Use of Imaging in the Follow-up of Workers Exposed to Lung Carcinogens:

Practices in Occupational Medicine and its Determinants

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We studied occupational physicians' (OPs) practices of referrals for imaging of workers occupationally exposed to lung/pleural carcinogens and the factors associated with them. This cross-sectional telephone survey of 379 OPs practicing in Southeastern France showed that 81% of them referred exposed patients for chest radiographs, 33.5% for computed tomography (CT), and 16.1% for neither. Making no referral was positively associated with believing cancer risks are lower in one's own geographic sector than elsewhere and negatively associated with keeping employee risk records up-to-date. Referrals for CT were positively associated with work at in-house occupational health services (OHS), and completing employee exposure histories often/always. Both the OHS type and factors that may shape OPs' awareness of cancer risks in their sector appear to influence imaging referral practices. Occupational physicians would benefit from guidelines clarifying benefits and risks associated with imaging in such patients. An effort to harmonize regulatory provisions and guidelines also appears necessary. *Key words*: occupational health physicians; CT scanner; x-ray; radiography; lung neoplasms.

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Occupational exposure to carcinogens remains an important public health issue despite prevention efforts.[1] Approximately 5% of cancers in Europe are thought to be of occupational origin.[2,3] A 2003 survey estimated the prevalence of occupational exposure to carcinogenic products in France at 13.5%.[4] Because a large proportion of occupational cancers are lung cancers and mesothelioma[5–8] and the most important prognostic factor for lung cancer is stage at diagnosis,[9] early screening in populations occupationally exposed to lung carcinogens is an important issue. The published data now available do not provide evidence of the benefits, in terms of specific mortality, of lung cancer screening by chest radiography (CR), standard sputum cytology,[8] or computed tomography (CT).[10–12] For the moment and while we await the results of studies now underway, international guidelines do not recommend lung cancer screening in asymptomatic individuals except in the context of randomized studies.[9,13,14] Mesothelioma screening does not appear to be medically useful at this time, in view of the performance of potential screening methods and the absence of adequate treatment.[9,15]

Legislation in some countries nonetheless mandates that employees who are or were exposed to particular occupational carcinogens should receive periodic medical examinations during their working life and afterward.[16] In France, this medical surveillance for people still working is provided by occupational physicians (OPs). The national register of physicians includes about 7,000 OPs; about 70% of them have specialist training in occupational hygiene, acquired during a specialized residency. Regulations define the OP's role as an advisor to both the employer and employees. Only employees of the private sector are routinely monitored by OPs, although some workers in the public sector are monitored (i.e., public hospital employees as well as local government employees). Occupational physicians are responsible for monitoring workers' health and exposure as well as for assessing each workstation to identify its hazards and assess its risks.

Besides lung cancer screening, medical surveillance of workers exposed to lung carcinogens may be useful for the detection of nonmalignant pleuropulmonary lesions that may result from some carcinogens, such as

asbestos. Such lesions, however, may be still less amenable to any intervention than malignant diseases.[9,17] Detection of malignant or nonmalignant lesions may trigger the mechanisms for compensation (for example, indemnification).[18] The Labour Code in France defines the criteria for the implementation of this surveillance (such as the list of carcinogens for which it applies), but does not define its contents,[19] except for specific cases.[20] Guidelines as to when and how such surveillance should be applied were published in 1999 in France for specific categories of workers exposed to asbestos.[18] They were not updated until April 2010, 12 months after our interviews ended. Finally, we are aware of no studies that have examined OPs' practices regarding medical surveillance after occupational lung exposure.

Between January and April 2009, we conducted a cross-sectional telephone survey of OPs in Southeastern France to determine their opinions, practices, and attitudes toward the prevention, screening, and reporting of occupational cancers. This article focuses on the use of different types of imaging during the medical follow-up of workers exposed to lung or pleural carcinogens, referred to as lung carcinogens. Its aims are to evaluate the extent to which OPs refer these workers for CR, CT, or neither, as well as to study the factors associated with each choice. Based on a previous qualitative study of OPs,[21] we tested the hypotheses that choices may be influenced by the type of occupational health service (OHS) in which the OP works, the constraints associated with it, and by the OPs' awareness of occupational risks in the companies he or she serves.

MATERIAL AND METHODS

Study Population

In France, OPs practice in two principal kinds of OHS: in-house and outsource service providers. In large companies (more than 250 employees), OHS are usually in-house: Employers must organize the monitoring of their employees' health themselves, and OPs are, therefore, company employees. Most companies, however, purchase OHS from an independent contractor, that is, they outsource their regulatory duties to a business supplying these services. Such outsource OHS contractors employ OPs to provide monitoring to numerous enterprises. We will generally refer to them as OHS contractors or outsource service providers. There were 559 OPs in the study area at the time of the study (OHS contractors: 426; in-house: 133). In light of these small numbers, we tried to contact all of them.

Survey Procedure

We began by sending OPs a letter explaining the goals of the survey and its procedure. Two weeks later, professional interviewers used a computer-assisted telephone interview system to call and question the OPs. Before concluding that an OP could not be reached, interviewers had to make 15 attempts at different times of the day and on different days.

Questionnaire

We developed a standardized questionnaire based on an earlier qualitative study of the practices and attitudes of OPs toward occupational cancer prevention, screening, and reporting.[21] The questionnaire was then pilot-tested with 10 OPs for length, clarity, and face-validity. It covered the physicians' professional characteristics, practices, attitudes, and opinions in the field. The questionnaire can be found in the Appendix to this article. In the preliminary letter sent before the survey, we asked the OPs to look for some of these data (Appendix) in their 2007 "annual reports." Each OP must prepare this report each year according to a standardized format and send it to the regional labor department officials. This report must describe the OP's annual activity; it is a source of statistical data about the characteristics of the population they follow. The questionnaire included the following questions: "In the case of occupational exposure to lung carcinogens, do you refer the patient for: CR (yes/no)/CT (yes/no)?" We also included the question: "In your daily practice, are you bothered by the lack of regularly updated guidelines about the referral of patients for screening tests for occupational cancers?" For this question, participants answered on a scale ranging from 0 (not at all bothered) to 6 (greatly bothered).

Statistical Analysis

We used Fisher exact tests to compare qualitative variables and the ANOVA F-statistic for quantitative variables. We performed simple and then stepwise multiple logistic regressions to test factors associated with the following two dependent variables (p entry = 0.15; p exit > 0.05): "referring employee for neither CR nor CT versus referring them for at least one radiological test" or "referring employee for CT versus CR alone" for subjects occupationally exposed to lung carcinogens. We forced age, gender, and the OHS type (in-house and outsource contractors) in the models. We systematically tested the following categories of explanatory variables: (1) professional characteristics; (2) knowledge of occupational risks in the companies followed; (3) practices in the companies followed; and (4) perceptions of occupational risks and opinions on their evaluation and management in the companies followed. We used the Hosmer & Lemeshow statistic to test model fit. The analysis was performed with SAS® (SAS Institute Inc.®, Cary, NC, USA, v9.1).

TABLE 1 Characteristics of the Occupational Physicians who Participated in the Study (Southeastern France, 2009)

	Type of Occupational Health Service			
	Contractor (*n* = 286)	In-house (*n* = 93)	Total (*n* = 379)	*p**
Sociodemographic characteristics				
Gender				
Male	28	22.6	26.6	0.35
Female	72	77.4	73.4	
Age in years (± SD)	53.3 (±7.1)	52.8 (±6.9)	53.2 (±7)	0.54
Professional characteristics				
Years of practice[a]	19.0 (±9.3)	17.9 (±9.8)	18.8 (±9.4)	0.3
Half-days in the workplace in 2007				
≤ 100	39.1	57	43.5	< 0.001
> 100	42.7	19.3	37	
NSP	18.2	23.7	19.5	
Companies monitored in 2007				
≤ 300	42	93.5	54.6	< 0.001
> 300	49.3	0	37.2	
NSP	8.7	6.5	8.2	
Workers followed in 2007				
< 1500	4.2	40.9	13.2	< 0.001
1501–2500	29.4	41.9	32.5	
> 2500	59.8	9.7	47.5	
Unknown	6.6	7.5	6.8	
Workers requiring close monitoring in 2007***				
≤ 872**	44.8	45.2	44.9	0.8
> 872	45.4	43	44.9	
NSP	9.8	11.8	10.2	

*Fisher's exact test for qualitative variables, ANOVA for quantitative variables (SAS® V9.1)
**Median
***Definition in appendix

RESULTS

We reached 523 of 559 OPs, 71 of whom were ineligible (because they were ill, deceased, retired, or had moved outside the study area). Of the remaining 452 eligible OPs, 380 (84.1%) agreed to participate. Because missing data required the exclusion of one questionnaire, 379 questionnaires were analyzed. The response rate did not differ according to OHS type ($p = 0.17$). Overall, participants' mean age was 53.2 years, and their mean duration of practice 18.8 years; 73.4% were women. These characteristics did not differ according to the OHS type, but the number of half-days in the workplace did: it was higher in contractor than in-house OHS (Table 1). Participation in research was reported more frequently by contractors than in-house OPs (56.6% versus 45.2%, $p = 0.06$).

Eighty-one percent of OPs referred patients for CR (with or without CT), 50.4% for CR alone, 33.5% for CT (with or without CR), 2.9% for CT alone, and 16.1% referred patients for neither. The lack of guidelines for these referrals bothered 41% of OPs greatly (Table 2).

The multiple logistic regressions showed that making no referrals was positively associated with lack of knowledge of the number of workers requiring close monitoring (see definition in Appendix) in one's own geographic sector in 2007, believing that cancer risks are lower in one's own geographic sector than in others, and reporting a satisfactory margin of maneuver in the companies followed. It was negatively associated with always keeping occupational risk and employee risk records updated in one's company files (see definition in Appendix) and participating in scientific research (Table 3). A positive association was found between referring patients for CT (versus referring them for CR only) and working at an in-house OHS, a high number of employees receiving close monitoring, lack of knowledge of this number, and completing exposure histories for employees leaving their company often or always (Table 4).

DISCUSSION

Most OPs referred subjects exposed to lung carcinogens for CR while only 33.5% referred them for a CT and 16.1% for neither. Our results suggest that this heterogeneity may have several causes: some associated with regulations and available guidelines, others with OHS constraints, and finally others with factors that may shape OPs' awareness of cancer risks.

TABLE 2 Occupational Physicians' Self-reported Practices Related to Screening for Work-related Cancers (Southeastern France, 2009)

	Type of Occupational Health Service			
	Contractor (n = 286)	In-house (n = 93)	Total (n = 379)	p*
You refer workers exposed to respiratory carcinogens for (% yes):				
CR	81.8	78.5	81	0.54
CR alone	55.9	33.3	50.4	< 0.001
CT	29.4	46.2	33.5	0.004
CT alone	3.5	1.1	2.9	0.31
Neither	14.7	20.4	16.1	0.2
The lack of regularly updated guidelines on screening for work-related cancers bothers you:				
Slightly, if at all (0–2)	16.8	31.2	20.3	0.01
Moderately (3–4)	39.9	35.5	38.8	
Greatly (5–6)	43.3	33.3	40.9	

*Fisher's exact test for qualitative variables, ANOVA for quantitative variables

Statutory and Regulatory Requirements

Two situations must be distinguished for people still working: occupational exposure (past or current) to asbestos and to other carcinogens. French labor regulations do not specify the content of monitoring for most of the latter (that is, arsenic and its derivatives, chromium, iron oxides, *bis*-(chloromethyl) ether, and nickel). It, thus, leaves the choice of examinations to the OPs. The same regulatory vagueness exists for asbestos exposures except for the particular situation of current risk of exposure during asbestos removal or confinement operations: In those cases, labor regulations call for a CR every two years, but CT is not mentioned.[20] In the case of asbestos exposure, CR may be justified by the detection of nonmalignant pleuropulmonary lesions (such as pleural plaques, asbestosis, and visceral pleural fibrosis). Computed tomography provides a more specific work-up and diagnosis of such lesions.[22]

Available Guidelines and Discrepancies with Regulations

At the time of the survey, in early 2009, OPs did not have any recent practice guidelines for the follow-up of employees exposed to asbestos or other pulmonary carcinogens. The only French guidelines were those from a consensus conference on medical monitoring of people exposed to asbestos, published in 1999. For workers exposed to moderate levels of asbestos, these guidelines recommended CR, and for those exposed to high levels, CT alone. A new guideline was published very recently (April 2010), one year after our study started, on the follow-up of retired workers exposed to asbestos in the past.[17] It is, thus, not directed at OPs, who see only patients who are currently employed. This recent guideline recommends the establishment of a specific system for post-retirement follow-up of people who were occupationally exposed to asbestos, basing this recommendation on the "right of people exposed to asbestos to know their health status" and on "the existence of compensation measures." Computed tomography is to be offered to people who were exposed for at least one year, with a minimum latency period of 20 or 30 years depending on the certainty, duration, and level of exposure, but only after the subjects are informed about the "expected results and benefits" of this examination, "the consequences in terms of morbidity and mortality of the invasive diagnostic explorations that might ensue from the results (in particular, non-negligible risks associated with lung surgery of benign lesions)," and the absence of any demonstrated medical benefits of such a CT screening for either malignant or non-malignant disease for these subjects. Finally, the guidelines do not recommend pulmonary radiography for screening for conditions, malignant or not, associated with asbestos exposure. Although not aimed at OPs, these guidelines raise questions about their prescription practices for lung radiography and for imaging, in particular, before the expiration of the minimum recommended latency periods (20 or 30 years), justified by the latency periods of asbestos-related diseases. The follow-up of employees exposed to pulmonary carcinogens other than asbestos is not discussed in these guidelines even though these are now the most common of all exposures to pulmonary carcinogens.[4]

The lack of updated recommendations at the time of our study was reported to bother 41% of the participants greatly (Table 2). This finding is in line with the results of previous studies that suggest that OPs are more positive than general practitioners toward evidence-based guidelines.[23] Additionally, discrepancies between regulations and available guidelines may impede the implementation of evidence-based practices in occupational medicine, as underscored elsewhere.[24] Occupational physicians are also likely to favor heterogeneity in practices, as our results suggest for CT referrals.[25]

TABLE 3 Factors Associated with Referral for Neither CR nor CT (61 OPs) for Workers Occupationally Exposed to Lung Carcinogens versus Referral for CR and/or CT: Simple and Multiple Logistic Regressions* (n = 379)

Explanatory Variables	n	Unadjusted OR	p Wald	Adjusted OR	95%CI
Sociodemographic characteristics					
Gender					
Men	101	1		1	
Women	278	0.93	0.81	0.95	0.49–1.83
Age (in years, continuous)	379	1.02	0.34	1.01	0.97–1.06
Type of OHS					
Contractor	286	1		1	
In-house	93	1.49	0.19	0.94	0.47–1.87
Knowledge factors					
Workers requiring close monitoring in 2007, in the companies followed	≤ 872	170	1	1	
> 872	170	0.69	0.22	0.73	0.38–1.39
Unknown	39	1.91	0.11	2.94	1.21–7.14
Activities: scientific research					
No	175	1		1	
Yes**	204	0.5	0.01	0.52	0.29–0.95
Practice factors					
Update employee risk records in company files:					
Never/sometimes	157	1		1	
Often	143	0.52	0.04	0.51	0.26–1.02
Always	79	0.47	0.06	0.37	0.16–0.87
Risk perception and opinions factors					
In terms of carcinogenic exposure, compared with other geographic sectors, your own sector is at:					
Greater risk	66	1		1	
Less risk	184	2.78	0.03	2.75	1.06–7.13
Similar risk	105	1.29	0.63	1.14	0.39–3.31
No response	24	1.43	0.63	1.72	0.36–8.1
Your margin for maneuver for workplace activities is:					
Nonexistent to satisfactory (0–6)	379	1.3	0.03	1.43	1.09–1.88
The risk assessment and employee safety plan accurately reflects the risks					
Never/sometimes	136	1		—	—
Often	158	1.52	0.23	—	—
Always	64	2.26	0.05	—	—
Never or rarely have access to it	21	4.03	0.01	—	—

*Stepwise logistic regression (entry threshold p = 0.15, exit threshold p = 0.05); Hosmer and Lemeshow test: p = 0.79; percentage of concordant pairs: 71.9

Note: Variables tested but not significant in the simple regressions (and not presented above):

- Professional characteristics: Workers followed (according to your 2007 activity report);
- Knowledge factors: Are you involved in the evaluation of your professional practices? Professionally, do you spend time in trade union activities? In teaching activities?
- Practice factors: Do you complete carcinogenic exposure histories for workers leaving their company?
- Risk perception and opinions factors: How high a priority do you think prevention of occupational cancers is in your geographic sector. Globally, do you consider that risk assessment of carcinogenic risks is satisfactory in the companies you follow? In your practice, what are the obstacles to preventing occupational cancer risks? Lack of time? Lack of resources?

Role of OHS Constraints

Computed tomography referrals (versus CR alone) varied according to the type of OHS, independently of other variables (Table 4). This may be linked in part to financial constraints: The high cost of CT (compared to CR) may limit referrals for CT in some OHS with strict financial constraints.[21] In France, examinations ordered by OPs are paid for either by the employer or by the OHS. In-house departments have the financial resources to facilitate referral for CT because they are in large companies. The outsource contractors, however, cannot

TABLE 4 Factors Associated with Referral for CT (with or without CR, n=127 OPs) of Workers Occupationally Exposed to Lung Carcinogens versus Referral for CR Only: Simple and Multiple Logistic Regressions* (*n* = 318)

Explanatory Variables	*n*	Unadjusted OR	*p* Wald	Adjusted OR	95%CI
Sociodemographic characteristics					
Gender					
Male	84	1		1	
Female	234	0.97	0.91	0.95	0.55–1.62
Age (in years, continuous)	318	1	0.93	1	0.97–1.04
Type of OHS					
Contractor	244	1			1
In-house	74	2.64	< 0.001	2.38	1.37–4.15
Knowledge factors					
Workers requiring close monitoring in 2007 in the companies followed					
≤ 872	141	1		1	
> 872	149	1.64	0.04	1.83	1.1–3.03
Unknown	28	2.38	0.04	2.84	1.21–6.68
Practice factors					
Complete exposure histories for workers leaving their company					
Never	170	1		1	
Sometimes	90	0.89	0.68	0.90	0.51–1.57
Often/always	58	2.92	< 0.001	2.87	1.51–5.45
Perception and opinions factors					
Assessment of carcinogenic risks is satisfactory in the companies followed					
Never	99	1		—	—
Sometimes	130	1.3	0.35	—	—
Often/always	89	2.95	< 0.001	—	—
Lack of resources is an obstacle to preventing occupational cancer risks					
Disagree	149	1.00		—	—
Agree	169	0.64	0.05	—	—

*Stepwise logistic regression (entry threshold $p = 0.15$, exit threshold $p = 0.05$). Hosmer and Lemeshow test: $p = 0.72$; percentage of concordant pairs: 66.9%.

Note: Variables tested but not significant in the simple regressions (and not presented above):

- Professional characteristics: Workers followed in 2007
- Knowledge factors: Are you involved in the evaluation of your professional practices? Professionally, do you spend time in trade union activities? In teaching activities? In scientific research activities?
- Practice factors: Do you update employee risk records in the company files for the companies you monitor regularly?
- Risk perception and opinions factors: How high a priority do you think prevention of occupational cancers is in your geographic sector? In terms of carcinogenic exposures, compared with other geographic sectors, would you say that your own sector is at: higher risk, lower risk, or a similar risk? Does the risk assessment and employee safety plan accurately reflect the reality of the risks in the companies you follow? What do you think is your margin for maneuver for activities in the workplace of the companies you follow? In your practice, what are the obstacles to preventing occupational cancer risks? lack of time?

always make the generally small companies for which they work pay for the CT nor can they—or do they—always want to pay for it themselves. In these conditions, the OP will sometimes tell employees to see their general practitioner for a referral for the examination.

Factors that May be Linked to Occupational Physicians' Awareness of Occupational Risks

The results of the multiple logistic regressions showed that the decision about referral was associated with factors that may shape OPs' awareness of the risks in the companies they follow, independent of OHS: their perceptions of occupational risks (that is, their subjective judgment about them), factors affecting their knowledge of these risks (that is, of their objective components), and practices regarding their evaluation.

Perception factors. Occupational physicians who perceived lower cancer risks in their geographic sector than elsewhere ordered radiological testing less often than others. The same relation was observed for OPs who reported that they had a sufficient margin of maneuver in the companies monitored: These OPs may have some latitude to implement prevention activities in the companies they follow and may thus be more confident about actual occupational exposures and their prevention.

Knowledge factors. Lack of referral for radiological testing (either CR or CT) was associated with OPs' lack of knowledge of the number of workers requiring close monitoring (Appendix) in the companies they follow (Table 3). This number must be indicated in the annual report that must be prepared each year by each OP and sent to regional labor authorities. The lack of knowledge of this number might indicate a certain lack of thoroughness in completing this report and reflect lower awareness of cancer risks in the companies OPs follow.[21]

The reasons for higher referrals for radiological imaging by OPs participating in research (Table 3) versus those who do not are unclear. Participation in research might affect the way OPs update their medical knowledge and perhaps also modify their adherence to guidelines and regulations.[25] Further investigation of this association showed that it existed in contractors (CI95% = [0.21–0.81]), but not in in-house OPs (CI95% = [0.31–2.37]), consistent with the contractors' higher rate of participation in research.

Practice factors. The frequency with which OPs complete individual exposure histories for workers leaving the company was positively associated with referral for CT (Table 4). The more often OPs update the company file (Appendix) the more often they refer workers exposed to pulmonary carcinogens for radiological testing (either CT or CR, Table 3). Both practices imply that OPs devote time both to monitoring workers and assessing the workstations at the companies, and both may increase OPs' awareness of the individual and collective risks in the companies they monitor.

We hypothesize that OPs aware of the risks are more likely to perceive an ethical requirement to refer workers for imaging (as opposed to doing nothing) and more often for CT rather than CR alone. These OPs would probably prefer to follow the dictates of an "obligation of means" (that is, due care) rather than "do nothing" or "less," especially when the medical evidence is unclear. They would prefer CT to CR because of its better performance in detecting pleuropulmonary lesions, perhaps because they are not necessarily aware of the risks associated with invasive diagnostic explorations of benign lesions (lung surgery). This attitude may be reinforced by demands of exposed workers for compensation and the public controversy about the responsibility for the epidemic of asbestos-related diseases observed in France.[26]

Strengths and Limitations of the Study

The response rate for this survey (84.1%) was high, and the distribution of the participants according to sex, age, and type of OHS was essentially as expected, that is, consistent with the national statistics on OPs.[27] Some of the information collected in the survey, on the characteristics of the OPs, their work practices, and the employees they handle, was obtained from their annual report, a source of information that may be considered different from self-reported data. This report incorporates routine statistics calculated by each OP. Nonetheless, these statistics may not always be reliable. This lack of reliability is unlikely, however, to affect our findings substantially, given that orders of magnitude are more important here than exact figures. We had planned a study design using the collection of information from employee files to evaluate OPs' practices, but decided that it was not feasible because of the lack of standardization of these files. For the same reason, we were not able to collect information to evaluate the percentage of employees that OPs referred for CR/CT, nor could we document the percentage of the referrals that resulted in the diagnosis of cancer. Because this survey was cross-sectional, when interpreting the associations observed, one must bear in mind the impossibility of demonstrating causality. Finally, in interpreting these results, we must bear in mind that OPs' imaging prescription practices might differ for patients with exposure to asbestos and to other carcinogens: the content of the regulations slightly differs between them (as mentioned previously), and no recommendation has been published for lung carcinogens other than asbestos.

CONCLUSION

To our knowledge, this study is the first to provide results about the practices of OPs in referring employees exposed to pulmonary carcinogens for imaging. It shows that the referral for CR after this type of exposure is a common practice among OPs in Southeastern France, while CT referral is not. Our study suggests that these practices are not based on medical evidence but rather are associated with OHS constraints and OPs' awareness of the risks of occupational cancers in the companies they monitor.

The publication of up-to-date guidelines directed at OPs on the topic of the appropriate medical monitoring and screening tests for people occupationally exposed to pulmonary carcinogens appears necessary. Such guidelines should be adapted to the OPs' environment; they should, in particular: (1) take into account all currently known occupational pulmonary carcinogens, not just asbestos; (2) clarify knowledge about the individual and collective benefits and risks of screening, according to the type of potential malignancy (bronchopulmonary cancer or mesothelioma) or nonmalignant diseases: and (3) propose a detailed overall follow-up strategy that takes into account the social context, including compensation regulations. An effort to harmonize regulatory provisions and good practice guidelines also appears necessary. Further research is needed in particular to assess the percentage of referrals for CR/CT by OPs, to document their

outcomes in terms of cancer diagnosis and to assess the impact of recommendations specifically designed for OPs', should these be published.

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