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NOTE

# Trends and evolution in computed tomography radiation dose from 2018 and 2023: a Swiss perspective of the medical radiation exposure*

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## Abstract

This study analysed computed tomography (CT) radiation dose trends in Switzerland from 2018 and 2023 with the aim to update the CT dose estimation for the 2023 national survey on radiation exposure of the Swiss population. Data from eight major healthcare providers, including all five Swiss university hospitals, were collected for nine key anatomical regions. The analysis showed large variability in dose length product changes, ranging from −55% to +30.2% across anatomical regions and providers. Most regions exhibited dose reductions, with the largest decreases in the *hip* (−15.4%) and *pelvis* (−11.4%), whereas the *spine* showed the greatest dose increase (+6.6%). The statistical analysis revealed no significant differences between university hospitals and other healthcare providers.

## 1. Introduction

Computed tomography (CT) is indispensable in modern medicine and provides detailed information that aids diagnosis and patient treatment. Despite its clinical benefits, CT carries health risks owing to the use of ionizing radiation [1, 2]. In 2018, CT examinations in Switzerland accounted for only 11% of all diagnostic procedures but contributed 64% of the total diagnostic radiation dose [3].

Monitoring the radiation exposure of the population caused by imaging procedures, such as CT, is a legal obligation in Switzerland [4] and in the EU [5]. Therefore, surveys of medical radiation exposure of the Swiss population have been performed regularly since 1998 (www.bag.admin.ch/str-monitoring). The aim is to determine the contributions of various x-ray applications (radiography, mammography, dental x-ray imaging, CT, fluoroscopy, and nuclear medicine imaging) to the effective dose per inhabitant. For this purpose, the frequencies are recorded for all examinations and applications and the effective doses are estimated. Thus, emerging changes and trends can be identified at an early stage. The most recent complete survey in Switzerland was conducted for the activity of the year 2018 [3].

This study aimed to analyse the development of CT doses from 2018 and 2023 for different anatomical regions across various healthcare providers in Switzerland. The results are an integral part of the update of the CT dose estimation for the 2023 survey of medical radiation exposure of the Swiss population. The results will also be used to assess the effectiveness of the implemented measures to optimize radiation exposure over time and to evaluate their impact on patient safety.

[*] Five-year analysis of CT dose variations across Switzerland.

**Table 1.** Number of scanners and name of manufacturers included in the study.

| | Provider A | Provider B | Provider C | Provider D | Provider E | Provider F | Provider G | Provider H |
|---|---|---|---|---|---|---|---|---|
| Number of scanners | 3[a] | 1 | — | ⩾4 | 4 | 3[b] | 4 | 4 |
| Manufacturers | GE, Canon | Siemens | — | Siemens | Siemens | Siemens | Siemens | Canon |

[a] During the observation period from 2018 and 2023: one scanner was replaced, two scanners were upgraded with AI capability.
[b] During the observation period from 2018 and 2023: two scanners were replaced.

## 2. Methods

### 2.1. Data collection

To gather comprehensive data on CT dose, medical physicists from eight major healthcare providers participated in data collection. These providers included all five Swiss university hospitals, one large private group (comprising several hospitals and radiology institutes), and two cantonal hospitals.

Each provider was requested to submit the median of the dose length products (DLP) of at least 50 examinations for each of the following anatomical regions: *chest and abdomen combined; upper abdomen and entire abdomen; spine; pelvis; chest, neurocranium; hip; neck* and *skull and sinuses* for the same months in the years 2018 and 2023.

If fewer than 20 examinations of an anatomical region were collected, data were excluded from the analysis. If a provider submitted data for different clinical indications of a specific anatomical region [6], the mean DLP value of these clinical indications was calculated.

Table 1 provides an overview of the number of scanners and manufacturers included in this study (provider C did not share this information). For the provider that submitted median DLP for more than one scanner, the mean value of all median DLP was calculated.

### 2.2. Data analysis

The change in DLP from 2018 and 2023, expressed as $\Delta$DLP, for each anatomical region was calculated from the data received by each provider $p$ as follows:

$$\Delta\mathrm{DLP}\,(p) = \frac{\mathrm{median\,DLP}(p)_{2023} - \mathrm{median\,DLP}(p)_{2018}}{\mathrm{median\,DLP}(p)_{2018}}.$$

A negative $\Delta$DLP indicates that the dose decreased between 2018 and 2023, and a positive $\Delta$DLP indicates that the dose increased (table 2).

The overall DLP change in an anatomical region was obtained by calculating the mean of all $\Delta\mathrm{DLP}(p)$ in this region (figure 1).

The effective dose per anatomical region from the 2018 survey [3] was multiplied by the corresponding overall DLP change to obtain the effective dose for 2023 (table 3). For anatomical regions that were not included in this survey, the effective dose from the 2018 survey was retained without any changes.

### 2.3. Statistical analysis

To determine whether there was a statistically significant difference regarding the practices and the development of the CT dose between the five university hospitals and the other three healthcare providers, a Mann–Whitney U test was conducted for each anatomical region. The Mann–Whitney U test was chosen because it is a non-parametric test that does not assume normal data distribution and can handle unequal sample sizes between the two groups.

For each region, the null hypothesis states that there is no significant difference between the distribution of changes for university hospitals and other healthcare providers. A significance level of 0.05 was used to determine if the results were statistically significant.

## 3. Results

The median DLP and $\Delta$DLP values for each anatomical region are summarized in table 2. The analysis revealed a large variability, ranging from −55% to 30.2% in the evolution of median DLP values across different anatomical regions and healthcare providers. Most anatomical regions showed an overall decrease in dose, whereas a few others showed an increase.

**Table 2.** CT dose from 2018 and 2023 per anatomical region. A negative ΔDLP indicates that the dose has decreased between 2018 and 2023, a positive ΔDLP indicates that the dose has increased; empty rows mean there were less than 20 examination records available; values in italic are calculated from different clinical indications.

| | Provider A | | Provider B | | Provider C | | Provider D | | Provider E | | Provider F | | Provider G | | Provider H | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2018 | 2023 | 2018 | 2023 | 2018 | 2023 | 2018 | 2023 | 2018 | 2023 | 2018 | 2023 | 2018 | 2023 | 2018 | 2023 |
| Chest and abdomen combined | | | | | | | | | | | | | | | | |
| DLP (mGy·cm) | 827 | 815 | 541 | 570 | 621 | 510 | | | | | 676 | 609 | | | | |
| ΔDLP | | −1.5% | | 5.4% | | −17.9% | | | | | | −9.8% | | | | |
| Upper abdomen and entire abdomen | | | | | | | | | | | | | | | | |
| DLP (mGy·cm) | 631 | 525 | 344 | 389 | *1700* | 1022 | | | *83* | *97* | 534 | 439 | *257* | *295* | *190* | *176* |
| ΔDLP | | −16.8% | | 13.1% | | *−39.9%* | | | | *15.8%* | | −17.9% | | *14.7%* | | *−7.2%* |
| Liver (one phase) | | | | | | | | | | | | | | | | |
| DLP (mGy·cm) | | | | | | | | | 92 | 117 | | | | | | |
| Liver (multiple phases) | | | | | | | | | | | | | | | | |
| DLP (mGy·cm) | | | | | 1700 | 1022 | | | | | | | 207 | 224 | | |
| Exclusion kidney stones | | | | | | | | | | | | | | | | |
| DLP (mGy·cm) | | | | | | | | | 75 | 76 | | | 307 | 365 | 190 | 176 |
| Spine | | | | | | | | | | | | | | | | |
| DLP (mGy·cm) | *541* | *505* | *363* | *421* | 890 | 820 | *316* | *389* | *234* | *199* | 407 | 530 | *353* | *394* | *477* | *483* |
| ΔDLP | | *−6.8%* | | *15.9%* | | −7.9% | | *23.1%* | | *−15.1%* | | 30.2% | | *11.8%* | | *1.1%* |
| Cervical spine | | | | | | | | | | | | | | | | |
| DLP (mGy·cm) | | | | | | | 258 | 290 | 234 | 199 | | | 313 | 318 | 340 | 325 |
| Thoracic spine, Lumbar spine | | | | | | | | | | | | | | | | |
| DLP (mGy·cm) | 541 | 505 | 363 | 421 | | | 373 | 487 | | | | | 393 | 471 | 615 | 640 |
| Pelvis | | | | | | | | | | | | | | | | |
| DLP (mGy·cm) | 442 | 357 | 212 | 230 | 361 | 300 | | | | | 303 | 250 | | | | |
| ΔDLP | | −19.2% | | 8.3% | | −16.9% | | | | | | −17.8% | | | | |
| Chest | | | | | | | | | | | | | | | | |
| DLP (mGy·cm) | *284* | *216* | 179 | 179 | 371 | 167 | 179 | *185* | *156* | *170* | 116 | 132 | *233* | *239* | *133* | *128* |
| ΔDLP | | *−23.9%* | | −0.2% | | −55.0% | | *3.6%* | | *9.0%* | | 14.2% | | *2.4%* | | *−3.4%* |
| Chest | | | | | | | | | | | | | | | | |
| DLP (mGy·cm) | 190 | 191 | | | | | 165 | 160 | 106 | 107 | | | 187 | 158 | 133 | 128 |

(Continued.)

**Table 2.** (Continued.)

| | Provider A | | Provider B | | Provider C | | Provider D | | Provider E | | Provider F | | Provider G | | Provider H | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2018 | 2023 | 2018 | 2023 | 2018 | 2023 | 2018 | 2023 | 2018 | 2023 | 2018 | 2023 | 2018 | 2023 | 2018 | 2023 |
| Exclusion PE (pulmonary embolism) | | | | | | | | | | | | | | | | |
| DLP (mGy·cm) | 378 | 241 | | | | | 192 | 210 | | | | | 184 | 178 | | |
| Angiography carotis | | | | | | | | | | | | | | | | |
| DLP (mGy·cm) | | | | | | | | | 207 | 234 | | | 329 | 382 | | |
| Neurocranium | | | | | | | | | | | | | | | | |
| DLP (mGy·cm) | 726 | 649 | | | 711 | 840 | 683 | 646 | 699 | 706 | 710 | 683 | 851 | 817 | 815 | 935 |
| ΔDLP | | −10.6% | | | | 18.1% | | −5.4% | | 1.1% | | −3.8% | | −4.1% | | 14.8% |
| Hip | | | | | | | | | | | | | | | | |
| DLP (mGy·cm) | 768 | 635 | | | 472 | 354 | | | | | 710 | 683 | | | | |
| ΔDLP (%) | | −17.4% | | | | −25.0% | | | | | | −3.8% | | | | |
| Neck | | | | | | | | | | | | | | | | |
| DLP (mGy·cm) | 307 | 326 | 309 | 290 | 329 | 426 | | | 152 | 146 | 270 | 172 | 211 | 230 | 404 | 367 |
| ΔDLP (%) | | 6.5% | | −6.2% | | 29.5% | | | | −3.9% | | −36.3% | | 8.8% | | −9.1% |
| Skull and sinuses | | | | | | | | | | | | | | | | |
| DLP 2018 | 191 | 106 | | | 479 | 514 | *100* | *80* | | | 188 | 175 | *193* | *163* | *108* | *117* |
| ΔDLP (%) | | −44.6% | | | | *7.3%* | | *−20.0%* | | | | −7.3% | | *−15.7%* | | *7.5%* |
| Face-Skull and sinuses | | | | | | | | | | | | | | | | |
| DLP (mGy·cm) | | | | | | | | | | | | | 269 | 236 | 143 | 145 |
| Low-dose sinuses (sinusitis) | | | | | | | | | | | | | | | | |
| DLP (mGy·cm) | | | | | | | 100 | 80 | | | | | 118 | 90 | 74 | 89 |

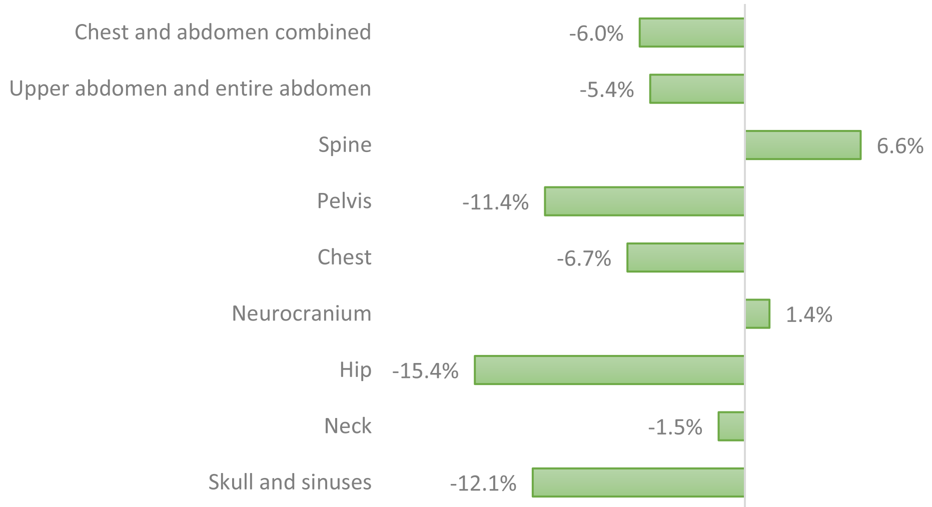


**Figure 1.** Overall DLP change between 2018 and 2023.

**Table 3.** CT dose in 2018 and 2023.

| | Effective dose 2018 (mSv) | Overall DLP change between 2018 and 2023 (%) | Effective dose 2023 (mSv) |
|---|---|---|---|
| Chest and abdomen combined | 12.1 | −6.0% | 11.4 |
| Upper abdomen and entire abdomen | 10.5 | −5.4% | 9.9 |
| Spine | 10.7 | 6.6% | 11.4 |
| Pelvis | 7.9 | −11.4% | 7.0 |
| Chest | 3.8 | −6.7% | 3.5 |
| Neurocranium | 2.36 | 1.4% | 2.4 |
| Hip | 11 | −15.4% | 9.3 |
| Neck | 2.1 | −1.5% | 2.1 |
| Skull and sinuses | 2.36 | −12.1% | 2.1 |
| Knee | 2.7 | N/A | 2.7 |
| Shoulder | 5.8 | N/A | 5.8 |
| Wrists/hand | 1.9 | N/A | 1.9 |
| Elbow | 3.2 | N/A | 3.2 |
| Foot/ankle | 0.06 | N/A | 0.06 |
| Dental | 0.6 | N/A | 0.6 |

### 3.1. Evolution from 2018 and 2023

The overall DLP change across all anatomical regions and healthcare providers was found to be small overall, with a maximum deviation of −15.4% and 6.6%, respectively, and a more frequent decrease than increase, as shown in figure 1.

The highest overall DLP increase (6.6%) was found in the anatomical region *spine*. The anatomical region *spine* also included a maximum individual $\Delta$DLP increase of 30.2% for provider G. The other anatomical region where an increase was observed was the *neurocranium* (1.4%).

The highest overall DLP decrease of −15.4% was observed for the anatomical region *hip*, followed by −12.1% for *face-skull and sinuses (incl. low-dose sinuses)* and −11.4% for *pelvis*. Provider C reported an individual highest $\Delta$DLP decrease of −55.0% for *chest*.

### 3.2. Provider variability

The highest mean $\Delta$DLP dose reduction for all anatomical regions was found for provider A (−14.9%), followed by provider C (−12.0%), and provider F (−5.8%). However, provider B demonstrated the highest mean $\Delta$DLP increase of 6.1%, followed by provider G (3%), and provider E (1.4%). For providers D and H, the mean dose for evolution was below ±1%.

### 3.3. CT dose 2023

The CT dose in 2023 showed an increase in the effective dose for *spine* (11.4 mSv) and *neurocranium* (2.4 mSv). For all other anatomical regions included in this survey, the effective dose decreased (table 3).

### 3.4. Statistical analysis

No significant differences were found between university hospitals and other healthcare providers in any anatomical region ($p > 0.05$). *Chest and abdomen combined, pelvis* and *hip* provided insufficient data to perform a valid comparison.

## 4. Discussion

Between 2018 and 2023, a decrease in the CT dose was observed in most anatomical regions. This indicates that optimization of medical radiation exposure is still ongoing in Switzerland. The effectiveness of previously implemented optimization measures by all involved stakeholders could already be affirmed in the 2018 survey [2] and during the establishment of Swiss national diagnostic reference levels for CT [7].

The anatomical regions, for which DLP dose values were collected, were chosen because they represent those CT examinations with the highest contribution in terms of effective dose to the annual exposure of the Swiss population from medical imaging in 2018 [3]. They all belong to the top 20 examinations stated by the European Commission guidance on estimating population doses from medical x-ray procedures [8]. Higher granularity of the anatomical regions was not required for the purpose of this study.

The *spine* is the anatomical region subjected to the highest dose increase. Because the DLP as a dose indicator used in this study depends strongly on the scan length, the number of vertebrae scanned in a specific CT examination has a major impact on the DLP itself [7]. Differences in the clinical indications considered in the data collected for *spine* could thus explain the observed increase. However, this remains an assumption, since in this study no information regarding the clinical indications was collected. For other anatomical regions such as the head, the scan length has only a minor influence on the DLP [9].

The largest reduction in dose observed for *hip* and *pelvis* joints can be explained by a shift in clinical decision-making, identifying more cases suitable for dual-energy protocols. This observation was reported by provider F. Another hypothesis might be the consequent use of metal artifact reduction algorithms [10].

The reduction in dose for *skull and sinuses (incl. Low-dose sinuses)* could be the outcome of a more rigorous application of indication-based low-dose protocols [7].

The evolution of the CT dose observed for each provider is dependent on the infrastructure, technical upgrades, and efforts invested in optimization activities during the observation period [11]. Some providers might have already invested considerable resources in the optimization of clinical protocols before 2018; therefore, no further significant dose reduction can be expected [7]. In addition, the replacement of CT scanners during the data collection period may have influenced the evolution of the CT dose. Provider A, who demonstrated the highest mean dose reduction over all anatomical regions, reported a replacement of one CT scanner as well as technical upgrades for the other two CT scanners between 2018 and 2023. Additionally, artificial intelligence (AI) deep learning was introduced in 2021 for the image reconstruction of all scanners. The capabilities of AI image reconstruction with regards to dose reduction have been demonstrated [12].

No conclusions could be drawn from the different types of healthcare providers. Statistical analysis showed no statistically significant differences between the two groups of healthcare providers. It is therefore assumed that the results are representative for all types of providers.

The major advantage of our approach is that identical methods of data collection and analysis have been applied by providers for both years, avoiding variations within an institution. Because the same months were considered for both years, seasonal variations could also be excluded. In addition, using the CT dose from the 2018 survey and correcting it with the observed changes will allow for traceability and connection between the 2018 and 2023 surveys.

The main limitation of our study was the need to make assumptions regarding protocol allocation to anatomical regions. In addition, the granularity of the data was not equal for all the providers. Also, no adjustments were made for patient characteristics. Therefore, a comparison of the absolute DLP values among different providers is not appropriate. Finally, as five of the eight healthcare providers participating in this study were university hospitals, they may have been overrepresented. In Switzerland, in 2022, a total of 101 private and public hospitals, including the five university hospitals, operated a CT scanner [13].

## 5. Conclusion

The results of this study are sufficiently robust to be used for the CT dose estimation in the 2023 national survey of the annual exposure of the Swiss population to medical imaging. Nevertheless, there is a clear need in the immediate future not only to consider the relative change in CT effective dose, but also to carry out national surveys to determine the absolute CT dose evolution. Such dose surveys will quantify the effects of significant technological progress, such as the use of AI [12] or photon-counting CT [14], which are currently ongoing. The Federal Office of Public Health as a national authority in medical radiation protection in Switzerland is implementing a national registry that allows for fully automated and digital dose surveys in medical imaging in the future.

## Data availability statement

The data that support the findings of this study are openly available at the following URL/DOI: www.bag.admin.ch/str-monitoring. Data will be available from 01 August 2025.


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## Author contributions

BO and RT contributed to the design, data collection, analysis of the results, and writing of the manuscript. PRT contributed to reviewing and providing feedback on the manuscript.'.


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