓器の年齢・体格は今後の拡充予定!

操作 線量計算のフローチャート

1. インターフェイス画面を通して、撮影条件、患者の情報を入力
2. 管理サーバで被ばく線量を計算
3. 線量の計算結果はPC画面で確認

公開するWebシステムWAZA-ARI

CT撮影の機種 | 患者の情報 | 線量データベース

線量データベース

臓器の種類ごとに日本人成人男女、小児の被ばく線量データベース (管理サーバに構築)

被ばく線量の計算

計算結果のテーブル化

WAZA-ARI ver.1.0.0 (http://waza-ari.nirs.go.jp/waza-ari/) (平成24年12月1日より試験運用を開始)

試用版システム入口

*ブラウザのポップアップも、ツールバーを含めて、全て許可に設定してください。
*仮のコードとパスワードは次の通りです。次の画面で入力してください。

コード:waza
パスワード:ari

試用版の使用に際して

本システムは、多くの診療放射線技師の方に利用していただくために、試用版として公開し、さまざまなコメントをいただくことにしています。平成25年度からは、独立行政法人放射線医学総合研究所、独立行政法人日本原子力研究開発機構及び公立大学法人大分県立看護科学大学の共同研究により、本システムの運用方法を改善し、CT撮影による患者線量の統計情報を把握していくためのシステムに拡大していく予定です。

*計算の入力条件によっては、システムが対応していない場合もあります。
*仕様上、SiemensとHitachiの機種は、headは対応していません。bodyのみ選択して下さい。

コメントの送り先
waza-ari@nirs.go.jp

Homepage

Waza-ari

～ CT線量計算システム ～

コード

パスワード

ログイン

本システム「WAZA-ARI」は、X線CTの撮影条件を入力情報として患者の臓器線量および実効線量を計算するWebアプリケーションである。

Free login

計算条件

| 項目名 | 入力値 |
|----------|--------------|
| メーカー | Siemens |
| 機種 | Sensation 16 |
| スキャンモード | body |
| 管電圧 | 120 kV |
| 回転時間 | 1.0 sec |
| ビームピッチ | 1.5 |
| ビーム幅 | 16*0.75 |
| 性別 | 男 |
| 年齢 | 成人 |
| スキャン開始位置 | 1569 mm |
| スキャン終了位置 | 1200 mm |
| ABC | OFF |
| 管電流 | 100.0 mA |

計算結果

| 臓器・組織 | 平均線量 (mSv) | 臓器・組織 | 平均線量 (mSv) |
|-------|------------|-------|------------|
| 生殖腺 | 0.01 | 乳房 | 5.14 |
| 前立腺 | 0.05 | 食道 | 6.44 |
| 膀胱 | 0.05 | 腸線 | 7.01 |
| 結腸 | 1.65 | 甲状腺 | 9.21 |
| 小腸 | 1.08 | 肺線 | 0.44 |
| 腎臓 | 4.20 | 口腔粘膜 | 0.20 |
| 脾臓 | 5.89 | 胸郭外領域 | 0.08 |
| 胆嚢 | 6.02 | 眼 | 0.05 |
| 胃 | 6.00 | 脳 | 0.06 |
| 膵臓 | 6.52 | リンパ節 | 3.56 |
| 副腎 | 5.69 | 筋肉 | 1.52 |
| 肝臓 | 6.59 | 皮膚 | 1.27 |
| 心臓 | 7.47 | 骨 | 3.69 |
| 肺 | 6.92 | 赤色骨髄 | 2.39 |

実効線量相当 (ICRP103ベース) : 4.05 mSv
実効線量相当 (ICRP 60ベース) : 3.66 mSv
DLP: 203.26 mGy·cm
CTDIvol: 5.51 mSv

印刷

Calculation result

被験者の情報・撮影範囲

| | |
|---------|----------------------|
| メーカー・機種 | Siemens Sensation 16 |
| スキャンモード | body |
| 管電圧 | 120 kV |
| 回転時間 | 1.0 sec |
| ビームピッチ | 1.5 |
| ビーム幅 | 16*0.75 |

項目名 | **入力値**

性別 男 女

年齢

右の図の中をマウスでドラッグするか範囲を入力してください。

スキャン範囲
開始位置: 1569 mm
終了位置: 1200 mm

戻る **次へ**

Input condition

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

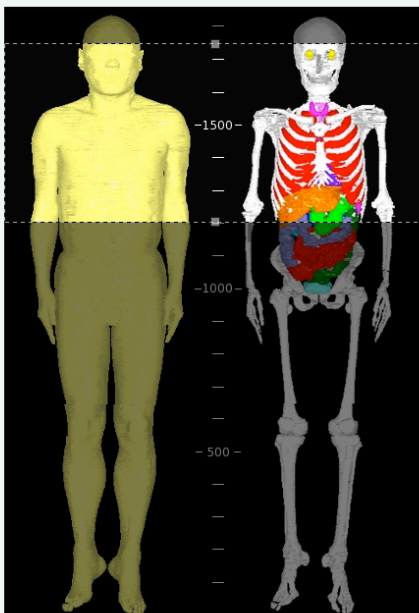
Selectable phantoms in WAZA-ARI

被験者の情報・撮影範囲

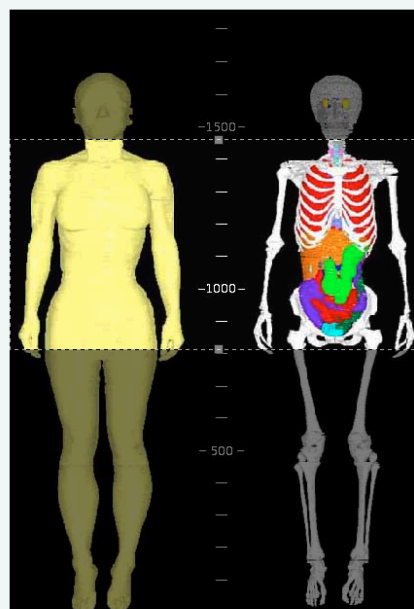
| | |
|---------|---------------------|
| メーカー・機種 | Roshiba Aquilion 64 |
| スキャンモード | body |
| 管電圧 | 120 kV |
| 回転時間 | 1.0 sec |
| ビームピッチ | 1.5 |
| ビーム幅 | 6mm |

| 項目名 | 入力値 |
|--------|---|
| 性別 | <input checked="" type="radio"/> 男 <input type="radio"/> 女 |
| 年齢 | 成人 |
| スキャン範囲 | 右の図の中をマウスでドラッグするか数値を入力してください。 開始位置: 1750 mm 終了位置: 1200 mm |

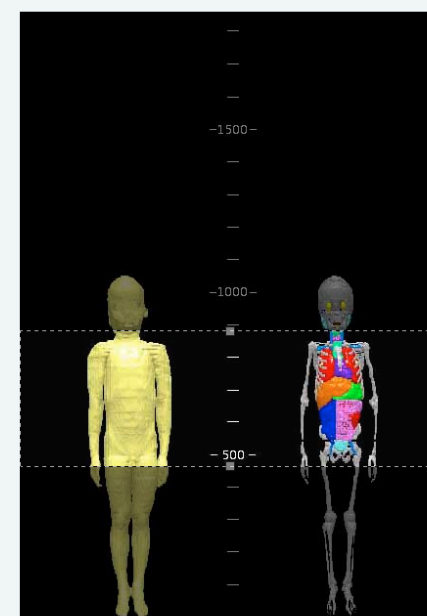
戻る 次へ



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-AR1v2

- 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 ?



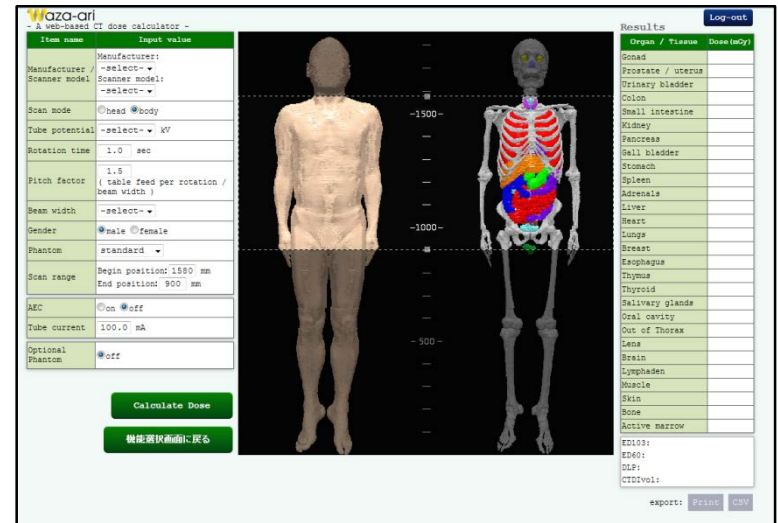
Dose calculation using children and thin/fat phantoms

- Increase selectable CT models and exposure condition

Development of WAZA-ARiv2

System open: Jan 30, 2015

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



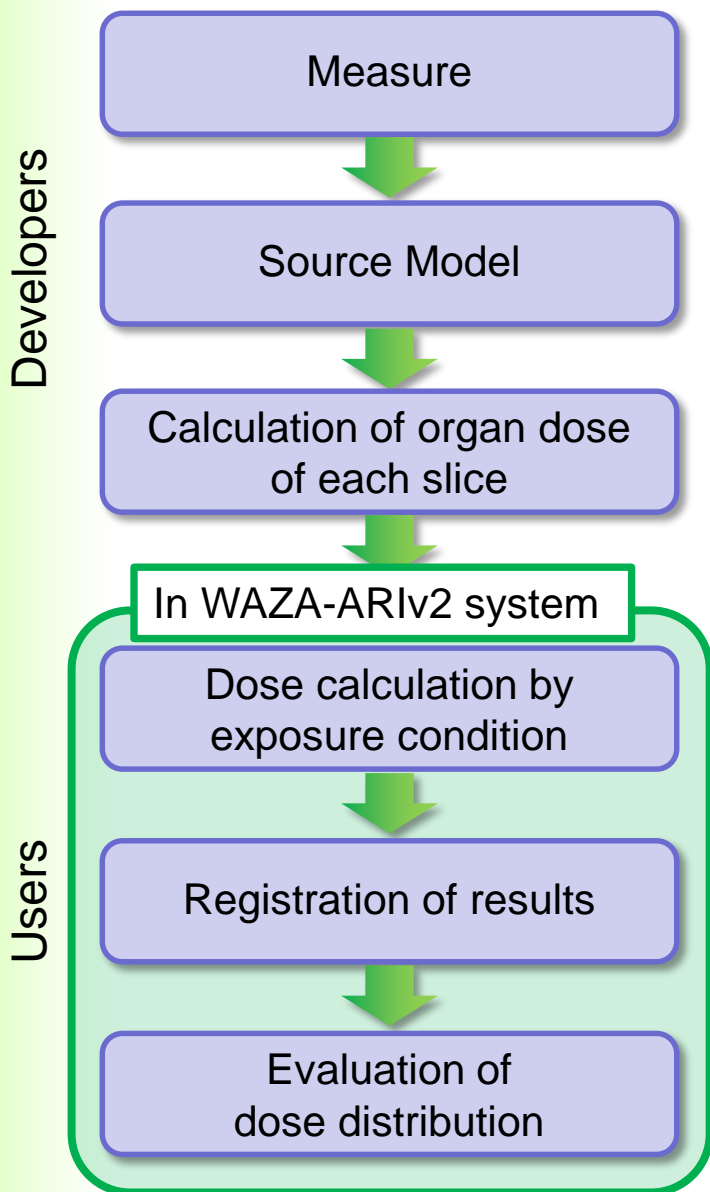
Features

- 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)

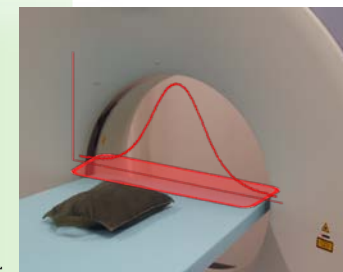
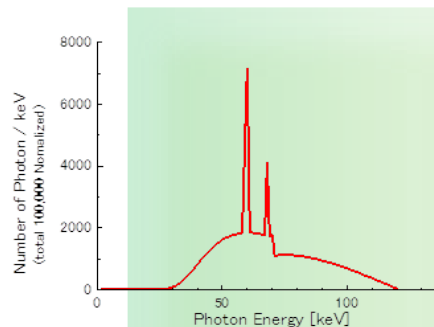
Comparison of CT exposure dose calculation tools

| | 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) |

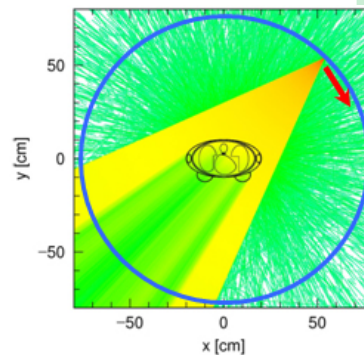
Dose-calculation procedure in WAZA-ARiv2



HVL

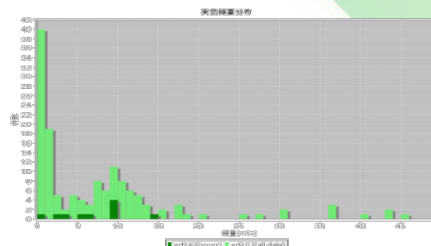


Lateral profile



Monte Carlo Calculation using PHITS

Setting of exposure condition in WAZA-ARiv2 system



Statistics information of registered data in WAZA-ARiv2 server

Voxel Phantoms

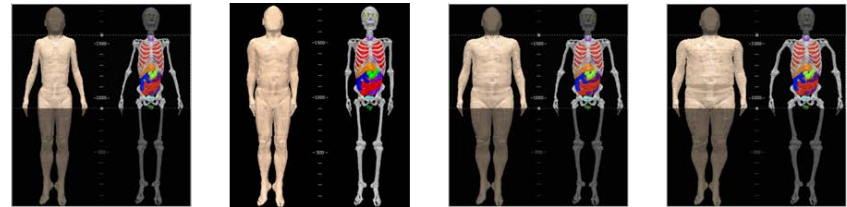
- Adult phantoms¹⁾
 - developed by JAEA
 - 4 types

- Thin type(-2 σ)
- Standard type
- Fat type(+2 σ)
- Fat type(+5 σ)

* σ : standard deviation based on statistics data in Japan

- Child phantoms^{2,3)}

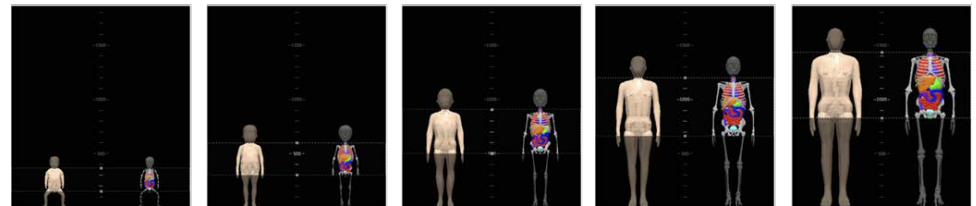
- developed by University of Florida
- 5 types
 - 0, 1, 5, 10, 15 years old



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



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



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



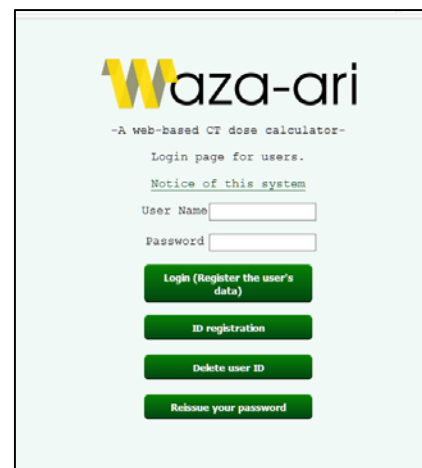
Child female: 0, 1, 5, 10, 15 years old

- 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

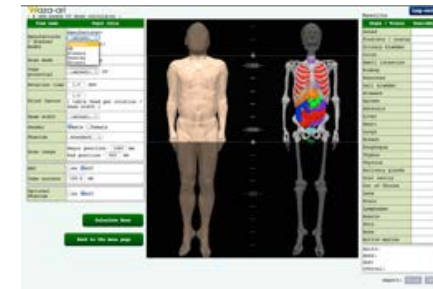
Optional function

History of results

Dose distribution

User's facility Info.

password



History of your calculations

| Calculation ID | Calculation Name | Calculation Date | Calculation Status | Calculation Type | Calculation Method | Calculation Result | Calculation Error | Calculation Time | Calculation User |
|----------------|---|------------------|--------------------|------------------|--------------------|--------------------|-------------------|------------------|------------------|
| 1 | Calculation of the X-ray CT exposures | 2014-12-01 | Success | Normal | Normal | 10.0 | 0.0 | 10.0 | admin |
| 2 | Calculation of dose with data in a csv file | 2014-12-02 | Success | Normal | Normal | 20.0 | 0.0 | 20.0 | admin |

Dose distributions

Specify range of display?

Fiscal year: 2014

Date for the search: All facilities

Name of medical facility: Specify the name of medical facility

Time range of dose data: 2013

Type of CT exams: All

Search options: All, Yes, Minimum, Maximum, Range

Show the graph Back to the menu page

Register the number of X-ray CT examinations

Current registered data

| Fiscal year | Number of beds | Number of CT exams |
|-------------|----------------|--------------------|
| 2013 | 9 | 20 |
| 2011 | 9 | 30 |

Input new data on the annual number of CT exams

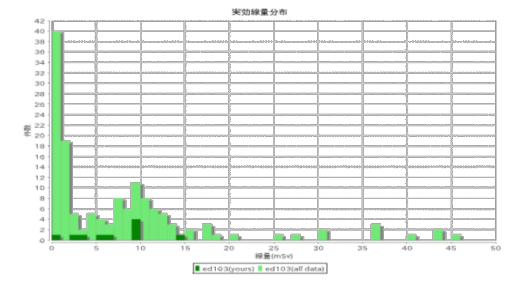
The information on the database will be overwritten, if another information of a fiscal year for which is same as the information on the database is written to the database.

Fiscal year: 2014

Number of beds: 9

Annual number of CT exams:

Confirm Back to the menu page



Change the password

Enter your current password:

Enter your new password:

Enter your new password (Re-enter):

Eight or more characters available.

Change the password Back to the menu page

Dose Calculation Window

Exposure Condition Settings

Calculation Result of Organ Dose

Waza-ari
- A web-based CT dose calculator -

| Item name | Input value |
|------------------------------|--|
| Manufacturer / Scanner model | Manufacturer: GE Scanner model: LightSpeed 16 |
| Scan mode | <input type="radio"/> head <input checked="" type="radio"/> body |
| Tube potential | 120 kV |
| Rotation time | 1.0 sec |
| Pitch factor | 1.5 (table feed per rotation / beam width) |
| Beam width | 10mm |
| Gender | <input checked="" type="radio"/> male <input type="radio"/> female |
| Phantom | standard |
| Scan range | Begin position: 1580 mm End position: 920 mm |
| AEC | <input type="radio"/> on <input checked="" type="radio"/> off |
| Tube current | 100.0 mA |
| Optional Phantom | <input checked="" type="radio"/> off |

Calculate Dose

Back to the menu page

Scan type: Head[Routine Head(non-helical)] Scan date & time: 2015/02/26 19:29 Register export: Print CSV

| Organ / Tissue | Dose (mGy) |
|-------------------|------------|
| Gonad | 6.57 |
| Prostate / uterus | 13.79 |
| Urinary bladder | 11.99 |
| Colon | 12.92 |
| Small intestine | 13.21 |
| Kidney | 12.40 |
| Pancreas | 12.61 |
| Gall bladder | 12.60 |
| Stomach | 13.52 |
| Spleen | 12.71 |
| Adrenals | 10.74 |
| Liver | 12.68 |
| Heart | 12.87 |
| Lungs | 12.28 |
| Breast | 8.97 |
| Esophagus | 11.20 |
| Thymus | 12.00 |
| Thyroid | 16.35 |
| Salivary glands | 0.91 |
| Oral cavity | 0.58 |
| Out of Thorax | 0.17 |
| Lens | 0.10 |
| Brain | 0.11 |
| Lymphaden | 13.46 |
| Muscle | 5.25 |
| Skin | 3.97 |
| Bone | 11.16 |
| Active marrow | 7.49 |

ED103: 10.61 mSv
ED60: 10.56 mSv
DLP: 509.31 mGy*cm
CTDIvol: 7.72 mGy

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.

Dose distributions

Specify range of display?

Fiscal year:

Data for the search:
 All facilities
 Specify the name of medical facility

Item name of dose data:

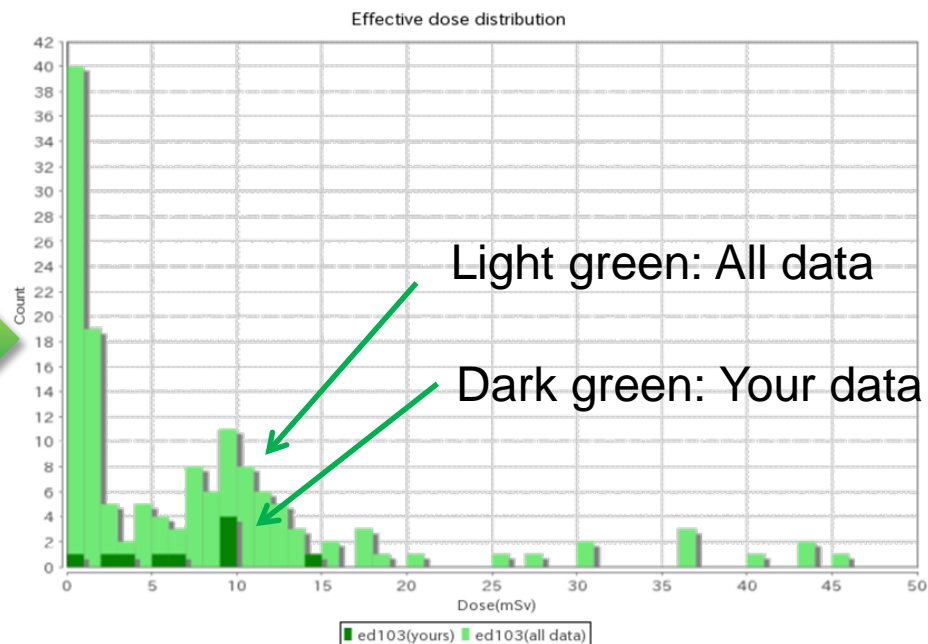
Type of CT exams:

Search option:
 No
 Yes Minimum: Maximum: Step:

Show the graph

Back to the menu page

search condition setting



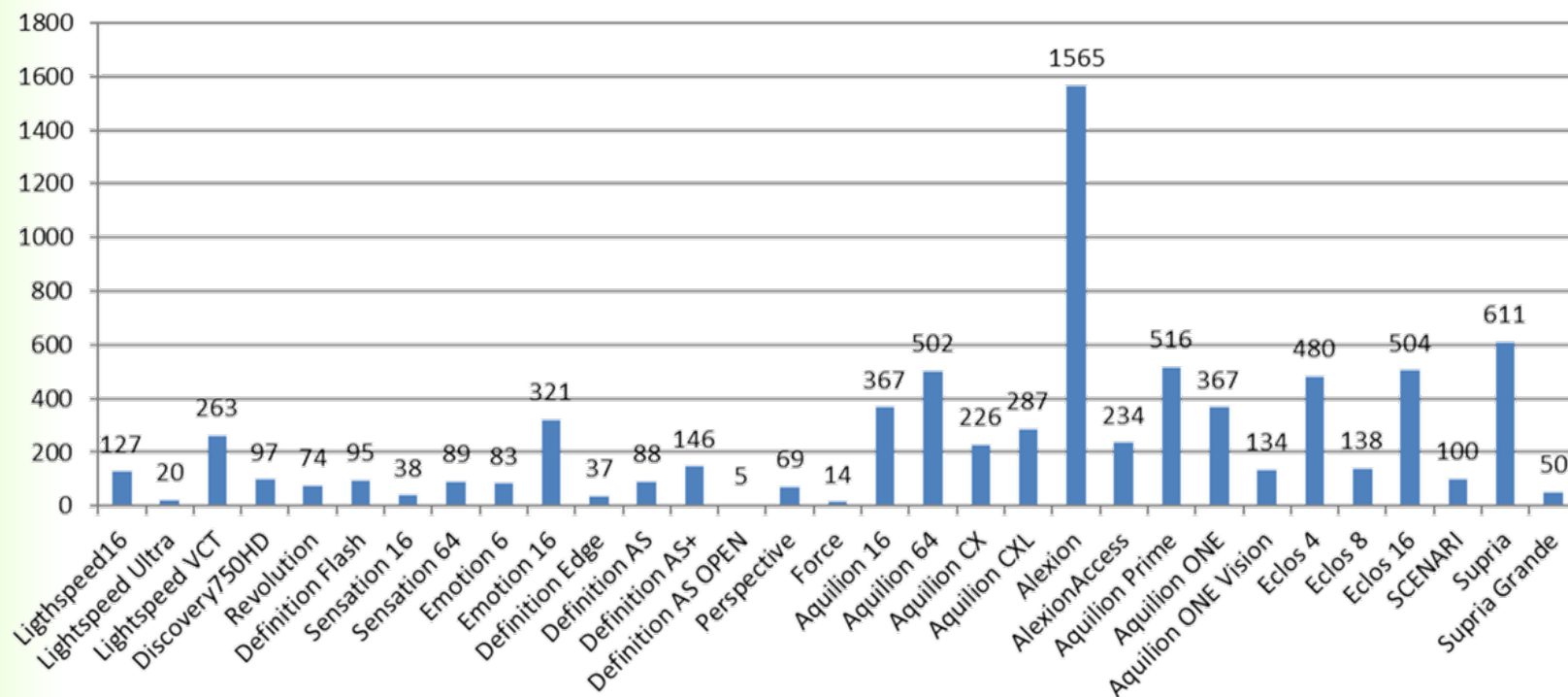
Selectable CT model / Tube voltage

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



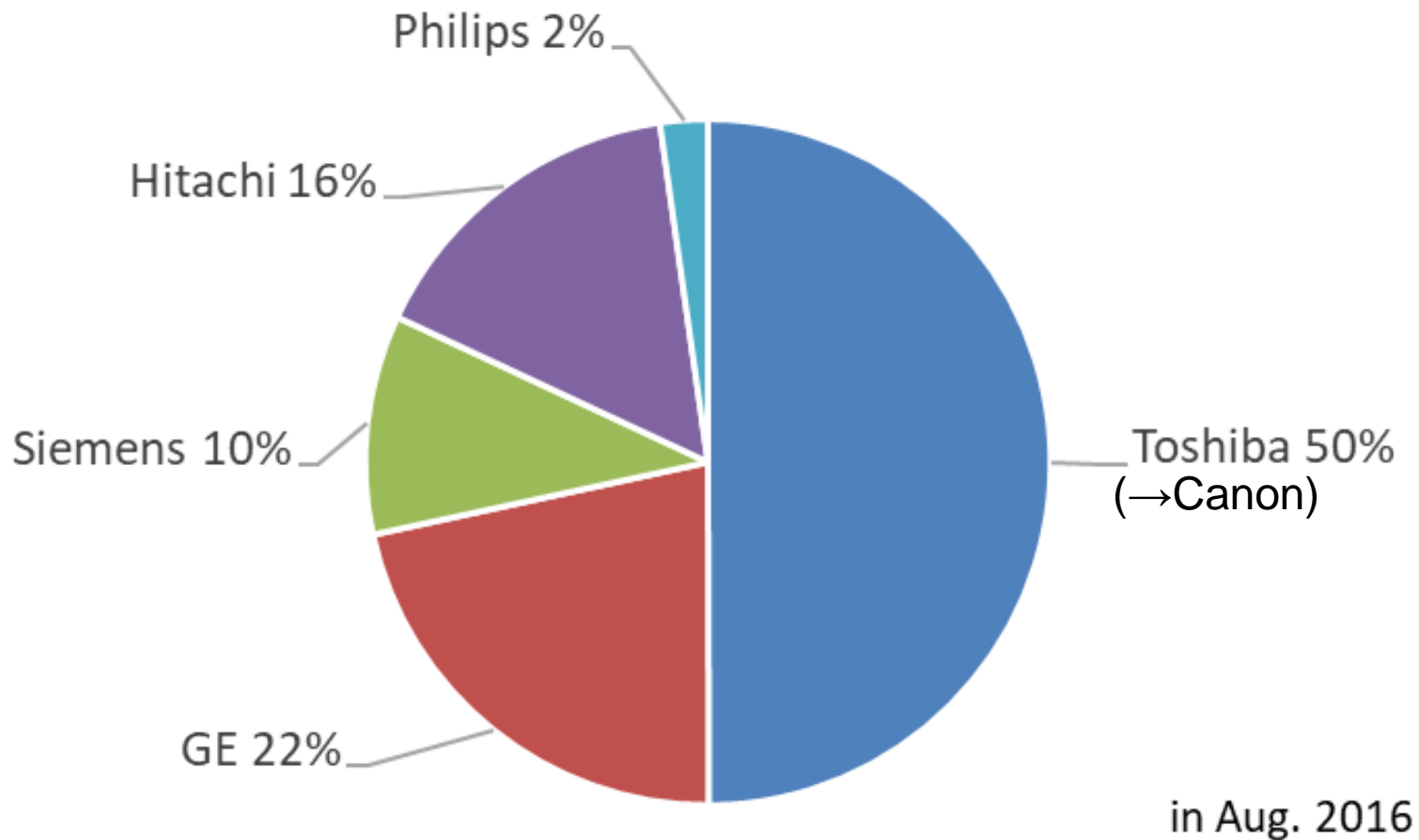
Number of each CT model installed in Japan



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

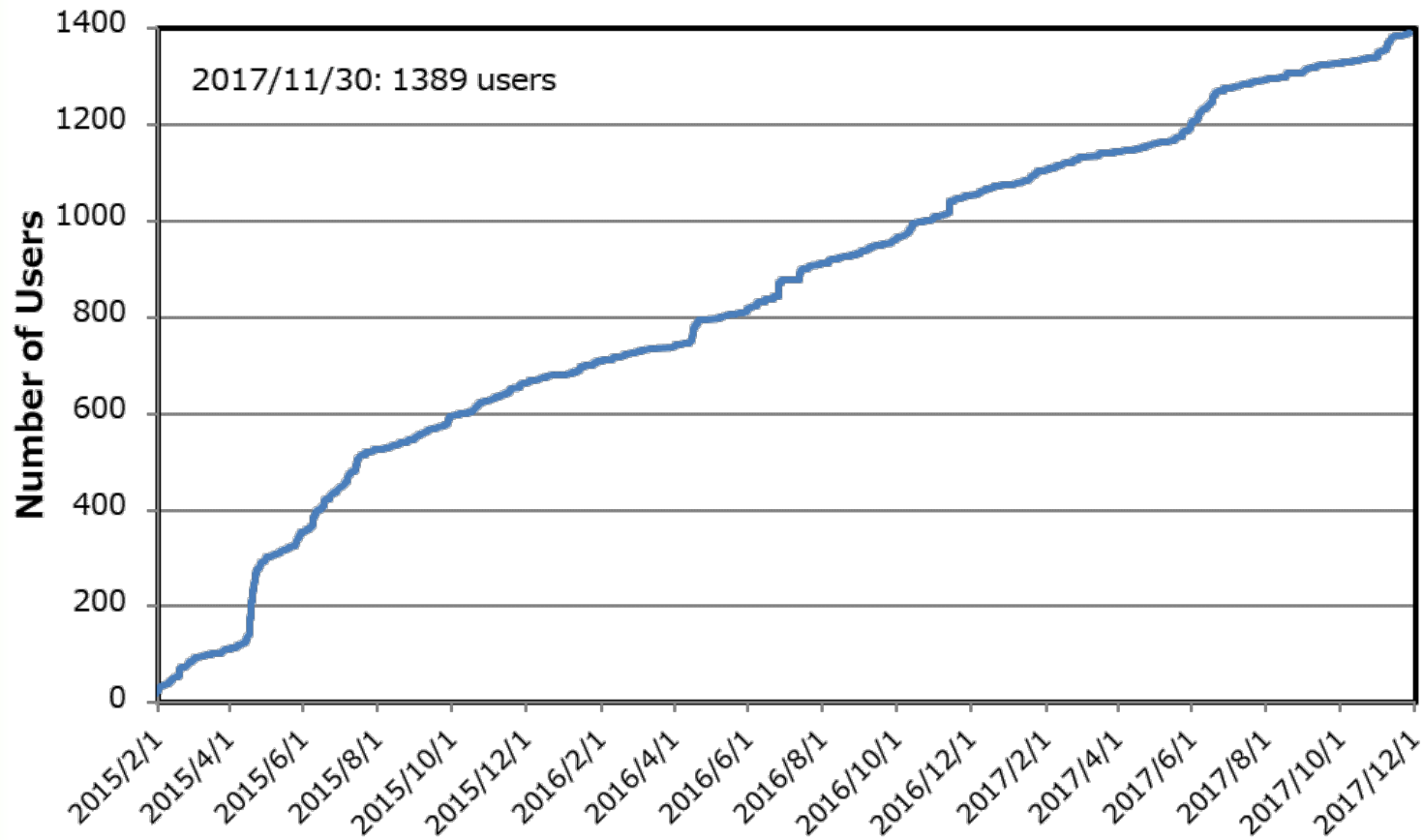
Ref. Data book of medical devices & systems (Japanese 医療機器システム白書) (at August 1. 2016)

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



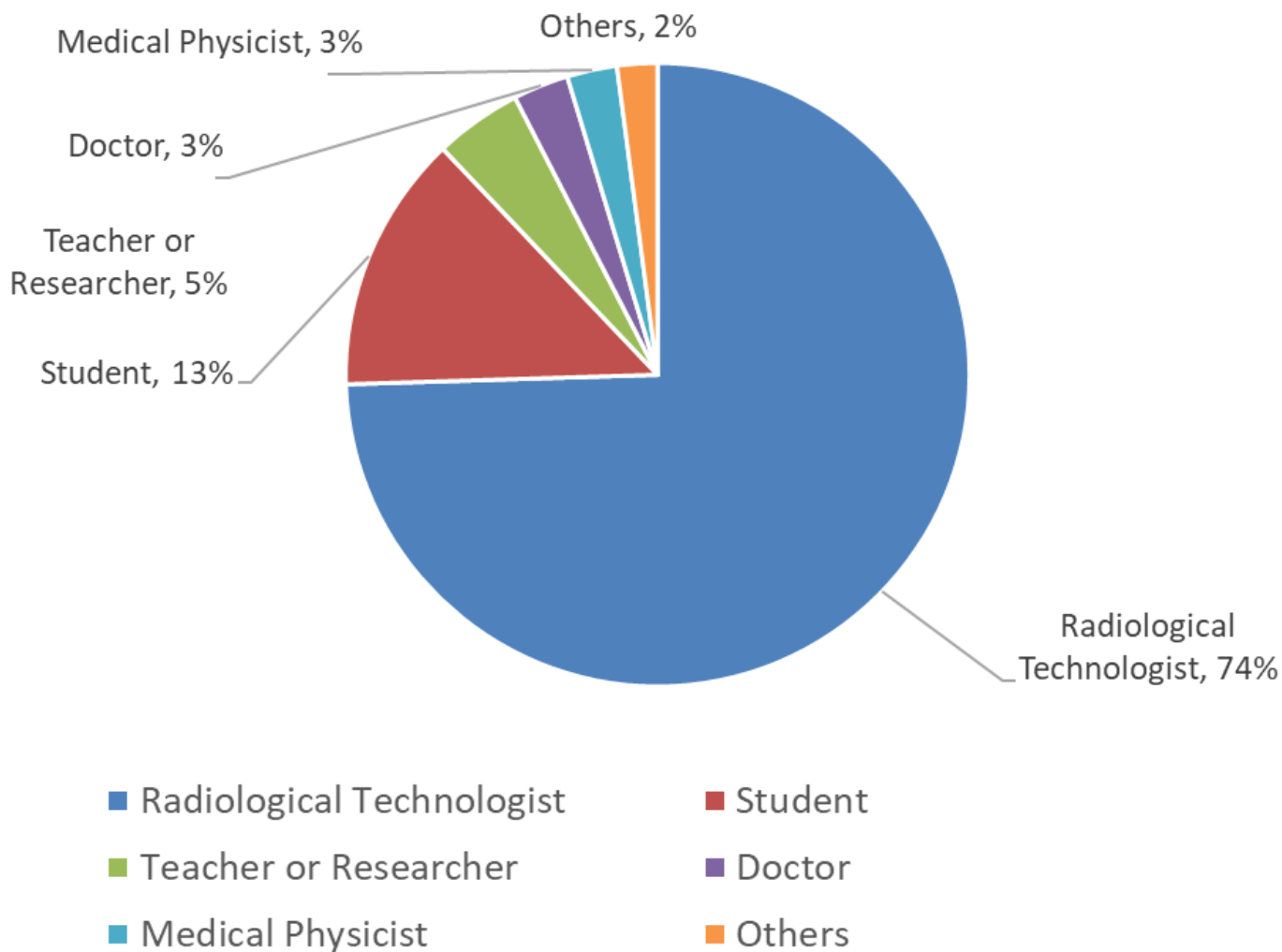
Registered Users : 1389 (Nov. 2017)

- Japanese 1359 users
- Others 30 users

Number of facilities: 881

Number of data: 12,159

Occupation of Users



Summary

- WAZA-ARlv2 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-ARlv2 system, you access the WAZA-ARlv2 HP (<https://waza-ari.nirs.qst.go.jp/>), and need to register as a users.
- Currently over one thousand user are registered on WAZA-ARlv2 system.
- WAZA-ARlv2 system is useful for various research and education.