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Body Imaging

Mapping the cancer imaging research landscape: which cancers are more and which cancers are less frequently investigated?

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ABSTRACT

Objective: To investigate the proportion of published imaging studies relative to incidence and mortality rate per cancer type.

Methods: From a random sample of 2500 articles published in 2019 by the top 25 imaging-related journals, we included cancer imaging studies. The publication-to-incidence and publication-to-mortality ratios (defined as the publication rate divided by the proportional incidence and mortality rate, respectively) were calculated per cancer type. Ratios >1 indicate a higher publication rate compared to the relative incidence or mortality rate of a specific cancer. Ratios <1 indicate a lower publication rate compared to the relative incidence or mortality rate of a specific cancer.

Results: 620 original cancer imaging studies were included. Female breast cancer (20.2%), prostate cancer (13.0%), liver cancer (12.9%), lung cancer (8.8%), and cancers in the central nervous system (8.1%) comprised the top 5 of cancers investigated. Cancers in the central nervous system and liver had publication-to-incidence ratios >2, whereas nonmelanoma of the skin, leukemia, stomach cancer, and laryngeal cancer had publication-to-incidence ratios <0.2. Cancers in the prostate, central nervous system, female breast, and kidney had publication-to-mortality ratios >2, whereas esophageal cancer, stomach cancer, laryngeal cancer, and leukemia had publication-to-mortality ratios <0.2.

Conclusion: This overview of published cancer imaging research may be informative and useful to all stakeholders in the field of cancer imaging. The potential causes of disproportionality between the publication rate vs. incidence and mortality rates of some cancer types are multifactorial and need to be further elucidated.

1. Introduction

Cancer is a major health problem and a leading cause of mortality.^{1,2} Imaging plays an essential role in the management of cancer, with important contributions to diagnosis, guiding biopsy and treatment, and determining treatment response and prognosis.^{3,4} A search in Medline using the terms “cancer” and “imaging”⁵ demonstrates a considerable increase of the number of studies related to cancer imaging between the years 2000 and 2021 (9774, 20,413, and 41,316 citations in the years 2000, 2010, and 2021, respectively).

Incidence and mortality rates are leading metrics in determining the global burden of individual cancer types.² These metrics could possibly also guide societies' priorities for cancer research. Identification of cancer types that stay relatively underexposed in the scientific literature

relative to their incidence and mortality may be important for policy makers, funding bodies, patient organizations, scientists, and journals to reconsider research and publication priorities. A previous study that evaluated publications in several leading general medicine and oncology journals showed that some cancer types are relatively underrepresented, whereas other cancer types are relatively overrepresented relative to their incidence.⁶ However, such data are currently lacking for research performed in the medical imaging field.

The purpose of this study was therefore to investigate the proportion of published imaging studies relative to incidence and mortality rate per cancer type.

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2. Methods

In accordance with the Dutch Medical Research Involving Human Subjects Act, ethical approval from a medical ethics committee was not required for this bibliographic study, which has a retrospective, non-blinded design.

2.1. Study selection

The Journal Citation Reports website⁷ was searched for the top 25 imaging-related journals in the category “Radiology, Nuclear Medicine & Medical Imaging” according to impact factor (IF). Journals which only publish articles on cardiovascular imaging, radiation therapy or obstetrics, and journals which only publish review articles, were excluded. The 25 selected journals are displayed in Table 1. Altogether, these 25 journals published 9010 articles in PubMed/Medline in 2019. A random sample of 2500 articles (27.7%) was extracted from these 9010 articles using the random number generator in Microsoft Excel (Microsoft Corporation). Original studies and systematic reviews/meta-analyses on cancer imaging were included. Studies which were not directly related to cancer, studies which were not directly related to imaging, and studies on radiation therapy were excluded. Commentary, editorial, case report, narrative review, guidelines/society statement, erratum, retraction notification, or study description (i.e., the article only reported the design of a study), it was also excluded. The study selection flowchart is shown in Fig. 1. After exclusion of 1880 studies, a total of 620 studies were finally included (Fig. 1).

2.2. Data extraction

For each included study, the type (s) of cancer investigated (based on codes from the International Statistical Classification of Diseases and Related Health Problems 10th Revision²), the publication date, the study topic (i.e., descriptive imaging features, diagnosis, health services research and policy, image guided biopsy, image guided treatment, prediction of treatment response, prognosis, technical development study, nuclear therapy, combination, or other), whether the study concerned an original study or a systematic review/meta-analysis, and the number of citations as indicated on Clarivate Analytics's Web of Science on November 21, 2021,⁸ were extracted. Any single study that included

Table 1
Names and impact factors (IFs) of the 25 selected journals.

Journal	IF
Radiology	11.105
Journal of Nuclear Medicine	10.057
European Journal of Nuclear Medicine and Molecular Imaging	9.236
Clinical Nuclear Medicine	7.794
Ultraschall in der Medizin	6.548
Investigative Radiology	6.016
Journal of the American College of Radiology	5.532
European Radiology	5.315
Insights into Imaging	5.231
Journal of Magnetic Resonance Imaging	4.813
Diagnostic and Interventional Imaging	4.026
American Journal of Roentgenology	3.959
Cancer Imaging	3.909
American Journal of Neuroradiology	3.825
Ultrasonography	3.675
Clinical Neuroradiology	3.649
European Journal of Radiology	3.528
Korean Journal of Radiology	3.500
Journal of Vascular and Interventional Radiology	3.464
Journal of Neuroradiology	3.447
Academic Radiology	3.173
British Journal of Radiology	3.039
Abdominal Radiology	3.039
Journal of Thoracic Imaging	3.000
Ultrasound in Medicine and Biology	2.998

multiple types of cancer was first divided according to the ratios of the different cancer types in that study. The publication rate per cancer type was then calculated as the number of studies for a specific cancer type divided by the total number of included studies. The proportional incidence and mortality rates of each cancer type (i.e. relative to all cancers types) were extracted from the GLOBOCAN 2020 worldwide cancer estimates.² Note that GLOBOCAN estimates are not affected by the impact of COVID-19, because they are based on cancer data from earlier years before the COVID-19 pandemic.²

2.3. Data analysis

For each cancer type, we determined the publication-to-incidence ratio and the publication-to-mortality ratio. The publication-to-incidence ratio was calculated as the publication rate divided by the proportional incidence of each cancer type. The publication-to-mortality ratio was calculated as the publication rate divided by the proportional mortality rate of each cancer type. Ratios >1 indicate a higher publication rate compared to the relative incidence or mortality rate of a specific cancer. Ratios <1 indicate a lower publication rate compared to the relative incidence or mortality rate of a specific cancer. Type. Linear regression analysis was performed to assess the association between the type of cancer investigated and citation rate, adjusted for the number of days since the study has been published, the IF of the journal in which the study was published, study topic, and whether or not the study was an original study or systematic review/meta-analysis. Level of significance was set at $P < 0.05$. Statistical analyses were performed by using IBM SPSS Statistics for Windows (Version 25.0, IBM Corporation, Armonk, NY, USA).

3. Results

3.1. Cancer types studied

Fig. 2 displays the percentages of imaging studies per cancer type. Most imaging studies concerned female breast cancer (20.2%), prostate cancer (13.0%), liver cancer (12.9%), lung cancer (8.8%), and cancers in the central nervous system (8.1%). All together, these malignancies comprised 63% of all cancer types studied. 8.6% of imaging studies were categorized as “other”, which encompasses all cancers that each account for less than 1% of all cancer types studied.

3.2. Publication-to-incidence ratio

The publication-to-incidence ratios for the different cancer types ranged from 0 to 5.04 (Fig. 3). Cancers in the central nervous system (5.04) and liver (2.74) had publication-to-incidence ratios >2, whereas nonmelanoma of the skin (0), leukemia (0), stomach cancer (0.10), and larynx cancer (0.07), had publication-to-incidence ratios <0.2.

3.3. Publication-to-mortality ratio

The publication-to-mortality ratios for the different cancer types ranged from 0 to 3.43 (Fig. 4). Cancers in the prostate (3.43), central nervous system (3.23), female breast (2.92), and kidney (2.13) had publication-to-mortality ratios >2, whereas esophageal cancer (0.16), stomach cancer (0.07), laryngeal cancer (0.07), and leukemia (0) had publication-to-mortality ratios <0.2.

3.4. Post-hoc subanalysis

Central nervous system cancers were shown to have high publication-to-incidence and publication-to-mortality ratios, but this may be related to the fact that 3 of the top 25 imaging-related journals that were investigated concerned subspecialty neuroradiology journals (*American Journal of Neuroradiology*, *Clinical Neuroradiology*, and *Journal*

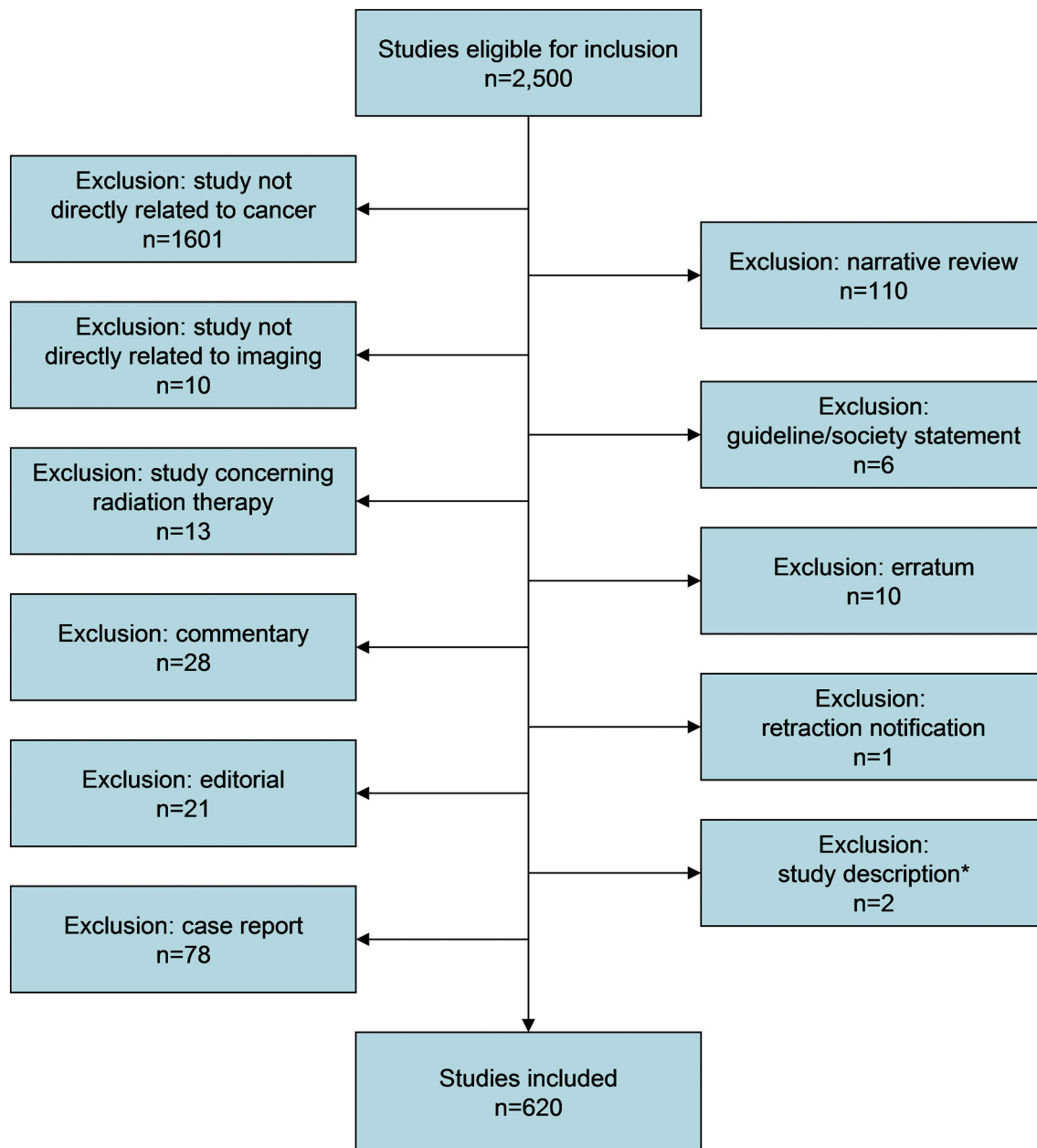


Fig. 1. Flow diagram of the study selection process.

*The article only reported the design of a study.

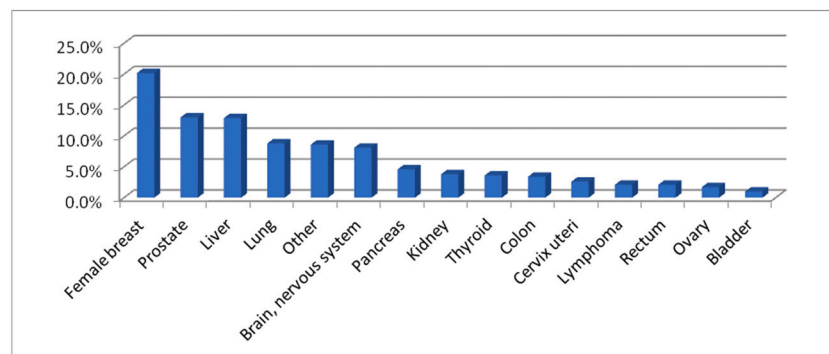


Fig. 2. Proportion of imaging studies per cancer type.

Cancers constituting less than 1% of all studied cancer types are not displayed in the graph.

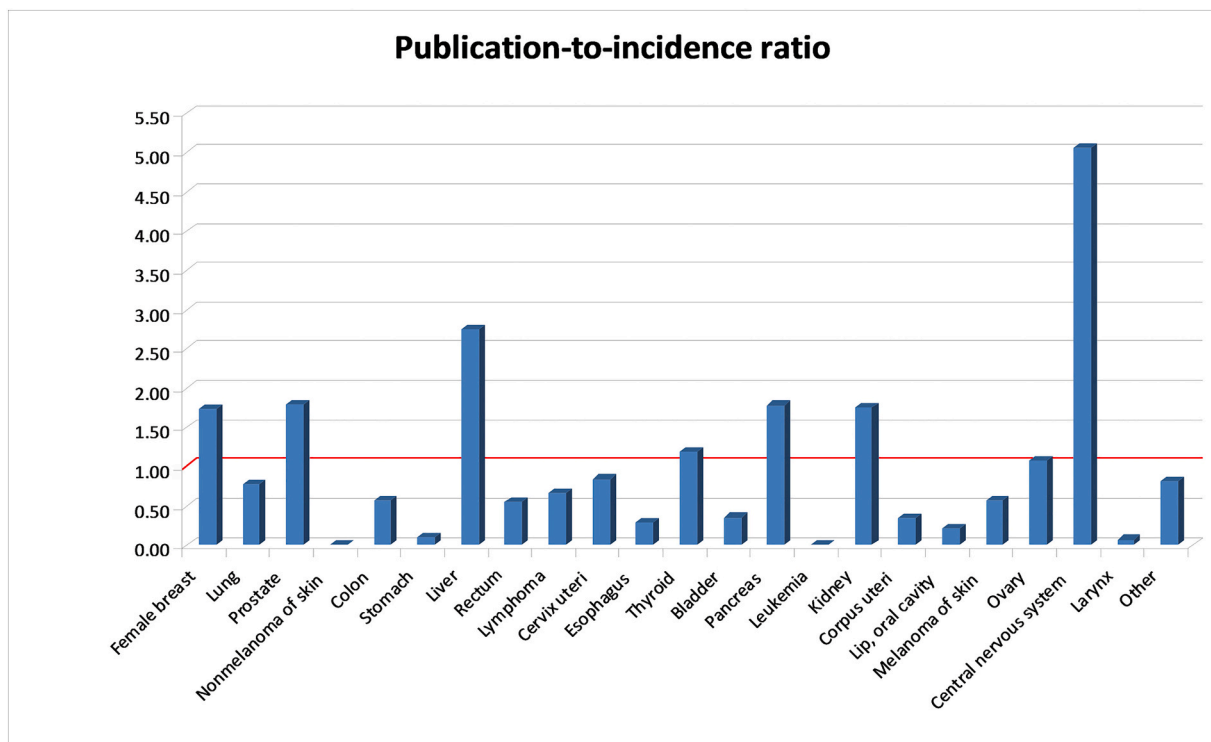


Fig. 3. Publication-to-incidence ratio per cancer type. Cancers with an incidence of less than 1% compared to the incidence of all cancers are not displayed in the figure. Ratios >1 indicate a higher publication rate compared to the relative incidence of a specific cancer. Ratios <1 indicate a lower publication rate compared to the relative incidence of a specific cancer.

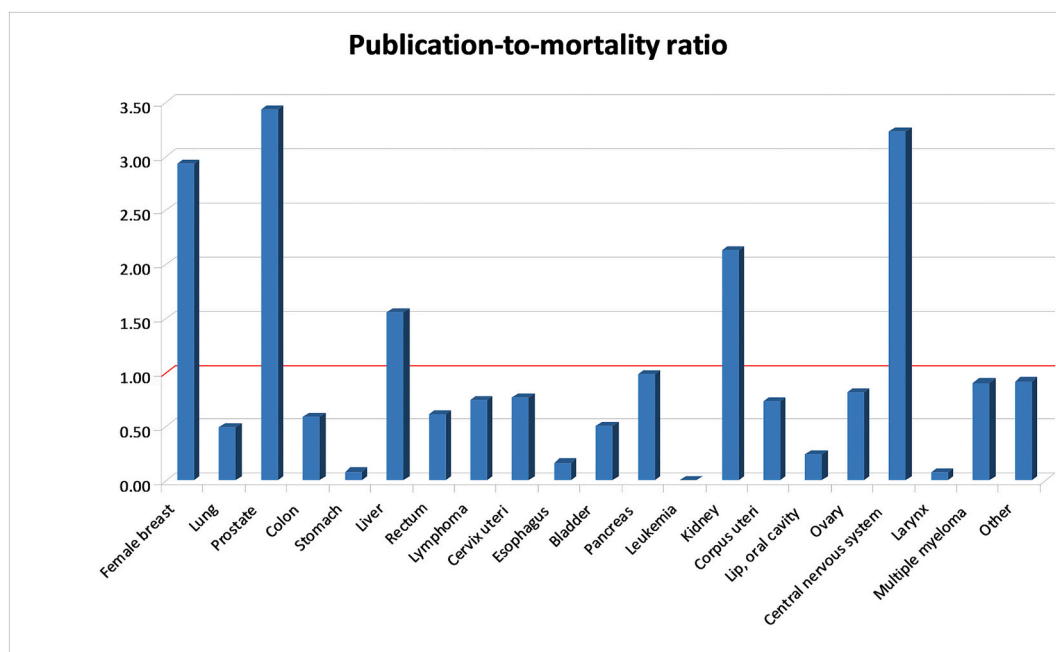


Fig. 4. Publication-to-mortality ratio per cancer type. Cancers with a mortality rate of less than 1% compared to the mortality rate of all cancers are not displayed in the figure. Ratios >1 indicate a higher publication rate compared to the relative mortality rate of a specific cancer. Ratios <1 indicate a lower publication rate compared to the relative mortality rate of a specific cancer.

of *Neuroradiology*). Therefore, a post-hoc subanalysis was performed to assess this potential relationship. However, after exclusion of studies published in these 3 neuroradiology journals the publication-to-incidence and publication-to-mortality ratios of cancers in the central nervous system remained high (4.12 and 2.64, respectively).

Only 20 out of 2500 included studies (0.8%) concerned systematic reviews/meta-analyses. The exclusion of these studies did not affect the results.

3.5. Citation rate

In adjusted linear regression analysis, the type of cancer investigated was not significantly associated with citation rate ($P \geq 0.26$ for all cancer types).

4. Discussion

Cancer imaging research is booming, as can be deduced from the increasing number of publications in this field.⁵ However, an overview of the distribution of studies with regard to which cancer types are being investigated has been lacking so far.

The publication-to-incidence and publication-to-mortality ratios for central nervous system cancer remained high after exclusion of three subspecialty journals in neuroradiology, which indicates a disproportionate distribution in more general imaging journals as well. Interestingly, the type of cancer investigated was not significantly associated with citation rate. This suggests that cancers with high publication-to-incidence or publication-to-mortality ratios do not achieve a higher impact (in terms of citations per publication) compared to studies with lower publication-to-incidence or publication-to-mortality ratios.

The current overview of the status of cancer imaging research may be informative and useful to any stakeholder in cancer imaging (including policy makers, funding bodies, patient organizations, researchers, and journals). The unbalanced publication-to-incidence and publication-to-mortality ratios of some cancers can be attributed to the fact that some cancer types typically would not require imaging, such as non-melanoma of the skin and leukemia. This fact could skew the data. However, it is also plausible that some cancer types are simply under-investigated although they are important in terms of incidence and/or mortality. The researcher's and/or institutional's choice to perform imaging-related research depends among others on the institution's patient population, the clinical demand, expected clinical impact of the research, prior expertise, and technical possibilities. Some cancer types may be more easier/more straightforward to image than other cancer types, such as tumors which typically grow to large sizes and with high metabolic activity. Furthermore, the availability of financial resources is a definite factor which influences the possibility to perform imaging-related research. Funding bodies for cancer imaging research may be influenced by public interest in different cancer types, which is not necessarily equivalent to the relative societal burden of each cancer type. Although our results do not provide direct evidence to support the hypothesis that some cancer types are simply underinvestigated, they give reason for further analysis and reflection. This may perhaps lead to a more equal distribution of research resources among the various cancer types, and ultimately improve the effectiveness of cancer imaging research for the needs of society.

A previous bibliometric study of publications in leading general medicine and oncology journals in the year 2007 showed that some cancer types (including breast, prostate, lung, and intestinal cancer) may be relatively underrepresented in the scientific literature, whereas rarer malignancies may be relatively overrepresented with respect to their actual incidence.⁶ Another study that used National Cancer Institute funding data from 2010 showed that some cancer types (including breast cancer, prostate cancer, and leukemia) were funded at levels far higher levels than their relative societal burden, whereas other cancer

types (including bladder, esophageal, liver, oral, pancreatic, stomach, and uterine cancers) were relatively underfunded.⁹ To our knowledge, there are no other recent studies related to this topic and in particular not in the field of cancer imaging. As such, the findings of our study may serve as a baseline and benchmark for future studies.

Our study has some potential imitations. First, it remains speculative why there is a disproportion between the publication rate vs. the incidence and mortality rates of some cancer types. Further study is needed to elucidate the potential causes of disproportionality. Second, we only included studies published by the top 25 imaging-related journals according to IF. However, these leading journals may be considered to have the highest clinical impact. Furthermore, a high IF may be considered a reasonable indicator of the quality of a journal.¹⁰ Third, we included studies that were published in 2019, which may not represent the most actual status of cancer imaging research. However, we choose not to include studies published in 2020 or 2021, because of the possible confounding effect of the COVID-19 pandemic.¹¹

In conclusion, this overview of published cancer imaging research may be informative and useful to all stakeholders in the field of cancer imaging. The potential causes of disproportionality between the publication rate vs. incidence and mortality rates of some cancer types are multifactorial and need to be further elucidated.

Declaration of competing interest

All authors have no conflicts of interest to declare.

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