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Research

# A novel method for retrospective analysis regarding appropriateness of radiological examinations

## 2023:03

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## **SSM perspective**

### **Background**

The use of X-ray diagnostic examinations, especially computed tomography, has increased in recent decades and it is essential that this increase is justified and contribute to a better care of the patients. There are many reasons to refrain from performing inappropriate radiological examinations, including not to expose patients to unnecessary ionising radiation. In the radiation protection system, this is expressed as the justification principle and is of particular importance for medical exposures because dose limits for this type of exposure are exempt.

Evaluating the appropriateness of radiological methods is complicated. The methods should provide correct information to contribute to an adequate medical management of patients or increase the probability of a correct diagnosis. Different examinations can provide this information to different extents, i.e. the benefits differ. The radiation health effects along with other disadvantages should be included when evaluating examinations. Furthermore, it should be decided what type of examination, if any, is appropriate for a specific patient. To facilitate the process, international guidelines using the available evidence for various examinations have been introduced to facilitate and help make the right choice.

The purpose of the project was to investigate the conditions for developing a method, based on evidence-based criteria, to retroactively evaluate a large number of investigations regarding appropriateness and to test the method on clinical cases.

### **Results**

In the project, a method based on the European guidelines, iGuide, has been developed. The method utilized the fact that iGuide constitutes an electronic clinical decision support system. This means that data can be handled digitally, which facilitates the evaluation of a larger number of examinations. The system provides a ranking and results in a score from 1 to 9 for a medical indication. Scores 1-3 are said to indicate usually not appropriate, scores 4-6 may be appropriate and scores 7-9 are usually appropriate for a given medical indication.

In a previous project, iGuide was adopted for use in Sweden and for this project, some further adjustments were made. Information about the medical indication was digitally extracted from the referrals and matched against the medical indication in iGuide. Clinical cases from 4 healthcare regions were collected, and a total of approximately 25 000 referrals were included. Some challenges was encountered, e.g. handling different codes for the same procedure in the health care regions.

The medical indication in just over half of the referrals could be matched against medical indications in the iGuide. It was concluded that the European iGuide database was useful for conducting a large retrospective study. The result of the evaluation was carried out and 66% of all examinations scored in the group 7-9, 20% scored 4-6 and 14% scored 1-3.

The study shows that referral criteria can be used to evaluate the suitability and there is a potential to do this in an efficient and automated way.

### **Relevance**

It is of great importance to include evaluation of justification and appropriateness in the performance evaluation and audit of an X-ray department and preferably be part of the clinic's quality management system. To do so, evidence-based referral criteria are paramount. In this study, European guidelines were used as there are no such national referral guidelines. The evaluation method must also be efficient and manageable. Furthermore, it is interesting to be able to streamline the evaluation so that a larger number of investigations can be evaluated with reasonable resources.

### **Need for further research**

The method used in this study has both advantages and disadvantages. The significant number of referrals that could not be evaluated is a limitation. The strength is that established criteria are used without the influence of individual observer's assessment. It may be beneficial to be able to evaluate a large number and further method development may be justified.

It would be possible to develop other methods, e.g. point prevalence surveys could be an alternative. A smaller number of examinations are then evaluated and more information about the patient could be included. It could also be appropriate to specially review individual patient flows from e.g. the emergency department. The advantages and disadvantages need to be further evaluated.

### **Project information**

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# 1. Sammanfattning

*Introduktion:* Antalet radiologiska undersökningar i Sverige ökar från år till år. Ökningen behöver inte utgöra något problem under förutsättning att undersökningarna är berättigade och sker med lämpliga metoder. Dock saknas en metod för att göra retrospektiva berättigandebedömningar på ett resurseffektivt sätt.

*Metod:* Denna studie har analyserat om det går att göra retrospektiva berättigandebedömningar av större volymer genom att jämföra uppgifter i remisserna med rekommendationer i iGuide. iGuide är en europeisk databas som på en vetenskaplig grund ger rekommendationer om undersökningar utifrån frågeställning, ålder och kön, samt med information om stråldos och kostnad. Under oktober månad samlades genomförda datortomografiundersökningar (DT) och magnetkameraundersökningar (MR) av vuxna individer in från fyra regioner i Sverige.

*Resultat:* Totalt samlades 19 210 DT-undersökningar och 5 822 MR-undersökningar in. Av de undersökningskoder som ingick i materialet kunde 93% mappas till undersökningar i iGuide. Automatisk mappning av frågeställning gjordes som nästa steg, och av DT-undersökningarna kunde totalt 57% (10 141 undersökningar) analyseras. Motsvarande siffra för MR-undersökningar var 53 % (2 934 undersökningar). Av de undersökningar som kunde bedömas var 63% av DT-undersökningarna och 73% av MR-undersökningarna otvetydigt berättigade, och 14% respektive 11% av DT respektive MR-undersökningarna icke-berättigade.

*Slutsats:* iGuide är ett användbart verktyg för att göra retrospektiva berättigandebedömningar på stora volymer.



## 2. Introduction

### 2.1. Background

All medical exposures using ionizing radiation for individual patient diagnostic imaging procedures should be justified, requiring that the benefits of the use of radiation outweigh the associated risks and hazards (BSSD, 2013). All medical exposures should therefore undergo a justification process. This process should decide the most appropriate modality and protocol, given the patient and situation, and choose the method which has a radiation level that is as low as reasonably achievable (ALARA principle; ICRP, 2007). According to the international radiation protection guidelines, this justification process should involve both the referrer as well as the practitioner (defined as a healthcare professional who is entitled to take clinical responsibility for an individual medical exposure, in accordance with national requirements). (Article 2; BSSD, 2013)

Radiological examinations are steadily rising in numbers (see figure 1), and for CT, the rise is amounting to approximately 10% per year. In a recent overview by the Swedish Radiation Safety Authority, the number of CT examinations increased by 130% between 2005 and 2018. The increase of radiation exposure to the population from all radiological examinations during the same years has been estimated to be 30%. The increased number of CT examinations is given as a major cause of this increase of radiation exposure to the population (Almén et al, 2020).

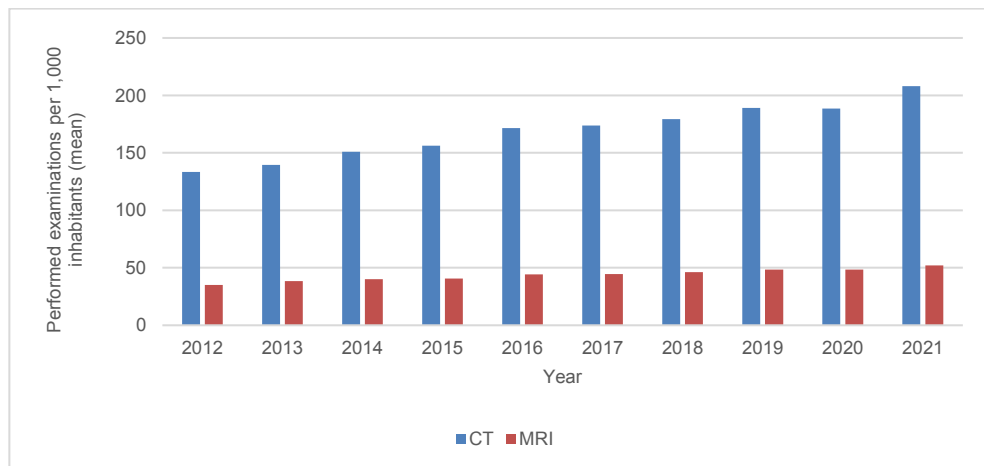


Figure 1: Radiological examinations in nine Swedish health care regions 2012-2021 (NYSAM, 2022)

In 2006, the Swedish Radiation Safety Authority retrospectively collected all referrals resulting in an CT examination performed on adults in Sweden during one day – a total of 2 435 examinations. The referrals were assessed by a team of one radiologist and one referrer. The results showed that 20% of all CT examinations were inappropriate: 5% should not have been performed at all, and 15% should have been performed with another modality than CT (Almén 2009). Primary care physicians were responsible for the highest number of inappropriate referrals (36%). The number of inappropriate examinations referred by physicians at university hospitals, regional hospitals and small hospitals ranged between 16 to 18%. The result for geographical locations throughout Sweden did not differ significantly. The most inappropriate examinations were found within the body parts colon, spine and urinary tract. Results also showed that 13% of the referrals from primary care physicians

did not contain enough information to make an appropriate decision. From hospital referrers (no matter the hospital size), the level was 5-6%. In a follow-up study using the same methodology, but only analyzing CT examinations in children, it was found that only 51% were justified (Jorulf et al, 2015).

In both previous studies, eighteen different physicians (radiologists and referrers) were used in assessing justification. The retrospective evaluation process was extensive and time-consuming, and is stated to involve a certain degree of bias due to own area of competence. A relatively high inter-observer variance is stated in the 2009 study, but without giving any numbers. In the 2015 study of children, there was disagreement between the two physicians in 30% of the cases. A more automated and unbiased process would be preferred.

According to the BSSD and the regulations issued by the Swedish Radiation Safety Authority, (SSMFS 2018:5; 2 cha 1 par) there shall be referral guidelines for diagnostic radiological examinations available to referrers. Partly on this basis, a European database called iGuide has been created, based partly on pre-existing American guidelines. Expert groups within different topics (body parts) have gathered data from studies and personal competence in an extensive database, giving recommendations of examinations on the basis of indication (1 600 scored indications are included in the database), age and gender (ESR, 2018). For more information regarding iGuide, see the method chapter.

## 2.2. Main aims

The aims of the present study were:

- to improve the knowledge of how the degree of appropriateness and appropriate examination protocol can be evaluated by developing a concept for retrospective evaluation using the iGuide database. How many free text indications can be scored on appropriateness in a structured database?
- to test this appropriateness concept for a large number of examinations
- to evaluate if the number of scored examinations is large enough:
  - to assess the degree of appropriateness for CT and MRI examinations in Sweden
  - to investigate how appropriateness is affected by the geographical region, age and gender of the patient, as well as the level of care by referrer

## 3. Method

### 3.1. Data collection

Examination catalogues for CT and MRI examinations have been collected from Region Kalmar County, Region Västerbotten, Region Västra Götaland and Region Östergötland. The samples from Region Kalmar County include Kalmar County hospital; Region Västerbotten includes Umeå university hospital; Region Västra Götaland is in this study represented by SV Hospital Group which includes Alingsås Hospital, Angered Hospital, Frölunda Specialist Hospital and Kungälv Hospital and Region Östergötland includes Linköping university hospital, Vrinnevi hospital in Norrköping and Motala hospital.

Samples have been collected for all CT and MRI examinations performed in the month of October 2021. The samples include the performed examination, indication, age, gender and the level of the ordering department (university hospitals, county hospitals, small hospitals and primary care centers). Ethical approval was not needed since no sensitive data was collected.

Evaluation has been made based on performed examination, not the one requested by the referrer. The indication, free text, was the basis of the evaluation. Customary in Sweden, a longer explanatory free text is given as part of the radiology referral, and helps the radiologist in the justification process, but this body of text has not been included as part of this sample.

iGuide provides recommendations of methods on a nine-point scale based on the patient's age, gender and indication in the referral. Numbers 7-9 ("green") indicate examinations that are usually appropriate, numbers 4-6 ("yellow") indicate examinations that may be appropriate and numbers 1-3 ("red") indicate examinations that are usually not appropriate, but additional information could change that assessment. Access to additional information in the requests in addition to the indication (such as patient history and current problems) might change the scoring, usually from yellow to green (based on unpublished data regarding iGuide in clinical practice, from author experience in Region Jönköping County years 2017-2022.).

### 3.2. Delimitations

The study has been delimited to include the examination groups CT and MRI. Patients that were younger than 18 years old on the day of the examination has been excluded from the study.

The study has been limited to include the results generated by an automatic matching in iGuide, individual assessments by radiologists and referrers of additional information have not been conducted within the scope of the study. iGuide was programmed to only consider scored examinations.

### 3.3. Implementation

A portal was created for iGuide version 15 for this study. A previous translation of iGuide version 13 was available – however, the most recent version of iGuide was used to get guidelines based on the most updated knowledge. Additional indications and examinations included in version 15 were translated into Swedish within this study.

In the early stages of the study, a manual mapping was created in Excel where the local examination codes were mapped manually to one code in iGuide version 15. This mapping could not be loaded to the created portal since the mapping in iGuide is more complex and enables the possibility to map the examination codes to one or more iGuide code. Therefore, the local examination catalogues collected from each region were uploaded to the portal and mapped manually to one or more iGuide code in a mapping module in the portal. Since the examination codes differentiate between the regions, each region was mapped separately and this generated a total of 749 local examination codes of which 82% could be matched to one or more iGuide code, usually only differing at the level of whether or not to use an intravenous contrast agent. The local examination catalogs were also manually mapped to a body part in Excel to enable the possibility to analyze the results by body part and compare the results to previous studies.

The total number of performed examinations in the samples was 25 032 of which 93% could be matched to one or more iGuide code, see table 1. A retrospective analysis tool was created to run the samples and get a scoring for each session. The tool can receive free text indications as input and using an elastic search engine, the free text is run through the entire list of clinical indications available in iGuide version 15. The search engine considers the patient age, gender and requested examination, and generates potential matches.

Furthermore, the search engine sorts the potential matches by rank, returning the clinical indication with the most chances to be the proper one as the top ranked. In this way, iGuide considers the first clinical indication returned as the best indication matching so that one is auto-selected for generating the recommendations.

Performed examinations that could not be matched to a code in iGuide was excluded from the samples before the data was run through the tool, which resulted in that 23 196 performed examinations was run through the tool. For more details, see table 1.

Table 1. Mapped examinations towards iGuide

	Region Kalmar County	Region Västerbotten	Region Västra Götaland	Region Östergötland	Total
Local examination codes	159	251	176	163	749
Local examination codes mapped to iGuide code	124	199	151	139	613
<b>Mapped examination codes (%)</b>	<b>78 %</b>	<b>79 %</b>	<b>86 %</b>	<b>85 %</b>	<b>82 %</b>
Collected CT	4 158	4 205	3 192	7 655	19 210
Collected MRI	1 295	1 431	828	2 268	5 822
<b>Collected examinations total</b>	<b>5 453</b>	<b>5 636</b>	<b>4 020</b>	<b>9 923</b>	<b>25 032</b>
Mapped CT	3 784	3 753	2 879	7 220	17 636
Mapped MRI	1 251	1 253	828	2 228	5 560
<b>Mapped examinations total</b>	<b>5 035</b>	<b>5 006</b>	<b>3 707</b>	<b>9 448</b>	<b>23 196</b>
Mapped CT (%)	91 %	89 %	90 %	94 %	92 %
Mapped MRI (%)	97 %	88 %	100 %	98 %	95 %
<b>Mapped examinations total (%)</b>	<b>92 %</b>	<b>89 %</b>	<b>92 %</b>	<b>95 %</b>	<b>93 %</b>

To not only provide results on the score of the performed examination but also on what would be the best option according to the guidelines, an extension was created in the portal to cover all the other modalities and examination codes available in iGuide version 15. In this manner, iGuide was able to return any recommendation and score for any other examination that is available in the guidelines but not in the region's catalogue, and then include the best potential alternative option in the statistical results for the study. The extension was done by adding a 1:1 examination mapping for all unmapped iGuide codes to the original region's catalogue.

## 4. Results

The results generated in iGuide were exported to Excel where the data for all four regions were combined to analyze the results. Of the 23 196 examinations that were run through the tool 13 075 could be matched to a valid indication in iGuide and receive a score, and this represents 56%, see table 2. From ocular review, many of the non-matching indications are due to:

- non-matching text to iGuide, in several cases due to misspellings (e.g. “Abcess?”, “Skel-etskada?”, “Spnelomegali?”)
- unspecific requests when taken out of context (e.g. “Progress? Any changes?”, “uncertainty due to ambiguity last time the examination was performed”, “Please perform an evaluation examination on status changes from the last examination”)
- non-questions not recognized by iGuide (e.g. “SVF ovarian cancer”)
- questions not matching that examination in iGuide (e.g. asking about fractures on a CT thorax/abdomen)
- iGuide not matching relevant questions (e.g. “Ileus” on low dose CT abdomen, “Diverticulitis” on CT abdomen with iv contrast)

One per cent of the examinations were lacking a texted indication, which means they could not be matched to an indication and receive a score, see table 2. A total of 10 141 CT examinations (57%) had a valid indication, and the corresponding number for MRI was 2 934 (53%).

Table 2. Mapping results in iGuide

	Region Kalmar County	Region Västerbotten	Region Västra Götaland	Region Östergötland	Total
Valid indication iGuide	3 067	2 684	2 156	5 168	13 075
Valid indication iGuide (%)	61 %	54 %	58 %	55 %	56 %
Texted indication missing	15	84	85	44	228
Texted indication missing (%)	0,3 %	1,7 %	2,3 %	0,5 %	1,0 %

Of those 13 075 examinations with a valid indication matching in iGuide, 66% were appropriate (green), table 3. Small hospitals were found to have a slightly lower rate of non-appropriate examinations (10% red), and primary care centers a slightly higher rate (19% red).

Table 3. Appropriate examinations, overall and by referrer affiliation

	Green	Yellow	Red
<b>Total</b>	<b>66 %</b>	<b>20 %</b>	<b>14 %</b>
University hospitals	67 %	20 %	13 %
County hospitals	64 %	19 %	17 %
Small hospitals	69 %	21 %	10 %
Primary care centers	59 %	22 %	19 %

Region Västerbotten stands out with a lower rate of non-appropriate examinations (9% red), than the rest of the regions (14% red).

Table 4. Appropriate examinations by modality

	Green	Yellow	Red
<b>Total</b>	<b>66 %</b>	<b>20 %</b>	<b>14 %</b>
CT (n=10 141)	63 %	23 %	14 %
MRI (n=2 934)	76 %	13 %	11 %

More MRI examinations are appropriate than for the CT examinations (76% vs 66%). The number of examinations not appropriate is about the same, 14% for CT and 11% for MRI.

Most examinations were performed in the age groups 68-87 years, and the lowest level of appropriateness was found in the age groups 58-67 years (64%) and 68-77 years (64%), see figure 2.

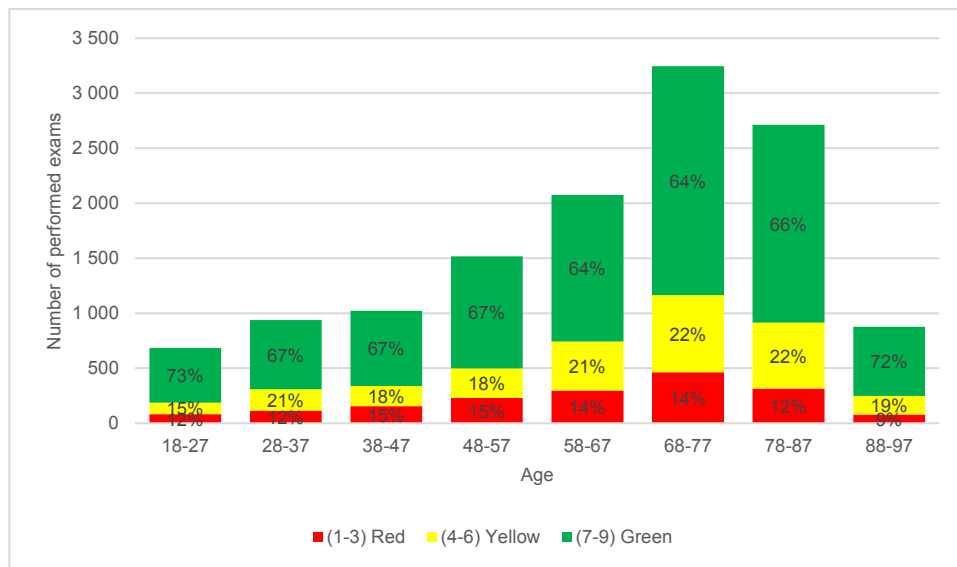


Figure 2. Appropriateness per age group

Looking at gender, there were only minor differences, 6 231 (48%) of the examinations were performed on males, with an appropriateness level of 67%. The corresponding appropriateness level for females was 65%.

## 5. Discussion

The main purpose of this retrospective study was to evaluate the feasibility of using iGuide as a means to assess the appropriateness of large samples of examinations. Given that iGuide uses standardized indications and this retrospective sample contained free text indications, the mapping levels of 93% at the examination level and 56% of those at the indication level are higher than expected, and this shows that a retrospective mapping of free text can be used. A total of 44% of the examinations could not be evaluated, and without an individual assessment of those, we do not know how many of them are appropriate, and this might of course change the overall result.

Potential improvements in mapping percentage at the examination code level would be possible by introducing a national code system, reducing the importance of the radiology departments' individual coding systems. Potential improvements in mapping percentage at the indication level, and thus greatly improving the included examinations in retrospective analysis, would be to introduce structured indications. This could be done manually, but usually involves a great effort to introduce and maintain. A less work-intensive option would be to introduce iGuide in clinical practice. This would obliterate the need for this kind of retrospective analysis, that all data, from all examinations, could be exported from iGuide directly. From the data in this study, one can assume that adding a dozen or so common indications to iGuide would greatly improve the mapping scores.

The current method opens up the possibility of retrospective analyses of large sample data, uses fewer physician hours to evaluate and reduces the potential bias in the evaluation of appropriateness. The number of examinations evaluated in the current study (n=13 075 CT and MRI examinations) is higher than the previous Swedish studies (n=2 435 CT examinations in Almén et al 2009; and 3 149 CT, MRI and ultrasound exams in Jorulf et al, 2015). The number of examinations evaluated is also higher than in a previous European study: n=718 CT and MRI examinations in Luxemburg (Bouëtté et al, 2019).

Individual assessments have not been performed at the examination referral level, and it is possible that some data would need manual adjustment or that more of the excluded data could be included, if that had been done. However, manual individual assessments are not excluded from this difficulty: in the Swedish 2009 study, 3,7% of the referrals lacked information to make justification assessments. In the Luxemburg study, 15% of the CT referrals and 5% of the MRI referrals lacked information to be evaluated by two individual radiologists, and in a further 19% of CT referrals and 19% of MRI referrals, an initial consensus of appropriateness was not reached by the evaluating radiologists. Guidelines were applicable in 73% of CT referrals and 79% of MRI referrals, the rest of the referrals were evaluated on personal knowledge.

In this retrospective analysis, 66% of the CT examinations were appropriate, and a further 23% might be appropriate given more information. However, without more detailed information regarding the yellow, "might be appropriate" examinations might as well move toward the more inappropriate, red level. iGuide results from clinical practice show that most of the examinations in the yellow category are deemed appropriate by radiologists (unpublished data). 14% were evaluated as not appropriate. The number of examinations that might be appropriate could further be diminished by a manual evaluation taking the whole referral into consideration and not only the indication by itself. Also, the numbers would change using iGuide not retrospectively but as part of the referral.

The number of appropriate MRI examinations is higher, amounting to 76%. This might be explained by the fact that MRI is still more uncommon than CT, and is also generally priced higher, and more care is taken both in writing the referral by the referrer and in the justification process by the radiologist. The trend is similar to an appropriateness study in



Luxemburg (Bouëtté et al, 2019), showing appropriate rates of 61% for CT and 79% for MRI.

iGuide has been used in one Swedish region for almost 3,5 years, where iGuide was used by six referral clinical (one at a small hospital and five primary care centers) using the whole modality spectrum available (not only for CT and MRI). Unpublished data from this project shows that of the scored examinations, 9,2% were in the “might be appropriate” (score 4-6, yellow) category. The percentage of inappropriateness is higher in this retrospective analyses than in the real-time use of iGuide, where the percentage of not appropriate (score 1-3, red) amounted to 1,2%. Note that in the real time project, the appropriateness evaluation is based on the examination suggested by the referral and not the one finally performed. This percentage discrepancy could suggest that it is more difficult to match free text indications to iGuide and that the number of non-appropriate examinations would diminish using matched indications at the point of the referral. However, it could also suggest that by using iGuide at the point of the referral creation, higher appropriateness is reached. In the real-time iGuide pilot, it was seen that 3% of the referrals were cancelled by the referrer themselves at the point of seeing the iGuide recommendations, and a further 2% of the referrers changed their initial choice of suggested examination based on the iGuide recommendations.

The high prevalence of CT examinations (10 141 CT vs 2 934 MRI) indicates a large potential of reduced radiation level to the patients if iGuide recommendations are followed. The highest level of inappropriateness was found in the slightly older age groups (58-77 years), and not in the 18-37 years of age, which is a more radiation-sensitive age group. The age groups 68-87 years are the most frequent radiology users in the current sample.

As in the previous study, the greatest level of potential improvement can be found at the primary care centers. This is perhaps not surprising, given the broad spectrum of patient concerns they frequently encounter, and the fact that they are the least specialized area of physicians. Similar results are shown previously (Almén et al, 2009; Bouëtté et al 2019)

In this study, only the indication was used to evaluate the appropriateness of the performed examination. The study does not take into consideration the appropriateness of the indication based on the patient’s symptom (e.g. if the indication is “pulmonary embolism”, the appropriate examination is CT of the pulmonary arteries. Whether or not the patient has a high clinical probability and shows symptoms of a pulmonary embolism is not evaluated.) Considering the whole referral information would have improved this appropriateness, but is not feasible to use in an automated iGuide database.

The appropriateness process in clinical practice is a shared responsibility between the referrer and the radiologist. The referrer needs to refer examinations only when clinically necessary, and should have taken previous results into consideration, as well as a judgement of whether the results of the examination would alter the clinical handling of the patient. The radiologist on the other hand, has the responsibility of choosing the correct examination given the indication. This study only evaluates the examination performed, and the results should be seen as the combination of those two appropriateness processes.

The iGuide database gives recommendations only based on the current science and does not take the availability of modalities or economical aspects into consideration. This does not mirror the clinical scenarios in actual healthcare today and might influence the results.

## 6. Conclusion

We conclude that:

- it is possible to use the European iGuide database to perform a large, retrospective appropriateness study.
- if a manual evaluation of both the indication question and the corresponding free text indication had been added, higher percentages of appropriateness would probably be reached. In this study, 56% of the examinations could be automatically evaluated.
- using automated mapping and matching to free text indications, it was found that 66% of all examinations were appropriate (score 7-9, “green”), 20% may be appropriate given more information (score 4-6, “yellow”), and 14% were not appropriate given the information at hand (score 1-3, “red”).
- referrers at primary care centers had a slightly lower degree of appropriateness. Referrers at small hospitals had a slightly higher degree of appropriateness.
- the northern region (Region Västerbotten) has a slightly higher degree of appropriateness.
- the highest percentage of non-appropriate examinations were performed in the 58-77 year age group. No difference was seen in gender.

## 7. Acknowledgements

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NYSAM Helseplan, report 2022. Data acquired online 2022-09-07.









The Swedish Radiation Safety Authority has a comprehensive responsibility to ensure that society is safe from the effects of radiation. The Authority works from the effects of radiation. The Authority works to achieve radiation safety in a number of areas: nuclear power, medical care as well as commercial products and services. The Authority also works to achieve protection from natural radiation and to increase the level of radiation safety internationally.

The Swedish Radiation Safety Authority works proactively and preventively to protect people and the environment from the harmful effects of radiation, now and in the future. The Authority issues regulations and supervises compliance, while also supporting research, providing training and information, and issuing advice. Often, activities involving radiation require licences issued by the Authority. The Swedish Radiation Safety Authority maintains emergency preparedness around the clock with the aim of limiting the aftermath of radiation accidents and the unintentional spreading of radioactive substances. The Authority participates in international co-operation in order to promote radiation safety and finances projects aiming to raise the level of radiation safety in certain Eastern European countries.

The Authority reports to the Ministry of the Environment and has around 300 employees with competencies in the fields of engineering, natural and behavioral sciences, law, economics and communications. We have received quality, environmental and working environment certification.

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