


The practice of reporting pulmonary nodules as incidental findings in the radiology department at the ZGT

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Summary

Purpose: In the report published by the Health and Youth Care inspectorate (IGJ) of September 2018 it was concluded that the radiology department of Ziekenhuis Groep Twente (ZGT) needed to improve the verification of the successfulness of the communication of non-acute incidental findings. In reaction to the IGJ report, the ZGT is in search for a new system for communicating non-acute incidental findings. In order to design a new system, an orientation of the current situation is required. The aim of this study is to assess the frequencies in which pulmonary nodules and predictive characteristics for malignancy are reported and the use of reporting methods in the radiology department in the period between September 2017 and August 2018.

Methods: By performing a quantitative retrospective analysis on radiological reports, descriptive statistics on the characteristics of the patients and the pulmonary nodules are provided. The characteristics discussed are predictive for malignancy or benignancy in pulmonary nodules. These characteristics are: age, gender, multiplicity, diameter size, suspicion for being metastases, attenuation, calcification, margin, lateralization, location throughout the lung and position. Subsequently, the associations between the predictive characteristics and the reporting methods that influence the follow-up rate are analysed. The reporting methods investigated are 1) the mention of pulmonary nodules in the conclusion, 2) the mention of contact with medical specialists about the incidental finding and 3) the mention of follow-up recommendations.

Results: Incidental pulmonary nodules were reported in 197 out of 197,842 radiological reports. The majority of these reports had unmentioned predictive characteristics of the pulmonary nodules. 1) 50.8% of the reports mention the pulmonary nodules in the conclusion. 2) 11.7% of the reports mention contact with the medical specialist. 3) 17.5% of the reports mention follow-up recommendations. Characteristics that are significantly associated with the mention of the pulmonary nodules in the conclusion were multiplicity (p -value < 0.01), size (p -value = 0.03), upper lobe location (p -value < 0.01) and perifissural position (p -value < 0.01). No significant association with predictor characteristics were found for the mentioning of contact with medical specialists. The characteristics size (p -value = 0.05), calcification (p -value = 0.05), and perifissural position (p -value < 0.01) were significantly associated with the occurrence of follow-up recommendations in the radiological reports.

Conclusions: In the practice of reporting incidental pulmonary nodules, the majority of the radiological reports mention incidental pulmonary nodules in the conclusion. Corresponding with the finding of the IGJ report that the successfulness of the communication of non-acute incidental findings with medical specialists is verified insufficiently, this study found that contact with medical specialists is rarely reported in the radiological reports at the ZGT. Finally, only a small part of the radiological reports recommend follow-up and no specific follow-up period were recommended.

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1. Introduction

The intervention of radiological imaging has provided medical professionals with the opportunity to analyse the pathology of tissues inside the body of a patient without performing surgery. In this way radiological imaging is used for determining diagnoses and prognoses for patients. During the analysis of these radiological scans, radiologists often discover findings outside the initial purpose of the radiological scan [1]. These incidental findings serve as an important screening method and optimization of the processes around incidental findings can benefit both patients and society.

In September 2018, The Health and Youth Care inspectorate (IGJ) examined the performance of Ziekenhuis Groep Twente (ZGT) in the reporting of incidental findings at the radiology department. The ZGT is a combination of two Dutch regional hospitals, located in Almelo and Hengelo, and is the initiator of this study [2]. The performance of the radiology department was compared with the standards set by the Dutch Association for Radiologists (the NVvR) in 2015. In their report, the IGJ concluded that the radiology department of the ZGT takes sufficient responsibility in communicating the acute and semi-acute incidental findings that need fast -within six minutes for acute and within six hours for semi-acute findings- and direct communication towards the medical specialists. According to the IGJ report, a point of improvement lies in the verification of the successfulness of the communication of non-acute incidental findings towards medical specialists [2]. Non-acute incidental findings are not immediately life threatening but can cause morbidity and therefore are required to be communicated within six days. According to the NVvR guidelines the report should mention 1) who was contacted, 2) the method, and 3) the date and time of the contact. In case of non-acute incidental findings, the contact can be indirect via e-mail [1]. This feedback given by the IGJ is the motivation for the radiology department to investigate and eventually improve the current practice of the reporting of non-acute incidental findings in the radiology department [2].

One such non-acute finding is the presence of pulmonary nodules. Corresponding to the definition of a non-incidental finding, pulmonary nodules are not directly harmful to the patient, but can represent a medical condition that is potentially life-threatening [3]. The definition of a pulmonary nodule derived from the Fleischner guidelines is: “a rounded or irregular opacity well or poorly defined, measuring up to 3 cm” (Azharuddin et al. 2018 pp. 14). The NELSON study is a large Dutch study on pulmonary cancer screening, that included 7557 (former) smoking patients from 14 municipalities. In the NELSON study an incidence of 1451 (19.2%) patients with one or more intermediate size (volume more than 50 mm³ and less than 500 mm³) pulmonary nodules was found [5]. Generally, the majority of the pulmonary nodules are of benign nature, with an incidence of only 1.1% to 1.4% of malignancy in incidentally found pulmonary nodules [4, 6 - 8]. Patient characteristics that are associated with malignancy in pulmonary nodules are age, female sex, (former) smokers, pack-years of smoking, family history, previous extra-pulmonary cancer, and asbestos exposure. [4, 6, 9-11] Predictive variables for malignancy within pulmonary nodules are size, ground-glass attenuation, upper lobe location, pleural

or parenchymal position, spiculated margin and a volume doubling time of less than 400 days. [4, 6, 8-11] Calcification is an indicator for benign nodules, as are smooth margin, perifissural position, and a higher count than 4 nodules found for one patient [4, 6, 8 - 11]. Pulmonary carcinomas have a high death rate of 80% in five years [12]. The prognosis of malignant disease improves when the detection and treatment is in an early tumour stage [4, 9, 10]. Follow-up is performed to discover and treat the incidental findings in an early stage [4].

Specifically for the follow-up policy of pulmonary nodules, the ZGT aims to follow the Fleischner guidelines of 2017. The Fleischner guidelines were designed to set a standard for follow-up policies that best fit certain risk-profiles. Here, the variables multiplicity, patient's risk-profile, morphology and the size of the pulmonary nodules are used to distinguish which policy is required for the patients [6]. McMahon et al (2017) reports the guidelines for the management of incidental pulmonary nodules by the Fleischner society, which can be displayed in a decision tree (see appendix 1). According to McMahon et al (2017), patients with pulmonary nodules that have a size of less than six millimetres do not require to receive follow-up. Only when these patients have a high risk profile, the guidelines recommend an optional 12 month follow-up [6]. The exception is for when there is an occurrence of multiple sub-solid lesions, which require a follow-up period of three to six months. When the diameter of the largest pulmonary nodule exceeds the six millimetres, follow-up is recommended in all cases. The required period is then dependent on other risk factors for malignancy [6]. The period for follow-up is determined by the pulmonologist. The role of the radiologist is to ensure that the findings are communicated to the pulmonologist and recommendations can be given for follow-up.

Previous research investigated multiple influences of the follow-up management for patients with pulmonary nodules [4, 7 – 11, 15 - 17]. Some studies focused on the characteristics of the pulmonary nodules associated with malignancy such as Ahn et al. (2010), McWilliams et al. (2013), Mets et al. (2018), and De Hoop et al. (2012) [7, 9, 10, 15]. Other studies focused on investigating the optimal guidelines for the follow-up [4, 8]. Finally, Blagev et al. (2014) investigated the reporting of incidental pulmonary nodules and its influence on the execution of the appropriate follow-up of these pulmonary nodules. The results of Blagev et al. (2014) showed that the follow-up rate of patients with pulmonary nodules was generally poor (29%). The mention of pulmonary nodules in the 'impression section' had a significant influence on the follow-up rate. The mention of follow-up recommendations had a positive influence on the follow-up rate for the patients as well. Although, there was not enough statistical power to confirm that the mention of follow-up in the impression section had significant difference in the follow-up rate when compared with only the pulmonary nodules mentioned in the impression section [18]. Despite the positive influences of these two reporting methods, the quality of the follow-up remained insufficient. Therefore, Blagev et al. (2014) concluded that there is a need for research on a new system to ensure that patients would receive appropriate follow-up [18].

In response to the IGJ report, the radiology department of the ZGT is in search for a system in the reporting of incidental findings that would increase the number of patients that receive appropriate follow-up. This mission corresponds with the recommendation of Blagev et al. (2014) to develop a new system for reporting incidental pulmonary nodules. The first step that has to be undertaken in the search for a new system, is to assess the current situation in the ZGT.

Research questions

The aim of this study is to make an assessment of how often and with which predictive variables the pulmonary nodules occur as incidental findings in the ZGT and the current practice that pulmonary nodules are reported in the radiology department. The research question is:

What is the practice of the reporting of pulmonary nodules as incidental findings in the radiology department of the ZGT in the period between September 2017 and August 2018?

Three sub research questions are formulated to support this research question:

- *What is the frequency in which incidental pulmonary nodules are reported?*
- *What is the frequency in which occurring characteristics associated with malignancy or benignancy are reported?*
- *What is the frequency in which 1) the pulmonary nodules are mentioned in the conclusion of the radiological report, 2) contact with a medical specialists is mentioned and 3) follow-up recommendations are given?*
- *What is the association between the occurrence of predictive variables for malignancy with the mention of the pulmonary nodules in the conclusion, the mention of contact with a medical specialists and/or the mention of recommendations for follow-up?*

2. Methods

2.1 Research design

This study contains a quantitative retrospective analysis of the current practices within radiological reporting of incidental pulmonary nodules in the period between September 2017 to August 2018. To prevent any influence of the IGJ report, the data was collected from the month prior to its publication.

2.2 Patient sample composition

The population sample consisted out of patients that underwent any form of radiological imaging in which pulmonary nodules were incidentally discovered. Excluded from the data collection were patients younger than 18 years old. This is because the usage of their data is ethically challenging. Additionally, patients older than 85 years were excluded as well. This fragile group of patients experience a greater burden from the follow-up and treatment of pulmonary nodules and are less likely to die from malignant lesions than other age groups [13]. Because of this, the medical specialists are likely to lean towards sparing the elderly patients from the burden of follow-up. As a result, the radiologists are influence by aspects other than the patient's risk for malignancy, causing a confounding bias.

2.3 Data collection

The data from the radiological reports for the analysis was collected through a search engine in PACS. This search engine provides the possibility to search the radiological reports in the electronic patient system (HIX) of the ZGT. With the help of three specialised radiologists from the ZGT, the terms that are most commonly used to refer to lung nodules in the radiologic reports were determined. These terms were then used to select the radiologic reports to use for the study. The terms listed by the radiologists were: “(long of pulmonale) noduli”, “- nodulus”, “- nodi”, “- nodus”, “interpulmonale lymfeklier”, “noduli in de longen”, “perifissurale noduli” and the abbreviation of perifissural nodules: “PFN”. Naturally, the search terms are in Dutch, since the main language used in the radiological reports of the ZGT is Dutch.

The patient data obtained from the search engine, included all reports that mentioned the combination of letters that form the search terms. The consequence is that because the letter combination of the abbreviation “PFN” also occurs in another abbreviation “PFNA”, therefore the search engine produces the reports that mention “PFNA” as well. “PFNA” stands for “Proximal Femoral Nail Antoritation” and is a surgical technique in which a nail is placed in the femur to stabilize a fracture. Because it does not concern pulmonary nodules, the reports that mentioned “PFNA” without mentioning pulmonary nodules were excluded from the data collection. Another consequence of the search engine technique, is that when multiple terms for pulmonary nodules are mentioned in one radiological report, the search engine would provide the same radiological report multiple times. These identical reports were excluded from the data collection as well.

After cleaning the data, the data that remained for the data collection concerns all the radiological reports that mention pulmonary nodules. As a result, the data included all reports that mentioned incidental pulmonary nodules not being present as well. During the data collection the following radiological reports were excluded for the data analysis:

First the radiological reports were excluded when the medical specialist, who requested the radiological imaging, was a pulmonologist. This was noted with “LON” in “specialisme”. If requested by a pulmonologist, the radiological report would be directly received by the pulmonologist, after it was constructed. Because it concerns their field of specialization, the pulmonary nodules would be immediately known by the medical specialist whom it concerns. Additionally, when the radiological reports are initiated by the pulmonologist, it is likely that the patient has a disease for which one would expect pulmonary nodules to occur, such as pulmonary sarcoidosis or COPD. Therefore, the pulmonary nodules might be anticipated for, even though it was not mentioned in the indication of the report.

Second, the radiologists had the habit of reassuring that other fields of the body were clear from abnormalities. The absence of pulmonary nodules was often mentioned in the reports as well. Additionally, the radiologists also mentioned pulmonary nodules in the radiological scan that were already known, often to describe any progression. In these cases no incidental pulmonary nodules occurred, therefore these radiological reports were excluded from data analysis. Specific terms in the radiological reports were determined that were linked with the mention of the absence of pulmonary nodules or the presence of known pulmonary nodules (see appendix 2). When these terms occurred, the radiological reports were excluded from the data analysis.

Finally, when the pulmonary nodules were accompanied with the mention of a pulmonary carcinoma, the radiological report was excluded from the data analysis. Pulmonary carcinoma are often mentioned in abbreviations such as “NSCLC”, which stands for non-small cell pulmonary carcinoma. Also, when a pulmonary lesion with a diameter larger than three centimetres was mentioned, the radiological report was excluded as well. Such findings are more severe than non-acute findings and therefore will require more direct communication than incidental pulmonary nodules.

All other radiological reports were sustained for the data analysis. For each radiological report the following information was used:

- Patient number;
- Examination number;
- Gender;
- Date of birth;
- Date of examination;
- The report section, in which the findings from the scans are reported;
- The conclusion of the report;

- The indication for the request for radiological imaging;
- The specialty of the medical professional that requested the radiological imaging.

2.4 Data variables

The data that was obtained from the search engine was either used directly for the data analyses or transformed into variables. Some variables were extracted from the text in the reports or conclusion. When data was derived from the report this was done by hand with Access, Microsoft Office 365 Pro-Plus (2011). This program provides the opportunity to create a database with the use of a separate form for each patient case.

The characteristics of the patients that were used as variables in the analysis were risk factors associated with malignancy in patients with pulmonary nodules. These are the variables 'age' and 'gender'. Based on the categorisation of Ost et al. (2012), the variable 'age' was divided in three age categories '18-45'; '45-60'; '60-85'. The study hereby adjusted for the fact that patients younger than 18 and older than 85 were not included for the data collection.

The risk-factors 'family history' and 'patient's history of smoking' were not in the analysis because these elements were often not mentioned in radiological reports. The exception is for reports of radiological imaging that were initiated by pulmonologists. As mentioned earlier the reports initiated by pulmonologists were excluded from this study.

The characteristics 'nodule size', 'solitary/multiple nodule(s)', 'attenuation', 'calcification', 'margin', 'position', 'lateralisation', 'location throughout the lung', and 'suspected for metastases' were studied as occurring predictor variables for malignancy in the pulmonary nodules. The variable 'nodule size' was divided into ' $\leq 6\text{ mm}$ ' and '>6mm'. The latter category is associated with a higher risk for malignancy in pulmonary nodules [4, 6 - 9, 11]. This study had six millimetre as threshold value, because when the largest pulmonary nodules found in a radiological scan is larger than six millimetres, the Fleischner guidelines recommends to perform follow-up at all times. This regardless of the other characteristics of the nodules [6]. The variable 'attenuation' was categorised into 'Solid' and 'subsolid' pulmonary nodules. For 'subsolid', pulmonary nodules with ground-glass and part-solid nodules - nodules with solid components- were included. These categories were used for determining the follow-up in the Fleischner guidelines as well.

When the radiologists suspected the pulmonary nodules to be metastases of primary carcinomas in other regions in the body, they were categorised as '*suspected for metastases*'. Metastases come from a malignant lesion and are, therefore, invasive by themselves. When the pulmonary nodules were suspected for metastases, they were not necessarily metastases and were still treated as incidental pulmonary nodules. However, because of the suspicion, the radiologists can act differently for pulmonary nodules suspected for metastases than for unsuspected pulmonary nodules. Therefore, this

variable is included in the data analysis. Finally, when the pulmonary nodule could not be placed in one of the categories, they were assigned to the category '*Unmentioned*' instead.

2.5 Data- and statistical analysis

The software that was used for the transformation and analysis of the data was Excel Microsoft Office 365 Pro-Plus (2011) and IBM Statistical Package for Social Sciences (SPSS) 25 (2017).

Descriptive statistics were used to answer the first, second and third research question. This was because of the explorative function, rather than the analytical function of both questions. The descriptive statistics included the mean and the standard deviation for the numerical variables. For the categorical and dichotomous variables, the number of patients in each category and the percentages of this number compared to the total group of patients were included in the analysis.

To answer the fourth research question, this study analysed the association between the predictor variables of patients and their lesions with the number of reports that 1) mention the pulmonary nodules in the conclusion of the report, 2) mention contact with the medical specialists and/ or 3) mention recommendations for follow- up. For the predictor variables solely the occurrence in the radiological report of the category associated with an increased chance for malignancy was compared with the categories that do not have that association. In this way the reports with multiple nodules for which different categories apply, can be included in the analysis as well. The statistical test that was used for this analysis, was the chi-square test. In case of sample sizes for variables were so small that the expected count for more than 20% of the categories was lower than five, the assumptions for the chi-square test were not met. Instead the Fischer's Exact test was used. For both tests the two-sided p -values were used to determine statistical significance. With a confidence interval of 95%, the dependence between two variables was considered statistically significant at p -value < 0.05 .

3. Results

3.1 Frequency of reported incidental pulmonary nodules

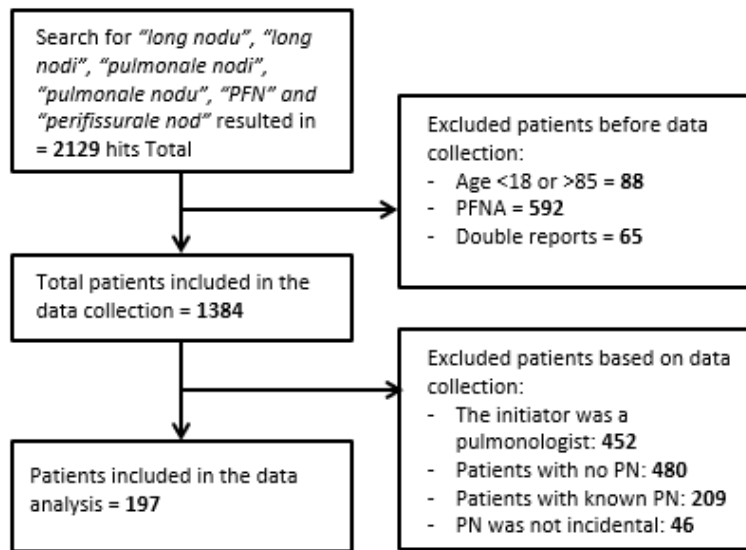
Between September 2017 and August 2018, the ZGT's radiology department produced a total number of 197,842 radiological reports on patients between 18 and 85 years old. In 2,041 of these reports, pulmonary nodules (or a synonym) were mentioned.

The search for an abbreviation for pulmonary perifissural nodules, PFN, also led to the selection of reports that contained the abbreviation "PFNA", which does not concern pulmonary nodules. Therefore, the 592 (27.8%) reports in which this occurred were excluded from the data collection. When multiple synonyms were used in one report, it caused multiple occurrence of the same report in the database. This was the case in 65 (3.1%) of the reports, which were also excluded from the data collection. After cleaning the data, 1384 reports from September 2017 to August 2018 were included for data collection.

During the data collection, a selection was made based on the content of the radiological reports on which reports should be included for the data analysis. In 452 (32.7%) cases the initiator of the reports was a pulmonologist. In 480 (34.7%) reports, there was a specific mention of pulmonary nodules being absent in the radiological scan. In 209 (15.1%) reports the observed pulmonary nodules were mentioned to be already known by the radiologist, or were compared with earlier pulmonary nodules. In 46 (3.3%) reports, pulmonary nodules were found for patients whom previously had pulmonary carcinoma or had a mention of pulmonary nodules present in the indication of the radiological report. In all these cases, the pulmonary nodules were not considered incidental findings and therefore were not included in the data analysis.

In total, incidental pulmonary nodules were mentioned in 197 out of 197,842 reports (0.1%). These reports were included in the data analysis. The flowchart of the exclusion of the reports for the data analysis can be found in Figure 3.1.

Figure 3.1. Flowchart exclusion of reports for the data analysis, for the period between September 2017 and August 2018.



3.2 Occurrence of characteristics associated with malignancy of benignancy

All findings on the characteristics of the patients and their pulmonary nodules that will be mentioned in the following paragraphs, are displayed in the tables 3.2.1, 3.2.1, and 3.2.3. These tables can be found at the end of the paragraphs.

3.2.1. Population characteristics

The patients had an average age of 64 years ($SD=13.9$). The majority (65.0%) of the population was in the age group with the highest risk for malignancy (60-85). The other two groups (18-45 and 45-60) were less represented with 9.6% and 25.4% of the population respectively. Considering gender, 42.6% of the population was female, which is the gender with the highest risk for malignancy in pulmonary nodules [6]. There were no missing values for these patients characteristics because both gender and date of birth are registered in the ZGT by default.

Table 3.2.1. The characteristics of the patients who have pulmonary nodules.

Variables	Categories	Outcomes	
		N	%
Age (in years)	18-45	19	9.6
	45-60	50	25.4
	60-85	128	65.0
Gender	Male	113	57.4
	Female	84	42.6
Total		197	100.0

3.2.2. Characteristics of the pulmonary nodules

The majority of reports did not mention most of the characteristics of the pulmonary nodules. As a result, for all characteristics the majority of the data were missing values. Moreover, almost all data (98.5%) for the margins of the pulmonary nodules consists out of missing values. Calcification and suspicion for metastases of the pulmonary nodules were mentioned in 17 (8.6%) and 21 (10.7%) reports respectively. In case of the attenuation, only ten (5.1%) reports mention ground-glass. Other attenuation categories (solid and part-solid) were never mentioned.

Two characteristics were mentioned more frequently. First, the pulmonary nodules were reported as solitary in 34 (17.3%) reports and with multiple in 53 (26.9%) reports. In the remaining 110 (55.8%) reports there was no indication of singularity of plurality, for example when the abbreviation “PFN” was used. Second, with respect to size, the average diameter of the largest pulmonary nodule mentioned in the reports was 8.3 millimetres ($SD = 5.0$). The largest pulmonary nodule was reported with a diameter size of six millimetres or less in 48 (24.4%) reports and exceeding six millimetres in 24 (12.2%) reports.

Table 3.2.2. The characteristics of the pulmonary nodules.

Characteristics	Categories	Outcomes	
		N	%
Multiplicity	Solitary	34	17.3
	Multiple	53	26.9
	Unmentioned	110	55.8
Size of largest PN (in mm)	≤ 6 mm	48	24.4
	> 6 mm	24	12.2
	Unmentioned	125	63.5
Suspected for metastases	Suspected	21	10.7
	Unmentioned	176	89.3
Attenuation ¹	Solid	0	0.0
	Ground-glass	10	5.1
	Unmentioned	187	94.9
Calcified	Completely/partly calcified	17	8.6
	Not calcified	180	91.4
Margin	Smooth	0	0.0
	Lobulated	1	0.5
	Spiculated	2	1.0
	Unmentioned	194	98.5
Total		197	100.0

3.2.3. Location of the pulmonary nodules

In 65 (33.0%), 38 (19.3%), and 52 (26.4) radiological reports the pulmonary nodules were found solely in the right lung, left and both lungs respectively. As for the location throughout the lung of the pulmonary nodules, in 65 (33.0%) reports, the pulmonary nodules occurred in one pulmonary lobe (lower, middle, or upper lobes), and in 21 (10.7%) reports they occurred in multiple pulmonary lobes. The location was for 55 (27.9%) report in the lower lobes, 20 (10.2%) in the middle lobe, and 34 (17.3%) in the upper lobes. As for the position of the pulmonary nodules in the pulmonary tissues, 31 (15.7%) reports describe pulmonary nodules as intra-pulmonary, 40 (20.3%) as sub-pleural, and 105 (53.3%) as perifissural pulmonary nodules. In respectively 21.3% and 58.8% of the reports, no details were mentioned concerning the lateralization of the lungs or the locations in the lobes in which the pulmonary nodules occurred.

Table 3.2.3. Location of the pulmonary nodules

Characteristics	Categories	Outcomes	
		N	%
Lateralization	Right	65	33.0
	Left	38	19.3
	Both sides	52	26.4
	Unmentioned	42	21.3
Location throughout the lung ¹	Upper lobe	34	17.3
	Middle lobe	20	10.2
	Lower lobe	55	27.9
	Unmentioned	111	56.3
Position ¹	Inter-pulmonary	31	15.7
	Subpleural	40	20.3
	Perifissural	105	53.3
	Unmentioned	50	25.4
Total		197	100.0

1. Overlapping values because multiple nodules are possible, percentages does not add up to 100%

3.3 The reporting methods

In approximately half (50.8%) of the radiological reports, the pulmonary nodules were mentioned in the conclusion of the report. In 23 (11.7%) reports, contact with a medical specialist regarding the incidental findings of the pulmonary nodules were mentioned. In the reports that mention contact, 78.3% mentioned the method of contact, 69.6% mentioned who was contacted, and 17.4% reports mentioned date and time. Recommendation for follow-up was mentioned in 35 (17.8%) reports. In the cases that recommendations for follow-up were given, they were to perform 1) follow-up, 2) supplementary

imaging, or 3) no follow-up. Precise details on the required follow-up period were not provided, with the exception of one case. In this case the recommendations were to perform a follow-up within two weeks, which fits a recommendation for supplementary imaging.

Table 3.3. The description of pulmonary nodules in the reports

Characteristics	Categories	Outcomes	
		N	%
Mention in conclusion	Mentioned	100	50.8
	Unmentioned	97	49.2
Mention of contact	Mentioned	23	11.7
	Unmentioned	174	88.3
Recommendations	Mentioned	35	17.8
Follow- up	Unmentioned	162	82.2
Total		197	100

3.4 Association of predictive variables with the reporting methods

In the next paragraphs, the associations between the predictive variables and the mention of pulmonary nodules in the reports are discussed. We elaborate on ‘the mentioning of the pulmonary nodules in the conclusion’, ‘the mentioning of contact with medical specialists’ and ‘the mentioning of follow-up recommendations’. In Table 3.4 an overall summary of the statistics is provided.

3.4.1. Reporting of the pulmonary nodules in the conclusion

Half (50.8%) of the reports mentioned pulmonary nodules in the conclusion. Mentioning pulmonary nodules in the conclusion was not associated with: age, gender, calcification and attenuation (p -value = 0.87, 0.45, 0.85, and 0.10 respectively).

The mentioning of the pulmonary nodules in the conclusion was done significantly more frequent for the patients that had: a count of more than one nodule (p -value <0.01), nodules with a larger diameter (p -value = 0.03), and nodules that were located in the upper lobe (p -value <0.01). When the pulmonary nodules were perifissural, they were mentioned significantly less frequent in the conclusion (p -value <0.01). When the pulmonary nodules were suspected for metastases, they were always mentioned in the conclusion of the report.

3.4.2. Reporting of contact with medical specialist

Contact with a medical specialist about the incidental pulmonary nodules was mentioned in 11.7% of the reports. None of the predictive variables for malignancy had a significant relationship with the mentioning of contact with a medical specialist in the report. Reports that mentioned ground glass and suspicion for metastases mentioned contact with medical specialist most frequently, with 30.0% and

52.9% respectively. Yet, no relations between these predictive variables and the mentioning of contact was confirmed significant (p -value = 0.10 and 0.08).

3.4.3. Reporting of follow-up recommendations

The pulmonary nodules of which the largest nodule had a diameter larger than six millimetres, were significantly more frequently recommended for follow-up. In contrast, the pulmonary nodules with calcifications were never given follow-up recommendations. This relation between calcification and the mention of recommendations was significant (p -value = 0.05). When the reports mentioned perifissural nodules, there was a negative association with the mention of follow-up recommendations. (p -value <0.01). In 8 (7.8%) cases of reports mentioning perifissural nodules, a recommendation for follow-up was given. Included were the two cases that the recommendation was to not perform any follow up. Additionally, the recommendations were only given to patients that also had intra-pulmonary nodules next to the perifissural nodules. The other predictive variables had no association with the mention of follow-up recommendations.

Table 3.4. The mention of pulmonary nodules in the conclusion, of contact with a medical specialist, and of follow-up recommendations and the relation with variables associated with malignancy and benignancy.

Variables	Mention in conclusion			Mention of contact			FU ¹ recommendation								
	No	%	p-value	No	%	p-value	No	%	p-value	Total					
Age															
18-45	8	42.1	11	57.9	0.87	17	89.5	2	10.5	0.99	14	73.7	5	26.3	19
45-60	27	54.0	23	46.0		44	88.0	6	12.0		41	82.0	9	18.0	50
60-85	62	48.4	66	51.6		113	88.2	15	11.7		107	83.6	21	16.4	128
Gender															
Male	53	46.9	60	53.1	0.45	97	85.8	16	14.2	0.21	94	83.2	19	16.8	113
Female	44	52.4	40	47.6		77	91.7	7	8.3		68	81.0	16	19.0	84
Multiplicity															
Solitary	34	64.2	19	35.8	<0.01	49	92.5	4	7.5	0.26	39	73.6	14	26.4	53
Multiple	35	31.8	75	68.2		95	86.4	15	13.6		90	81.8	20	18.2	110
Size largest PN															
≤ 6 mm	23	47.9	25	52.1	0.03	40	83.3	8	16.7	0.75 ²	40	83.3	8	16.7	48
> 6 mm	5	20.8	19	79.2		19	88.9	5	20.8		15	80.6	9	37.5	24
Calcified															
Calcified	8	47.1	9	52.9	0.85	14	82.4	3	17.6	0.43 ²	17	100.0	0	0.0	17
Not calcified	89	49.4	91	50.6		160	88.9	20	11.1		145	80.6	35	19.4	180
Attenuation															
Ground-glass	2	20.0	8	80.0	0.10 ²	7	70.0	3	30.0	0.10 ²	8	80.0	2	20.0	10
Unmentioned	95	50.8	92	49.2		167	89.3	20	10.6		154	82.4	33	17.6	187
Location															
Upper lobe	5	14.7	29	85.3	<0.01	30	88.2	4	11.8	0.99	27	79.4	7	20.6	34
Other lobes/ Unmentioned	92	56.4	71	43.6		144	88.3	19	11.7		135	82.8	28	17.2	163
Position															
Perifissural	66	62.9	39	37.1	<0.01	94	89.5	11	10.5	0.58	97	92.4	8	7.6	105
Other	31	33.7	61	66.3		80	87.0	12	13.0		65	70.7	27	29.3	92
Metastases															
Suspected	0	0.0	21	100.0	<0.01	16	76.2	5	23.8	0.08 ²	17	81.0	4	19.0	21
Not suspected	97	55.1	79	44.9		158	89.8	18	10.2		145	82.4	31	17.6	176

1. "FU" is an abbreviation for "follow-up"

2. The percentage of cells that had an expected count of less than 5 is larger than 20.0%. Fisher's exact test (2-sided significance) is used instead of the chi-square test.

4. Discussion

4.1 Addressing the research questions

This study investigated the general practice of reporting incidental pulmonary nodules in the radiology department of the ZGT. From the period between September 2017 and August 2018, 197 reports with incidental pulmonary nodules were identified. The reporting of characteristics of the pulmonary nodules and the use of three reporting methods that influence the follow-up rate, were investigated from the content of these reports. In this paragraph the results of this study will be discussed and interpreted.

The incidence of reported incidental pulmonary nodules in the ZGT was 0.1% over the total number of radiological reports. Due to differences in study design, this incidence cannot be compared to incidences found in other Dutch studies such as the NELSON study or international studies such as Blagev et al (2017) [5, 18]. The latter of which is most similar to this study in design, but determined the rate of the reported incidental pulmonary nodules over the number of individual patients, instead of over the number of reports [18]. In this study, the function of determining the incidence was to provide the ZGT with context for the practice of the reporting of pulmonary nodules, which supports the aim of this study. The context is that incidental pulmonary nodules are only reported in a small portion of the only a small option of the total number of reports produced in the ZGT.

This study showed that when the pulmonary nodules were mentioned in the reports, the majority did not mention all predictive characteristics. Although the location of the nodules had less missing values (21.3% to 58.8%) than the characteristics of the nodules themselves (55.8% to 98.5%). As a result of the many missing values, it is not possible to do any comparisons of the incidence of predictive characteristics with other studies that were not dependent on the reporting rate of radiologists. Even though this study cannot provide any insight on the case mix present in the ZGT, it does provide the insight that radiologists are inconsistent in the reporting of characteristics that are important for determining the risk for malignancy.

The first reporting method investigated in this study was the ‘mentioning of pulmonary nodules in the conclusion of the radiological reports’. The results show that half of the reports mentioned the pulmonary nodules in its’ conclusion. For the patients with pulmonary nodules that had characteristics associated with malignancy, the reporting in the conclusion is increased to percentages between 79.2% and 100%. Blagev et al. (2017) concluded that when the incidental pulmonary nodules were only mentioned in the findings section of the radiological report, follow-up did not occur. On the other hand, the mention of incidental pulmonary nodules in the conclusion is significantly associated with an improvement on the performance of follow-up [18]. According to the Fleischner guidelines, pulmonary nodules with a diameter size exceeding six millimetres are advised to be included in follow-up. Additionally, the period of follow-up depends on the occurrence of other predictive characteristics for malignancy [6]. The positive association of the diameter size and other predictive characteristics

with the mention of the pulmonary nodules in the conclusion is an indication that radiologists have the communication of high risk cases in mind while writing their reports.

Second, ‘the mentioning of contact with the medical specialists’ in the report was studied. The NVvR guidelines, on which the IGJ based its’ judgement of the performance of the ZGT, recommend contact with medical specialists via telephone or email. Thereafter, the contact should be reported in the radiological report [1]. In this study, only a small part of the reports (11.7%) mentioned contact with a medical specialist. Thus, the ZGT does not follow-up the NVvR guidelines in reporting communications of incidental pulmonary nodules with medical specialists. These findings correspond with the conclusion of the IGJ report that the verification of the successfulness of the communication with medical specialists at the ZGT is performed insufficiently [2]. At least for the communications of incidental pulmonary nodules, this study confirms that the ZGT is in need of a system that gives feedback to the radiologist that the information sent to the medical specialist is received.

The final reporting method that was investigated was ‘the mentioning of follow-up recommendations’. The results showed that the majority (82.2%) of the radiological reports do not mention any form of follow-up recommendations. In cases that recommendations were given, no precise details on the required follow-up period were provided. Previous research shows that even though radiologists fail to comply sufficiently with the Fleischner guidelines for follow-up, their knowledge of the guidelines is sufficient [19, 20]. There were signs for a similar situation in the ZGT visible as well. For example, multiple radiological reports from the ZGT recommended to (translated from Dutch) “perform follow-up according to the Fleischner guidelines” (radiological reports from ZGT, PACS teach, April 15 2019). When asked about these findings, the reaction of a radiologist from the ZGT was that the opinions about who is responsible for determining the follow-up period, differ among radiologists and between radiologists and medical specialists. The radiologists chose to leave out recommendations for a follow-up period, because medical specialists prefer to determine the follow-up period themselves without interference of the radiologist (O. Vijlbrief, Neuro-radiologist ZGT, August 14 2019).

When comparing the significant associations between the predictive variables with the mention of pulmonary nodules in the conclusion and with the mention of follow-up recommendations, the majority of the outcomes correspond with what is to be expected from literature. However, two deviant outcomes were found. The first deviant outcome is the low number of reports that mention attenuation of the pulmonary nodules, even though attenuation plays a prominent role in the Fleischner guidelines for determining a suitable follow-up [6]. When mentioned in the radiological report, ground-glass was the only attenuation category present. This outcome corresponds with the fact that ground-glass is the attenuation category most associated with malignancy [6]. The second deviant outcome is that some reports that mention perifissural nodules recommended follow-up for these patients, even though perifissural nodules are associated with benignancy and therefore do not need follow up. [4] However,

half of the findings of perifissural nodules for which follow-up was recommended were found next to (sub)pleural nodules. Furthermore, perifissural nodules had a significant negative association with the mention of follow-up recommendations.

4.2 Reflection on the methodology

As for all studies, the design of this study has its strengths and limitations. This paragraph will reflect on the data collection and the data analysis. Thereafter, the limits to which the conclusions of this study can be applied to the practice of the ZGT are discussed and recommendations for further research are provided.

Considering the data collection, the researcher did not have the intention nor the expertise to analyse the radiological scans directly. As a result, this study was dependent on the limited amount of information that was provided by the radiologists in the radiological reports. By using this approach, it was still possible to successfully examine the practices regarding the reporting of pulmonary nodules and come with relevant findings for the ZGT with limited time and resources at hand. Nevertheless, the majority of the reports had missing values, which likely have caused some form of availability bias. Furthermore, it was often impossible to identify the characteristics of each of the separate pulmonary nodules in the report. For this reason, the data is collected on report level instead of nodule level. Consequently, precise risk profiles could not be determined, because they need combinations of characteristics of separate nodules. Also, multiple categories of one variable can apply to one report. To work with this principle, analysis was performed on the occurrence of categories associated with malignancy or benignancy in the nodules. However, the occurrence of the other categories should be taken into consideration while interpreting the outcomes of this study.

A disadvantage of the chi-test test is that it is sensitive for a small sample size. As a result, the test's assumptions were violated for some of the variables. For these cases, the Fisher's exact test was used instead. Despite the use of the Fischer's exact test, the findings for some of the variables had less statistical power. Meanwhile, for the analysis of the associations between the predictive variables and the mentioning of pulmonary nodules in the conclusion, the sample sizes for both categories of the dependent variable were relatively large, providing high statistical power for this analysis.

The results of this study only apply to the practice of the reporting of incidental pulmonary nodules in the ZGT. Even though there is an positive association between the reporting of the pulmonary nodules in the conclusion and the performance of the follow-up, no conclusions can be made on the performance of the follow-up of incidental pulmonary nodules in the ZGT. It is recommended to investigate the performance of the follow up, to determine if the current practice of reporting incidental pulmonary nodules is effective in communicating the findings to medical specialists. Additionally, further research should be conducted before making any assumptions or taking any action for incidental findings other than pulmonary nodules.

5. Conclusion and practical implications.

In this study, the practice of the reporting of pulmonary nodules as incidental findings in the radiology department of the ZGT is examined. In general, the reporting of pulmonary nodules throughout the reports had many unmentioned predictive characteristics. Half of these 197 reports mentioned the pulmonary nodules in the conclusion. This increased to 79.2% - 100% when predictive variables for malignancy were mentioned in the reports. The contact with medical specialists was reported less frequently (11.7%). Therefore, the ZGT fails to follow the recommendations of the NVvR on the communication of non-acute incidental findings. Furthermore, follow-up recommendations were only mentioned in a small part (17.8%) of the radiological report. When follow-up recommendations were given, no specific period for the follow-up was mentioned. Based on these findings, the final conclusion of this study is that in the practice of the reporting of incidental pulmonary nodules, the radiologists focus most on reporting incidental pulmonary nodules with characteristics associated with malignancy in the conclusion of the radiological report.

Currently, the management of the ZGT is orienting on implementing a system where the radiologists no longer e-mail information on non-acute incidental findings, but contact the medical specialists directly. Then, when contact has been established, the radiologists report the contact in the radiological report. If the medical specialist could not be reached via telephone, the case will be passed over to the secretary, where a new attempt of contact is made until it is successful. With this system, the ZGT will comply directly to the NVvR guidelines. Therefore, these developments seem generally promising. However, currently the radiologists are reporting contact with the medical specialists in such a low rate, that the implementation of the stricter system would require a large change in the organizational culture. Also, if the radiologists would be obligated to contact a medical specialist for all incidental findings, the number of telephone calls for pulmonary nodules would increase by 174 telephone calls per year. This extra number of telephone calls seems feasible to add to the workload of the radiologists. However, the policy would not only apply for pulmonary nodules alone, but for all other non-acute incidental findings as well. Since the NVvR provides the freedom for hospitals to develop their own methods to comply to their guidelines, we recommend the ZGT to search for an alternative solution.

The alternative solution that we recommended is to implement an ICT adjustment to the electronic patient dossier that would provide the possibility for the radiologists to directly send the incidental findings to the medical specialist to whom it concerns. Subsequently, the medical specialist should get a clear notification of the message in the electronic patient dossier. After the medical specialist has received the message, the ICT adjustment should provide them the opportunity to select an action, for example proceeding with a follow-up. When the action is selected, a notification is sent to the radiologists. This would create a feedback loop. If the radiologist does not receive a notification that the medical specialist has read the message, contact via telephone remains optional. Such an ICT adjustment

would not significantly add to the workload of the radiologists, since they already report the incidental pulmonary nodules in the conclusion in the majority of their report. Also, the system would spare the medical specialist the constant interruption of their work by telephone calls. Most importantly, the verification of the successfulness of the communication of the incidental findings would then be improved, as is suggested by the IGJ report. After the implementation of a new system for reporting incidental findings, this study provides the opportunity for the ZGT to use the results of this study as a benchmark for future comparison, which can provide evidence of improvement to the IGJ.

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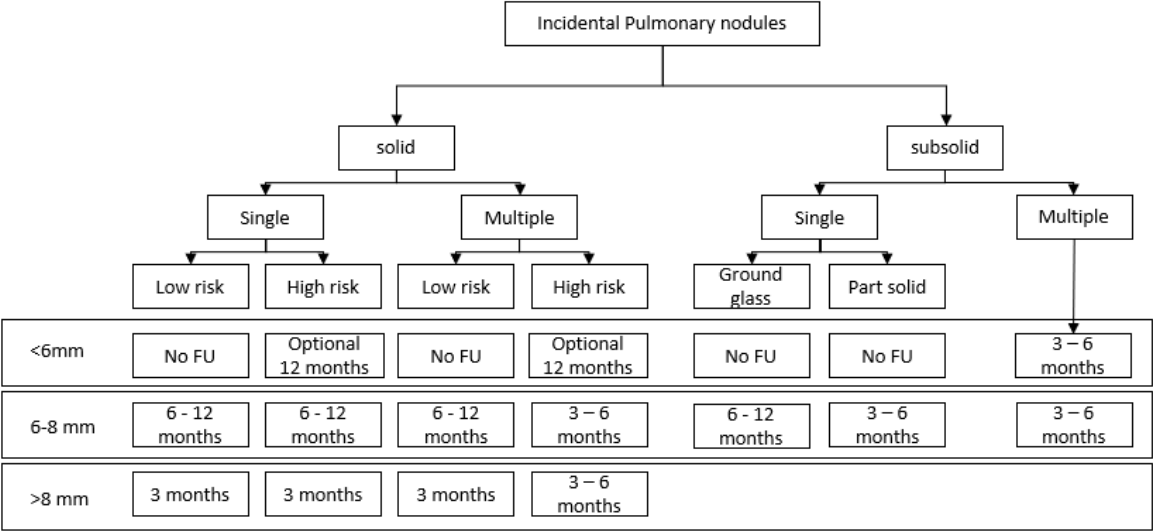
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Appendix A.

Decision tree for follow-up of pulmonary nodules as recommended by the Fleischner guideline 2017, derived from McMahon et al. (2017)



Appendix B.

Terminologies that indicate that there are no incidental pulmonary nodules mentioned in the report; with English translation.

Term in radiological report	Literal English translation	Categories
Geen PN ^{1*}	No PN	No PN
Geen verdachte PN ¹	No suspicious PN	No PN ^{2, 3}
Geen suspecte PN ¹	No suspicious PN	No PN ^{2, 3}
Geen nieuwe PN ¹	No new PN	No PN ^{2, 3}
Geen evidente PN	No obvious PN	No PN ^{2, 3}
Conform	conform	Known PN ⁴
Bekend(e)	known	Known PN ⁴
Ongewijzigd(e)	Unchanged	Known PN ⁴
Onveranderd	Unchanged	Known PN ⁴
Controle PN ¹	Follow-up PN	Known PN ⁴
Follow-up PN ¹	Follow-up PN	Known PN ⁴
FU PN ¹	Follow-up PN	Known PN ⁴
Stationair	Stationary	Known PN ⁴
Stabiele PN ¹	Stabel PN	Known PN ⁴
t.o.v. eerder.	Compared to earlier	Known PN ⁴
Toename/afname van PN ¹	Increase/decrease of PN	Known PN
Toename/afname in grootte PN ¹	Increase/decrease of the size of PN	Known PN
Progressieve PN	Progressive PN	Known PN
Geen nieuwe PN ¹	No new PN	Known PN ⁵

* In all tables included in this study, the term “pulmonary nodule” will be abbreviated as “PN”, of which “PNs” is plural.

1. PN or a synonym.
2. When it is the only thing said about PN in the report.
3. Is not applicable when an exception is mentioned.
4. Only when the term(s) is/are used to give information on the PN.
5. When the term is used next to the mention of other pulmonary nodules.