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## Original Research

# Mapping the European cancer prevention research landscape: A case for more prevention research funding

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## ABSTRACT

Despite the strong evidence of prevention as a prime defence against the disease, the majority of cancer research investment continues to be made in basic science and clinical translational research. Little quantitative data is available to guide decisions on the choice of research priorities or the allocation of research resources. The primary aim of the mapping of the European cancer prevention research landscape presented in this paper is to provide the evidence-base to inform future investments in cancer research. Using bibliometric data to identify funders that are active in prevention research in Europe and in the world, we have identified that 14% of cancer research papers had a focus on prevention research and those were funded by 16% of all the European cancer research funders. An important finding of our study is the lack of research on primary prevention with primary prevention funders accounting for 25% of European cancer prevention funders, meaning that less than 4% of all European cancer research funders identified show an interest in primary prevention. An additional analysis revealed that 7% of European cancer prevention research papers are categorised as implementation projects, meaning that only 1% of all cancer research publications are implementation research in cancer prevention. This paper highlights that the narrow focus on biology and treatment in Europe needs to be widened to include such areas as primary prevention and secondary prevention and a larger concentration on implementation research. These data can help support a more policy-focused cancer research agenda for individual European governments and charitable and philanthropic organisations and stimulate joining efforts across Europe to create a more systematic and structured approach to cancer prevention.

## 1. Introduction

Cancer is not a disease of the modern world; it is one that has been evolving with human history [1]. Cancer is the second leading cause of premature mortality defined as the potential years of life lost between the ages of 30–70 years [2]. With life expectancy increasing globally, around 1 in 5 persons are expected to develop cancer during their lifetime and 1 in 10 persons will lose their life to it [3].

In 2020 in Europe, defined in this study as the 40 countries in the

four United Nations-defined areas of Europe, 4.4 million people were diagnosed with cancer (excluding non-melanoma skin cancer), and 1.9 million died from this disease [4]. Numbers are estimated to increase by 2040–21% cancer incidence and 29% cancer death reaching 5.3 million cases and 2.5 million deaths, respectively [5], leading to more than 100 million new cancer patients over the next 20–25 years [6]. Estimations suggest that around 40% of cancers in Europe could be prevented if the current understanding of risk and protective factors was translated into effective primary prevention strategies [7,8] with further reductions in

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cancer incidence and mortality by screening, early detection, and medical prevention.

There has been tremendous scientific progress in the last 20 years. The progress in early detection and treatment has reduced the mortality from cancer to the point that cancer patient's prognosis and the chance of survival from several cancers have increased markedly [9]. These improvements have resulted in populations of cancer survivors facing considerable physical, social and psychological comorbidities in addition to the suffering associated with most cancer care. Cancer not only impacts patients, but it also severely affects the emotional health of their families and friends, rendering an important economic burden for societies, composed of direct costs, informal care costs combining services delivered by relatives and friends, and indirect costs pertaining to productivity loss from premature mortality and loss from morbidity. In 2018, the total cost of cancer was €199 billion in Europe (EU-27 plus Iceland, Norway, Switzerland, and the United Kingdom) from which €103 billion amounted for direct cost, or health expenditure on cancer care, alone [10]. These numbers, combined with the inadequate health system responses in place, are proof that governments cannot rely on care alone as a cost-effective cancer control measure to face the cancer burden. An integrated approach aligning at its forefront primary and secondary prevention backed by evidence-based cancer prevention research is warranted.

Despite the strong evidence of prevention as a prime defence against the disease, the majority of cancer research investment continues to be made in basic science and clinical translational research with the focus on the development of new therapies or improving treatment [11]. Successful coordination of cancer prevention in Europe requires long-term vision, a shared research agenda, and strategically targeted funding that can only be achieved with a good understanding of the current cancer prevention research funding landscape [12]. The primary aim of the mapping of the European cancer prevention research landscape presented in this paper is to provide the evidence-base to inform future investments in cancer research.

## 2. Methodology

### 2.1. Data extraction

The study builds on a previous mapping exercise using bibliometric data as the initial basis for creating a comprehensive database on all cancer research funding entities. Details are provided elsewhere [13], but in summary, funding acknowledgements were used as an indirect way to identify the cancer research funding actors in the period between 2008 and 2018. Funding institutions were extracted using the Clarivate Core Collection Web of Science (WoS) Database from the funding acknowledgements of a study set of more than 775,000 cancer research papers (articles and reviews) from 12,000 different journals. The investigation focused broadly on funding for cancer research along the axes of support to research projects, research infrastructures, and long-term research-based training such as doctorate or post-doctoral fellowships. All types of research were included: biomedical, clinical, population-based, health services, and social and behavioural. On the other hand, funding for advocacy, medical training, outreach activities, and cancer service delivery was excluded. For the purpose of this inventory, the database was updated to include the years 2019–2021, bringing the total number of cancer research funders identified in the World and in Europe to 4998 and 1477 respectively.

This study was designed to extract entities funding cancer prevention research and analyse trends. Cancer prevention has a broad scope, encompassing surveillance and descriptive data (e.g. incidence, mortality, survival and prevalence; economic analyses including cost-effectiveness; the prevalence of exposure to risk factors) as well as the areas of primary, secondary and tertiary prevention, and research in this domain ranges from the submicroscopic study of the mechanisms of carcinogenesis to the supramacroscopic analysis of the causes, also

known as the social determinants of health. A prevention research taxonomy consisting of a total of 65 keywords was developed with multi-disciplinary cancer researchers (see [annex 1](#)). The distinction between the different areas of cancer prevention were made following the three areas defined in the Common Scientific Outline (CSO) [14]: Aetiology, Primary Prevention and Early Detection, Diagnosis, and Prognosis (this refers in our study to “secondary prevention”). Tertiary prevention was excluded as it is classified as cancer care in the CSO and is outside the scope of the study.

Since WoS began routinely indexing funding acknowledgements data in 2008, our dataset for the part on bibliometrics is limited to the last decade. All cancer research papers published in WoS from 2008 to 2021 and containing at least one prevention-specific title keyword were extracted. The results were pooled into a set of studies comprising more than 123,300 research articles on cancer prevention, of which 38,000 were from Europe, i.e. the number of publications whose lead authors were affiliated with European-based institutions (including international organisations).

### 2.2. Data processing

A “bottom-up” approach similar to that used in the first study was applied, where funding acknowledgements were used to identify funders that are active in prevention research, to characterise aspects of their support, and assess trends in cancer prevention research. The results were limited to organisations that were either cited as funding sources in at least 13 research papers in the period between 2008 and 2021 (one per year) or at least in three research papers between 2018 and 2021 (to include more recently established organisations). On these parameters, the query resulted in 1798 data points for funding sources. Because the raw data from WoS give a wide array of names for any given individual funding entity, considerable manual investment was required to bring the list down to true unique values. The funding sources were thus manually standardised to remove variants of organisations' names and compared to the initial database of all cancer research funding entities, bringing the total to 576 unique values for the World and 243 for Europe.

In line with the methodology of the first study, organisations were classified according to 18 different types of legal status and then grouped into five broader categories for a simplified overview: governmental organisation, international organisation, not-for-profit (including charities, associations, foundations and cancer societies), private sector entity, and research facility (which include academic institutions, research institutes, hospitals, and research networks). Institutions and programmes that are part of larger legal entities but that manage their own research programmes and are endowed with their own budgets were treated as separate sources of funding. This includes, for instance, the 13 funding mechanisms of the European Commission involved in cancer research funding. To minimise the differences between regional governance models, regional or municipal governments and their divisions were considered as a single entity.

In order to identify implementation research projects, a sample of 2000 European cancer prevention research papers from the last 5 years were manually checked and coded, according to the National Institute of Health and Institute of Medicine endorsed description of translation stage 3 (“T3”) research [15]. Such research investigates may include assessment of: evidence-practice gaps; barriers or enablers of policy or practice change; quality improvement initiatives; or effectiveness, implementation and dissemination intervention trials.

## 3. Results

### 3.1. Who funds cancer prevention research in Europe?

Our analysis revealed that 14% of the 271,400 cancer research papers published by researchers affiliated to European institutions in the

period between 2008 and 2021 had a focus on prevention research and those were funded by 243 European organisations, representing 16% of the 1477 European cancer research funders identified in our previous study. These findings are particularly relevant when compared to estimations suggesting that 40% of cancer in Europe can be prevented through effective prevention (see above). Cancer prevention research funders are present in 23 European countries with 94% of them in the European Union (Fig. 1).

A comparison between global and European levels of prevention research funding indicates that Europe does slightly better in this area, with more cancer research papers focused on prevention published in Europe (14% of all cancer research papers published between 2008 and 2021) than in the World (11% of all cancer research papers published between 2008 and 2021) and more European cancer research funders interested in prevention research (16%) than in the World (12%) (Fig. 2a, b). European not-for-profit organisations are also more involved in prevention research as compared to the world, as they account for 45% of European cancer prevention research funders (Fig. 3a) and represent 15% of all European not-for-profit organisations funding cancer research (Fig. 2b). In comparison, 35% of cancer prevention research funders in the world are not-for-profit entities (Fig. 3a) and represent only 8% of all not-for-profit organisations funding cancer research (Fig. 2a). In addition, European not-for-profit received 31% of funding acknowledgements in our dataset while this percentage is 20%

for the World (Fig. 3b).

Although a direct link between funding acknowledgements and funding received cannot be established, funding acknowledgements provide indirect evidence of which funder might be supporting relatively more or less research in cancer prevention, compared with other research domains. European governmental sources (including the European Commission) represent 31% of the cited organisations (Fig. 3a) but received 48% of funding acknowledgements in our dataset (Fig. 3b). Thus, government funders support more cancer prevention research than typical not-for-profit organisations. Maybe unsurprisingly, only 8% of European prevention research funders are for-profit entities while they account for 16% of funders of all cancer research (Fig. 3a).

The number of funding acknowledgements per country was compared as an indicator of funders overall support for cancer prevention research, Germany and Italy are the three most acknowledged countries in cancer prevention research projects. By restricting the scope of funding acknowledgements to not-for-profit organisations, the United Kingdom, Spain and Sweden are the most active in cancer prevention research (Table 1). One reason for this may be the large number of funders of cancer research and cancer prevention research in these countries. Italy and Spain, in particular, have a large number of not-for-profit organisations supporting cancer prevention research. It is interesting to note that France is one of the main funders of cancer research in Europe but is less focused on cancer prevention research. These twelve

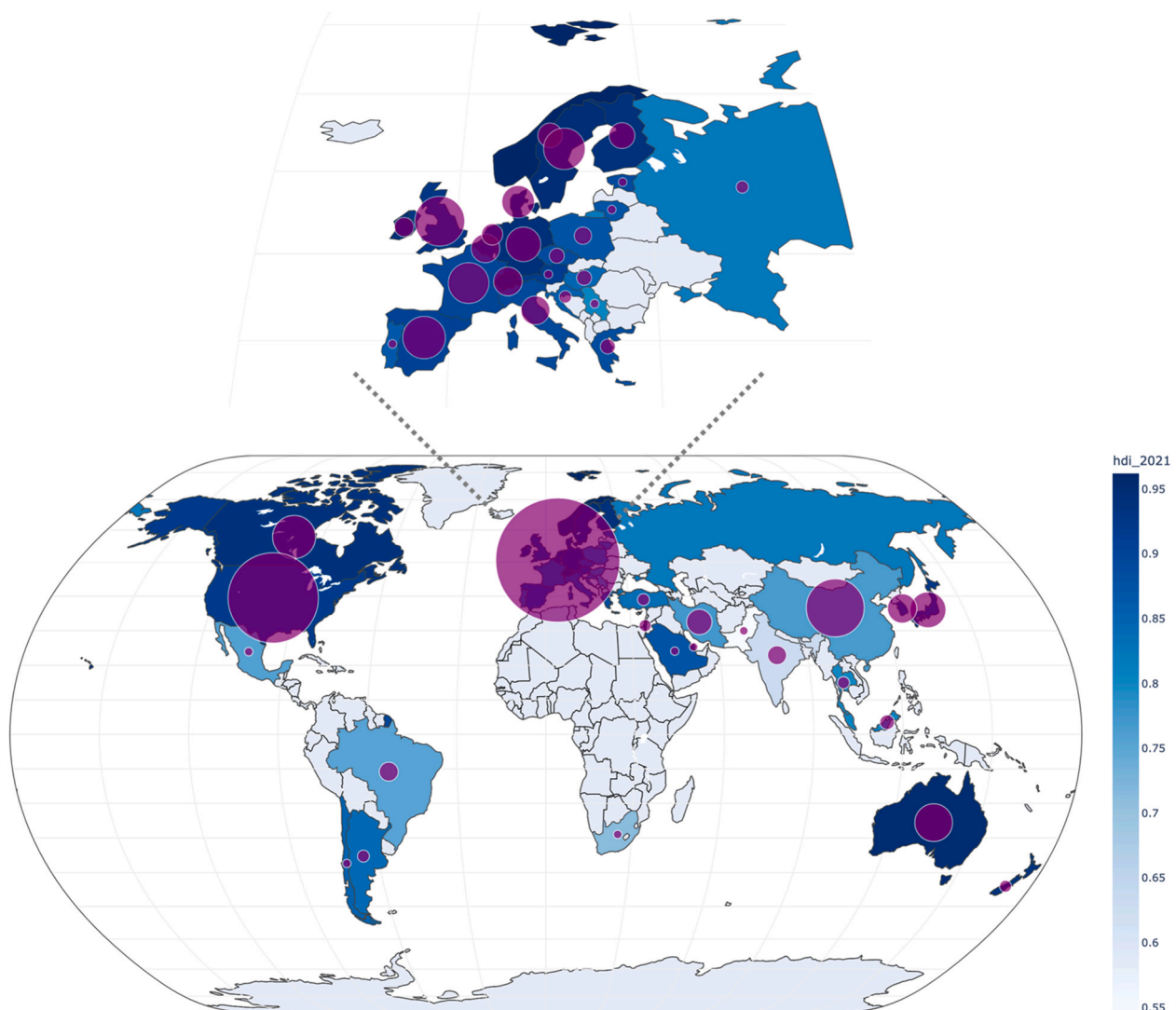
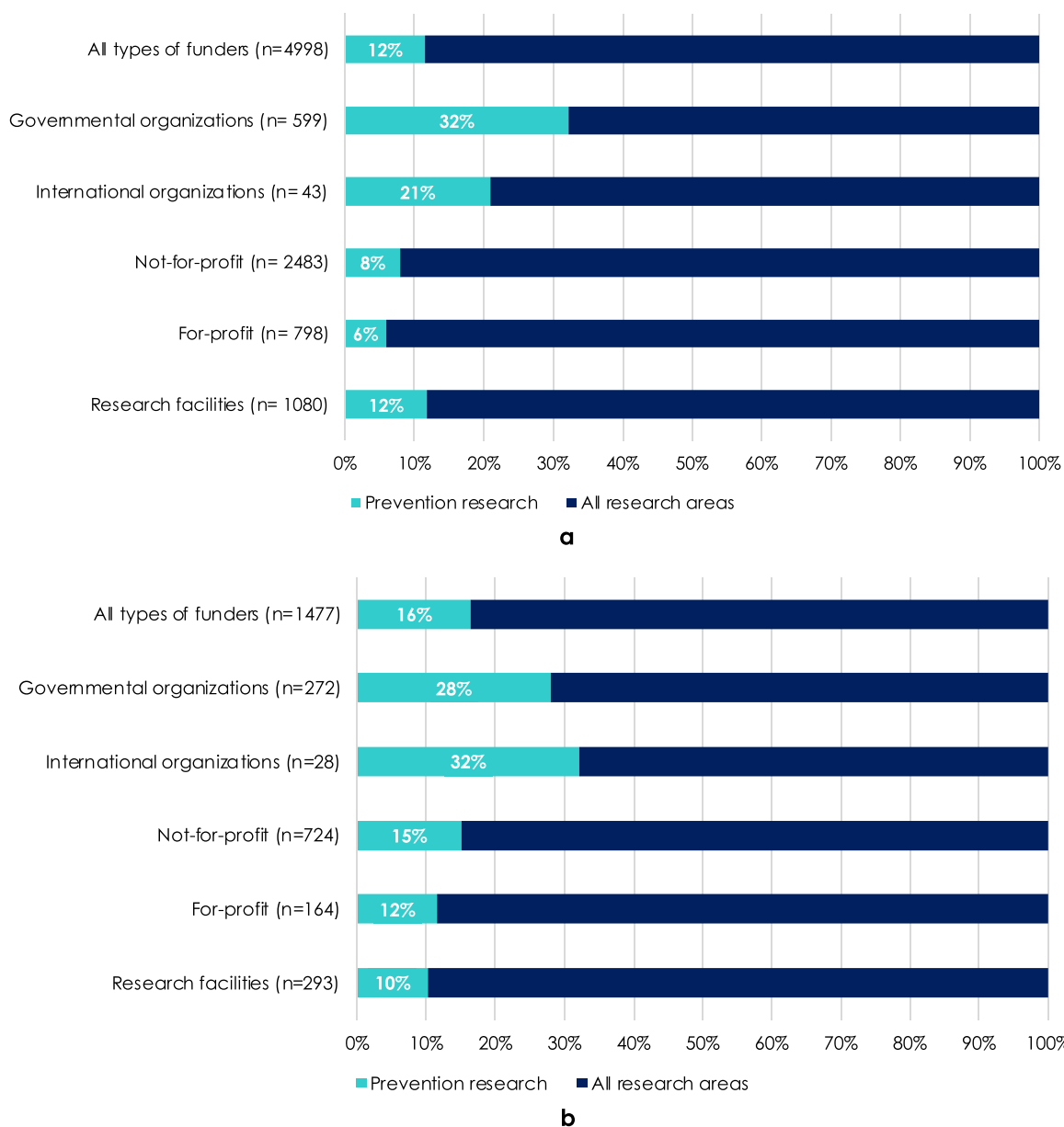


Fig. 1. Geographical representation of the number of funders supporting cancer prevention. HDI = Human Development Index.



**Fig. 2.** (a) Percentages of prevention research funders in the world for all cancer research funders. (b) Percentages of prevention research funders in Europe for all cancer research funders.

countries represent 81% of the 1477 prevention research funders in Europe but provide the main effort in terms of cancer prevention research (92% of the total funding acknowledgements).

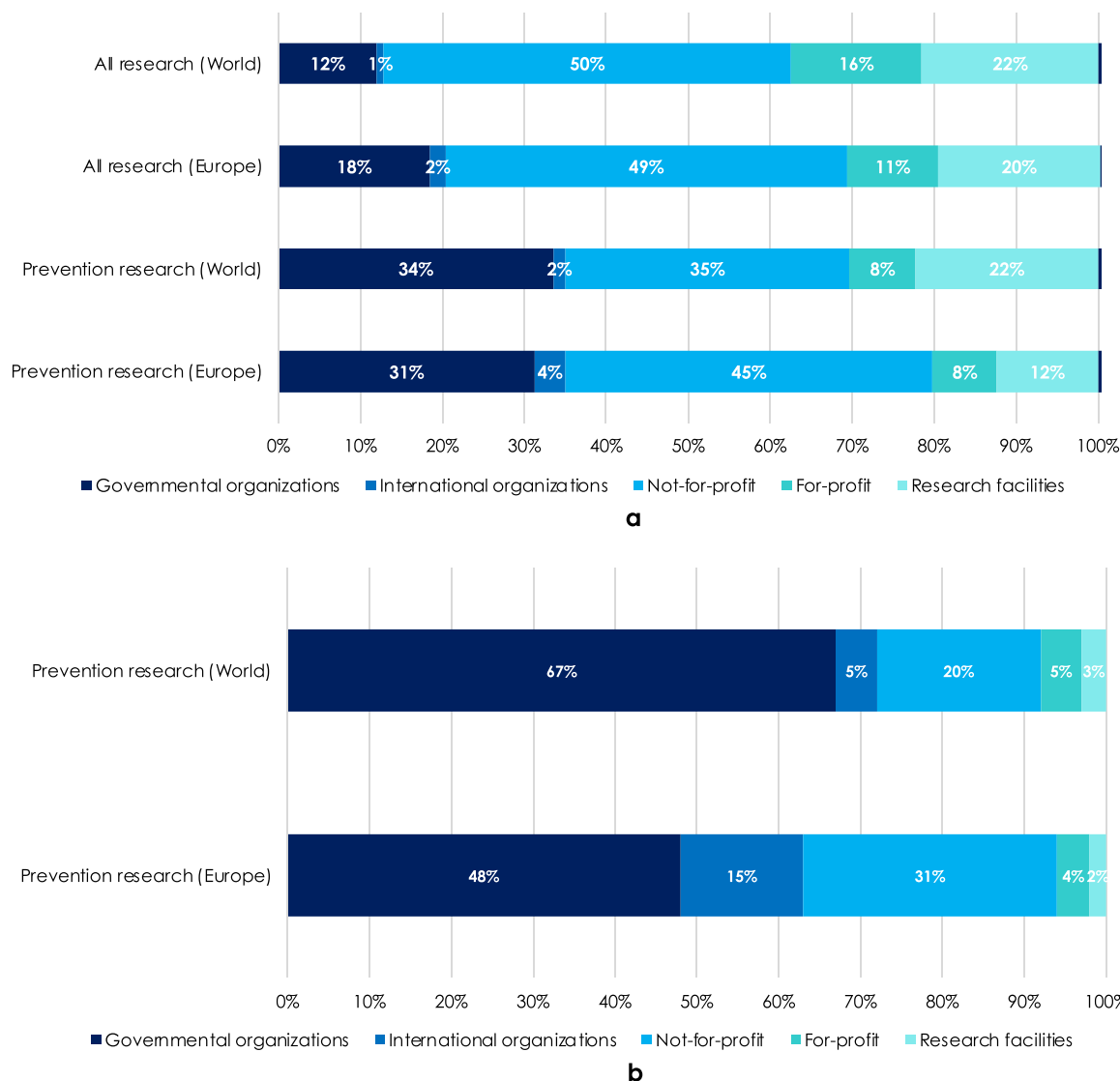
The evolution of cancer prevention research funders is another relevant element of comparison. The total number of European funding sources for cancer prevention research has more than doubled since 2008, resulting in a proportional increase in prevention research papers. This is primarily due to the multiplication of not-for-profit organisations and governments involved in prevention research as the number of other types of funding entities such as industry has stagnated. However, while interest in prevention research is steadily growing at a global scale, the last 6 years have been marked by a slowdown of the growth rate of the number of European cancer prevention research funders (Fig. 4).

**3.2. Primary prevention: a consistently neglected research area**

A breakdown by research areas in cancer prevention reveals that secondary prevention is the most funded area with 52% of European

cancer prevention research funders interested in it (Fig. 5b). Aetiology is funded by 47% of European cancer prevention research funders. Primary prevention is the least funded prevention research area, though higher in Europe with primary prevention funders accounting for 25% of European cancer prevention funders compared to 20% in the World (Fig. 5a). From a broader perspective, this means that less than 4% of the 1477 European cancer research funders identified show an interest in primary prevention.

European not-for-profit funders are associated with a greater proportion of secondary prevention as they represent 23% of secondary prevention funders (16% for the world) (Fig. 5a, b) and are acknowledged in 32% of secondary prevention research papers (Fig. 5c). In contrast, they represent only 8% of secondary prevention funders (Fig. 5b) and are acknowledged in 12% of primary prevention research papers (Fig. 5c). Governments (including the European Commission) are active on a slightly larger proportion of primary prevention with 13% of primary prevention funders being identified as governmental entities (Fig. 5b) and 69% of papers in primary prevention research containing



**Fig. 3.** (a) Types of cancer research funders for prevention research and all research in Europe and in the world. (b) Percentage of funding acknowledgements for cancer prevention research in Europe and in the world, by type of funder.

**Table 1**

Top 12 most acknowledged European countries in cancer research papers and cancer prevention research papers (2008–2021). FA = funding acknowledgements.<sup>a</sup>

Countries	Numbers of funders (all cancer research)	Percentages of FA received by funders (all cancer research)	Numbers of funders (cancer prevention research)	Percentages of FA received by funders (cancer prevention research)	Percentages of FA received by governmental organisations (cancer prevention research)	Percentages of FA received by not-for-profit organisations (cancer prevention research)
<b>United Kingdom</b>	213	15%	<b>34</b>	<b>13%</b>	13%	12%
<b>Germany</b>	151	11%	<b>17</b>	<b>11%</b>	12%	7%
<b>Italy</b>	69	7%	<b>12</b>	<b>10%</b>	12%	8%
<b>Spain</b>	48	6%	<b>25</b>	<b>10%</b>	10%	12%
<b>Sweden</b>	69	9%	<b>24</b>	<b>10%</b>	9%	11%
<b>France</b>	92	12%	<b>23</b>	<b>9%</b>	11%	8%
<b>Denmark</b>	39	6%	<b>15</b>	<b>6%</b>	4%	7%
<b>Netherlands</b>	32	5%	<b>7</b>	<b>5%</b>	4%	5%
<b>Belgium</b>	33	4%	<b>12</b>	<b>5%</b>	6%	5%
<b>Switzerland</b>	24	5%	<b>11</b>	<b>5%</b>	4%	5%
<b>Norway</b>	22	3%	<b>9</b>	<b>4%</b>	5%	4%
<b>Finland</b>	38	4%	<b>10</b>	<b>4%</b>	6%	4%
<b>Total</b>	830	87%	<b>199</b>	<b>92%</b>	96%	88%

<sup>a</sup> Bold values represent the most significant data (all types of cancer prevention research funders combined).



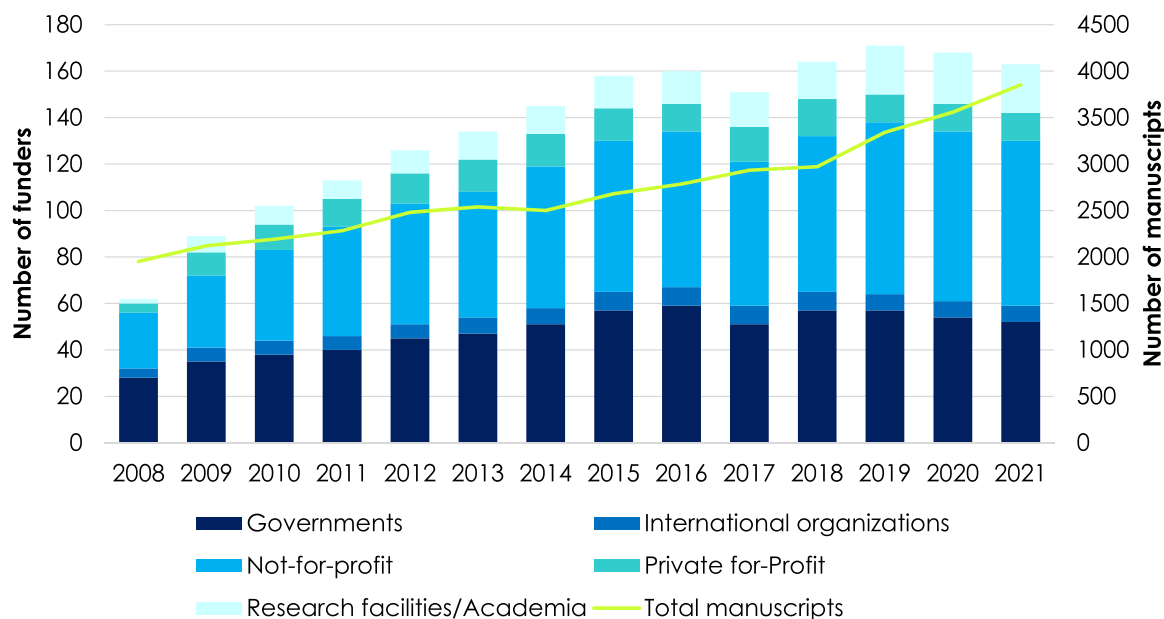


Fig. 4. Number of funders, types of funders, and number of manuscripts in cancer prevention research in Europe between 2008 and 2021.

acknowledgements for government funding (Fig. 5c).

### 3.3. Implementation research in cancer prevention: a call to action

These findings, and particularly the underfunding of primary prevention led to an additional analysis on the number of cancer prevention research projects categorised as implementation research. The World Health Organization (WHO) has defined implementation research as an integrated concept that links research and practice to accelerate the development and delivery of public health approaches [16]. As such, implementation research is a crucial element in proving that cancer prevention is effective. A high number of implementation research projects would mean that although funding capacity for prevention research is limited, efforts are concentrated on high-impact projects aiming at improving the implementation of health policies, programmes, and practices.

A sample of 2000 European cancer prevention research papers from the last 5 years were manually checked and coded to identify implementation research projects (see methodology). As a result, 7% of European cancer prevention research papers were classified as implementation projects (9% in the world), meaning that only 1% of all cancer research publications are implementation research in cancer prevention (Fig. 6).

## 4. Discussion and conclusions

Our study demonstrates that cancer prevention research, and especially implementation research, remains underfunded, in comparison with other research areas such as biology and treatment. This confirms previous studies of the cancer research ecosystem across Europe [11, 17].

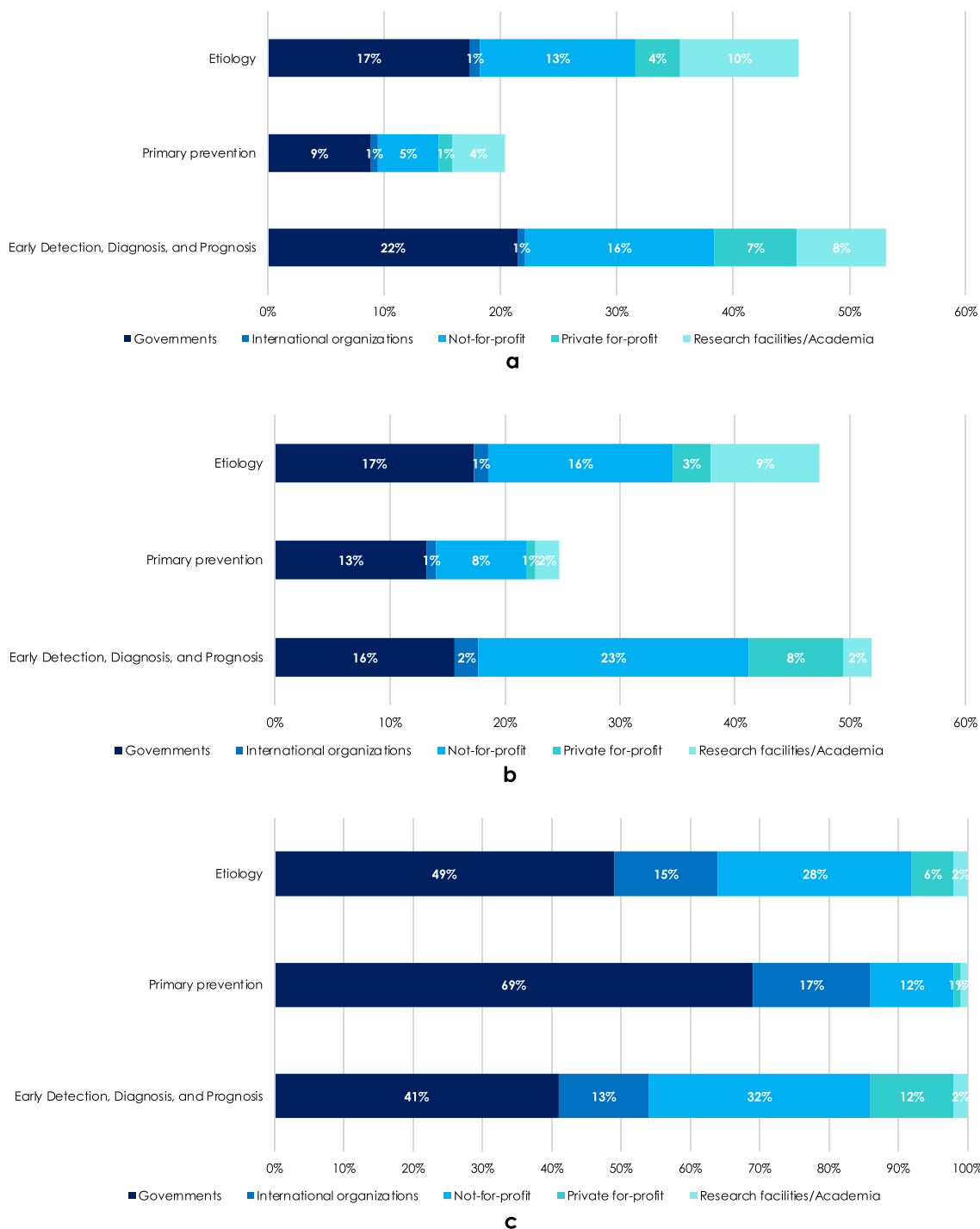
Limitations with the purely bibliometric approach have been highlighted previously [13]. Foremost among them is that referencing is based on self-reporting, which, although required by funding agencies, is largely unenforced (32% of cancer prevention research papers did not cite funding support), and on manual data entry, which lists in a non-standardised manner those acknowledged. These caveats are particularly important when using bibliometric analysis to make comparisons across different countries. Despite these limitations, we have reached evidence-informed conclusions that we consider to be robust.

An important finding of our study is the lack of research on primary

prevention. These results are in line with earlier studies that have identified primary prevention as the cancer research area attracting the least funding [11]. Investment in primary prevention has often been neglected partly because the impact may take several decades to emerge, and it is challenging to measure. In addition, primary prevention is mainly done outside the health system (e.g. nutrition, transportation, occupational and environmental carcinogens, physical activity) and requires inter-compartmental funding. But primary prevention also offers the most advantageous approach to reducing cancer and other Noncommunicable diseases (NCDs) by reducing the exposure to common risk factors and therefore producing important benefits for health [18].

There are evidence-based and cost-effective preventive interventions available for cancer. During the last decades, experimental and epidemiological studies enabled the identification of several causes of cancer. Examples include, but are not limited to smoking, alcohol consumption and high body fatness being strong risk factors of distinct types of cancer [19,20]. In Europe, cancer prevention research efforts have led to the development of several initiatives such as the 2007 World Cancer Research Fund/American Institute for Cancer Research Guidelines for Cancer Prevention [21] and the European Code Against Cancer (ECAC) of which the current 4th edition was led by the International Agency for Research on Cancer [22]. The application of the 12 evidence-based recommendations laid out by ECAC has been estimated to reduce up to 40% of all cancer cases and almost half of all deaths. Identification of additional risk factors and implementation of existing evidence-based prevention strategies would increase the effectiveness of ECAC and reduce the burden of cancer at its forefront. In addition, strengthening cancer prevention research will have not only a significant impact on cancer itself, but it will also reduce 25% premature death from non-communicable diseases, a goal set by the “25 by 25” United Nations and WHO initiative, as cancer shares common risk factors with other non-communicable diseases [23].

Detecting as early as possible the cancers which could not be prevented is crucial for delivering appropriate treatment in time and increasing the chances for a successful treatment, patient outcomes, as well as cancer costs [24]. Screening programmes have proven themselves crucial in widespread cancers that are detectable at the preclinical phase and for which treatment is available like colorectal and breast cancer. The efficiency of successful screening programmes lies in an identifiable target population for which enough resources have been



**Fig. 5.** (a) Percentages of funders in the world by cancer prevention research areas in the World. (b) Percentages of European funders by cancer prevention research areas in Europe. (c) Percentages of funding acknowledgements by cancer prevention research area in Europe.

allocated and patient care and follow-up is assured. To date, the European framework on Cancer screening programmes elaborated in 2003, includes breast (only female), colorectal and cervical cancer only. It is considering integrating screenings for prostate, lung or gastric cancer in the scope of the Europe’s Beating Cancer Plan [25].

Improving existing screening programmes as well as identifying additional cancers for successful cancer prevention is key to beating cancer and without appropriate investment in cancer prevention research, this cannot be achieved. Increased funding in the critical research areas of prevention and implementation research would clearly yield a significant return on investment. Europe’s Beating Cancer Plan,

ratified by the European Parliament on February 2022, represents a political commitment of Europe to mobilise collective efforts in a consolidated approach to address cancer [25]. The plan has four key pillars: prevention, early detection, diagnosis and treatment and quality of life. They will be informed by research and innovation to determine key actions and deliver solutions for patients, including those with comorbidities. Some of the results presented in this paper were used in the Lancet Oncology Commission, which formulated several calls to action in view of the situation [26], in particular, recommendations 4 and 7, which aim to encourage cancer research funding organisations and political decision-makers to "mandate a step change in cancer



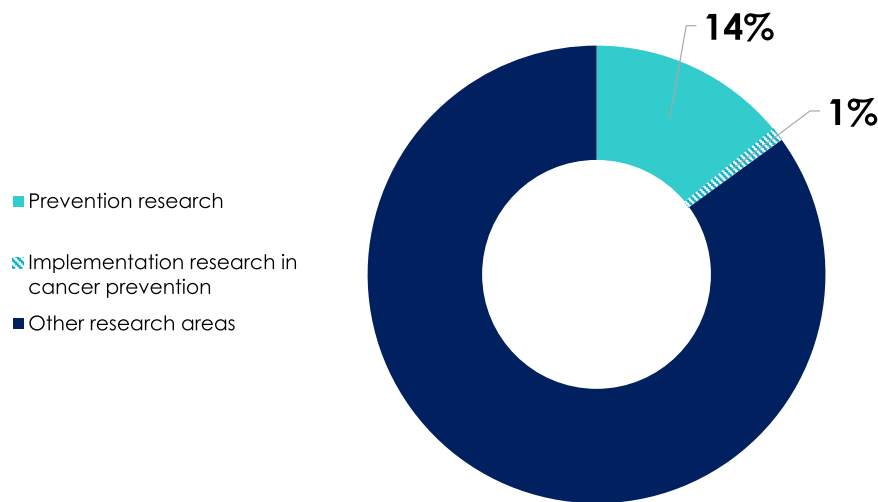


Fig. 6. Percentage of implementation research in cancer prevention in European cancer research papers (2008–2021).

prevention, cancer screening, and early cancer detection research" by "doubling the European cancer research budget to €50 per capita by 2030 and commit to supporting underserved research domains". According to the Commission, this objective could be achieved by doubling funding for prevention research by 2025 and aiming for a 20% share of the overall cancer research budget by 2030.

These data can help support a more policy-focused cancer research agenda for individual European governments and charitable and philanthropic organisations. Such an agenda would stimulate joining efforts across Europe to create a more systematic and structured approach to cancer prevention that would have a major impact at the public health, societal and economic levels. Moreover, the COVID-19 pandemic has clearly shown that a shared common fight and joined efforts and resources can make exceptional progress. No point in time is too early to invest in research prevention.

## Notes

Where authors are identified as personnel of the International Agency for Research on Cancer/World Health Organization, the authors alone are responsible for the views expressed in this article and they do not necessarily represent the decisions, policies or views of the International Agency for Research on Cancer /World Health Organization.

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## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Authors contributions

Anna Schmutz was responsible for the design of the study, literature search, data collection, data analysis, and production of figures. Morten Ervik designed the maps. Paolo Vineis contributed to the initial idea and

to the development of the prevention research taxonomy. Anna Schmutz, Michele Matta and Manon Cairat, Carolina Espina, Joachim Schüz, Ellen Kampman, Paolo Vineis and Olaf Kelm wrote and edited the final version of the manuscript. Olaf Kelm had overall responsibility for the direction of the project.

## Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at [doi:10.1016/j.ejca.2023.113378](https://doi.org/10.1016/j.ejca.2023.113378).

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