

The Allocation of Cancer Research Funding

Advocacy, Not Burden: Evidence from Seventeen Cancers and Nine Countries

Seventeen cancers in the United States, nine national project portfolios recorded in the ICRP

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1 October 2026

Abstract

The allocation of public research funding across cancers is routinely described as disconnected from disease burden.

This claim is re-examined using U.S. data, for seventeen cancers accounting for USD 2,953 million of National Cancer Institute funding and 77 % of cancer deaths. Several factors appear to account for the divergence between observed funding and disease burden.

Five main results emerge.

Funding is first ordered mainly by mortality, with an elasticity of 0.93, but it diverges strongly from it: observed funding typically departs by a factor of two, in either direction, from what mortality would lead one to expect. This gap is measured against an allocation based on disease burden alone, and not against an optimum, which section 2.1 shows does not coincide with proportionality to burden.

Three competing conceptions of the public objective are then evaluated separately, without any parameter being calibrated: total burden, burden weighted by the therapeutic margin, and the population in active disease. Ten of the seventeen cancers move in the same direction under all three conceptions, which defines a common core of USD 265.5 million, or 9.0 % of total imputed funding included in the analysis, for the United States alone.

The gap between observed funding and a burden-proportional allocation, USD 613.4 million or 20.8 % of the envelope for the United States, is accounted for to the extent of 65.7 % of its variance by a measured quantity devoid of normative content, the density of patient advocacy, proxied by the number of charitable organisations dedicated to each cancer, a share that rises to 70.6 % once the latter is also residualised with respect to disease size. A nineteen-year panel shows that this relationship is a long-run state rather than a dynamic: differential growth in organisations is not followed by significant growth in funding.

This advocacy is itself associated with the social stigma associated with the disease: holding disease burden constant, cancers linked to a socially disapproved behaviour have 76 % fewer organisations.

Finally, the international test yields a result opposite in sign to a widely circulated thesis. One quantitative study, Mirin (2021), concludes that diseases in which women are the majority are disadvantaged in the National Institutes of Health portfolio, on 34 diseases that are not sex-neutral; this conclusion is echoed in editorials and advocacy materials, among them the claim that 5 % of global health research and development was devoted in 2020 to specifically female conditions. The actual denominator of this figure, according to its primary source (McKinsey, 2023, note 30), is the number of drug candidates in clinical development in pharmaceutical industry pipelines, not health research as a whole; public funding, the object of the present study, is not in its denominator. Nor does it relate funding to any measure of burden, on either the female or the prostate, whose share is never published. It records a share in a count of industrial assets without any term of comparison, and therefore cannot establish the shortfall relative to need that it is used to support. These elements do not constitute a body of replicated results, and the relevant section examines what they are worth. Applied to the field of oncology, the same question yields the opposite result, and this time one supported by the data. Posed symmetrically and without a priori direction, then tested on nine national project portfolios recorded in the ICRP, each confronted with its own disease burden, it shows that female cancers, in the sense of exclusively or almost exclusively female cancers, account for a share of funded projects 7.94 percentage points higher than their share of burden, in all nine countries without exception ($p = 0.0004$; sign test, $p = 0.004$): an over-representation driven mainly by breast cancer, at 86 %, but which persists at a lower level, an excess of 1.10 percentage points, when breast cancer is excluded. For the prostate, no significant deviation from its share of burden is detected: the mean gap is -0.63 percentage points ($p = 0.432$). This international result concerns project counts, not on amounts; it establishes an over-representation in project portfolios, which the American result, the only one expressed in dollars, confirms for breast cancer.

This reversal is driven primarily by one cancer. Breast cancer supplies 6.84 of the 7.94 percentage points of the gap, or 86 %, with all nine countries above their disease burden. The three other female cancers together show an excess of 1.10 percentage points, seven times smaller but positive and significant at the 5 % level. The observed allocation therefore shows an over-representation of the female group relative to its burden, driven

mainly by breast cancer, which is the opposite of what the communication campaigns relying on the study mentioned above assert. Its magnitude, measured by the ratio of relative gaps between the two sexes, is 1.70, to be compared with the ratio of 1.84 to 2.49 in the opposite direction that Mirin claims to establish over the whole National Institutes of Health portfolio: the direction is reversed, while the magnitude is of the same order. The reversal is robust to the choice of denominator: of seven measures of need tested, five favour the female sex, one gives parity, and only one the reverse, that of years of life lost, for a mechanical reason related to the age at death of prostate cancer patients.

Keywords: research funding allocation, disease burden, political economy of health, interest groups, oncology, stigma, sex differences.

1. Introduction

The recommendation to compare research effort with disease burden dates back to the National Institutes of Health report of the late 1990s and was formalised by Gross, Anderson and Powe (1999). It rests on the following principle: under a constrained budget, a better distribution produces a social gain without additional spending. Burnet and coauthors (2005) introduce the use of years of life lost on British data and identify a so-called Cinderella group of cancers with high years of life lost and low funding. Carter and Nguyen (2012) take up the approach using U.S. data and conclude that breast, prostate and the leukaemias are funded beyond their burden, while bladder, oesophagus, liver, oral cavity, pancreas, stomach and uterus are funded below it. Carter, Delarosa and Hur (2015) replicate on British data and find a comparable structure.

This literature establishes the existence of a gap between actual spending and what an objective treatment of cancers would give. It does not settle the question of the factors explaining that gap. Saying that breast is over-funded and lung under-funded is a finding; identifying the variable that orders these gaps remains to be established. Kamath, Kircher and Benson (2019) suggest one lead by showing that American charitable funding is also disconnected from burden and that cancers associated with a disapproved behaviour are poorly funded within it. Mirin (2021) suggests another, concluding that diseases in which women are the majority are generally disadvantaged in the National Institutes of Health portfolio, a conclusion which the six reservations below show to exceed what its method establishes.

A third family of work concerns the sex dimension and holds that health research favours diseases in which men are the majority. It should be noted at the outset that this work does not deal with male or female diseases in the strict sense, but with diseases in which one sex is the majority, the majority threshold being most often set at 60 %. Its probative force must be weighed rather than taken for granted. The quantitative foundation rests on a single study, Mirin (2021), which covers 34 diseases that are not sex-neutral and concludes that the configuration favours men in roughly three cases out of four, with a chi-squared test at 0.015. The method is published in detail and the data with it, which made it possible to redo the exercise.

This re-examination, conducted in Appendix A from the study's own tables, yields six reservations. The reference against which the study compares each funding level is fitted on the sample, so that half of the diseases lie below it by construction. The burden metric chosen, which weights heavily the years lived with disability, tends to produce the result on chronic non-lethal conditions, which are mostly female. The funding units are non-exclusive accounting categories, not diseases. Three thresholds set by the author, one of which is not mentioned, govern the classification, without any sensitivity test. The tables count separately categories nested within one another, which doubles the weight of several female conditions. No control variable is introduced.

The appendix first reproduces the published values exactly, then moves the thresholds, de-duplicates the categories and introduces two disease characteristics other than sex, transmissibility and addiction. Three results emerge. The count survives, but its significance and the magnitude attributed to it do not: after correction, the test is no longer significant and the ratio of deviations is at parity in the median. Female-dominant diseases are not under-funded relative to sex-neutral diseases; it is male-dominant diseases that are over-funded, and this over-funding disappears as soon as transmissible diseases and addictions, funded by institutes with their own appropriations, are removed. Finally, the study's universe is asymmetric by construction of the nomenclature,

which individualises female conditions and aggregates male ones. These results do not make it possible to identify a disadvantage specific to diseases in which women are the majority.

Two disciplines follow for the present study, and they have governed its construction. The reference used here is not fitted on the sample: the scenarios of section 5.2 are explicit keys, built from burden and from published disability weights, external to the observed distribution of funding. And no transfer is asserted: this study finds that the two groups depart from their burden in opposite directions, not that one receives what the other loses.

The remainder of the evidence base is different in nature. It consists of editorials (Nature, 2023; Nature Reviews Bioengineering, 2024) and above all of a single statistic, repeated everywhere: 5 % of global health research and development is said to have been devoted in 2020 to specifically female conditions, four points of which to female cancers, a figure whose actual scope is examined below. It originates with an American advocacy organisation, Women's Health Access Matters, founded in 2020, and then circulates through the World Economic Forum, the McKinsey Health Institute, consulting firms and foundations, up to the scientific journals that cite it. In the field of oncology itself, a frequently cited analysis ranks ovarian cancer fifth for lethality but twelfth for the ratio of funding to lethality.

This statistic requires a methodological clarification, because it is used in a sense it cannot support. Its scope is first narrower than the use made of it, and successive citations have progressively broadened its scope. The primary source is a McKinsey analysis published in two stages. Kemble, Pérez, Sartori, Tolub and Zheng (2022) establish that non-cancer female conditions account for less than 2 % of the global pipeline, note 14 specifying the scope: Phase 1 to Phase 3 drugs in development recorded in the Pharmaprojects database as of June 2021. Burns, Grabowsky, Kemble and Pérez (2023) give the complete version: excluding cancer, 1 % of biopharma pipeline assets and 2 % of novel medical device approvals target female conditions, and these shares rise to 5 and 4 % respectively when oncology is included, note 30 citing the PharmaProjects database of July 2021 and EvaluatePharma. The denominator of the 5 % statistic is therefore a count of drug candidates in clinical development in the pharmaceutical industry. Nature Reviews Bioengineering (2024) restates it as “biopharma research and development spend in 2020”, and Women's Health Access Matters as “global health research and development funding”, each restatement widening the scope. In the primary source, it is the structure of the private biopharma pipeline, which obeys market size and patent life, and in which public funders, including the National Institutes of Health, do not appear. Using this figure to characterise public allocation is a change of object. It then measures a share of pipeline assets, not a gap to need: it relates the number of assets targeting specifically female conditions to the total number of assets in development, with no burden denominator. To conclude from it to under-funding, an implicit point of comparison must be added, most often the share of women in the population, about one half. But that comparison would presuppose that half of the disease burden is specifically female, which is false: the overwhelming majority of conditions affect both sexes. A fortiori, women mount more vigorous innate and adaptive immune responses than men (Klein and Flanagan, 2016). Moreover, a recent Danish nationwide study observes in oncology a cancer risk 52 % higher in men and, after diagnosis, a mortality 10 % higher (Stegenborg and coauthors, British Journal of Cancer, 2026). Expressed in cumulative risks before age 100, these gaps mean that one cancer in six and one cancer death in five among men would be avoided if their rates equalled those of women. In addition, men are more exposed to environments liable to cause cancer: the fraction of cancer deaths attributable to occupational exposure is 3.6 times higher among them in Great Britain (8.2 against 2.3 %; Rushton and coauthors, 2010) and 4.1 to 7.3 times higher in the United States (Steenland and coauthors, 2003).

A further difficulty is the absence of any symmetric comparison with specifically male conditions. None of these publications reports the symmetric share, that of pipeline assets devoted to specifically male conditions, nor the corresponding burden. The 5 % figure is therefore compared with a population and not with a need, and it is compared with nothing on the prostate. A statistic that has no denominator on either group cannot establish any asymmetry, whatever its direction. That is precisely what the present study builds for the field of oncology: a share of burden computed for each group, from mortality, years of life lost and morbidity, and confronted with the corresponding share of funding. In our own oncology sample, which is nonetheless the field in which sex-specific cancers are most numerous, the burden of female cancers represents 19.6 % of the total, and that of the

prostate 6.9 %. The relevant term of comparison is therefore in no case 50 %. Moreover, no returns function is presented, although it very probably differs across cancers.

The two arguments must nonetheless be distinguished. The 5 % statistic has no measure of burden; Mirin's study has one, expressed in disability-adjusted life years, but at the level of each disease taken in isolation. It classifies individual residuals and then counts them, and at no point computes the share of burden that female-dominant diseases represent together, to confront it with their share of funding. The question of whether a sex group receives a share of funding below its share of burden is therefore posed neither by the former, for lack of burden, nor by the latter, for lack of aggregation. It is that question, and that question alone, that section 5.6 poses on nine national project portfolios.

The figure is not invented and it measures something real. It is its use that is faulty: between the statement “5 % of funding goes to specifically female conditions” and the statement “women's health is under-funded relative to its burden”, what is missing is precisely the denominator that nobody publishes. The primary source itself puts it differently: less than 2 % of the global pharmaceutical pipeline targets specifically female conditions other than cancer (Kemble and coauthors, 2022). This version, which isolates the non-cancer field, is consistent with the present study rather than in contradiction with it, but it invites one to ask what purpose such a statement (“less than 2 %”) serves without any term of comparison, while deliberately foregrounding a female-gendered lens.

A third element is regularly presented as the founding evidence for this thesis: the exclusion of women from clinical trials in the United States until the early 1990s. The fact is established. In September 1977, the Food and Drug Administration published General Considerations for the Clinical Evaluation of Drugs, which recommended excluding any woman of childbearing potential from Phase I and early Phase II trials.

What the sources document, however, does not support the reading made of them. The motivation is explicit and unanimously reported, including by the institutions that campaign for women's health research: it was to prevent foetal exposure after the thalidomide and diethylstilbestrol affairs. The report of the American academies writes that these provisions reflected society's interest in protecting vulnerable populations; the Office of Research on Women's Health of the National Institutes of Health and the Society for Women's Health Research give the same genealogy. Two elements of scope confirm this reading: the exclusion did not apply to women with life-threatening diseases, and it covered only Phase I and early Phase II. It was trial sponsors who extended it to later phases, out of aversion to legal risk, not the regulation.

The episode therefore establishes a differentiated effect, real and lasting, not a decision rule based on sexist prejudice. It is nonetheless invoked as evidence of discrimination, including in publications which, a few lines earlier, correctly report its motivation. A thesis whose best-documented argument does not say what it is used to claim, and whose most-cited statistic is used with a denominator that is not its own, is not refuted by authority. That is what this study does in the field where the data allow it, oncology, by posing the question of asymmetry in a comparable way and without a priori direction.

The present study reaches the opposite conclusion in the field of oncology. Section 6.2 shows, moreover, that the oncology component of this thesis rests on a single denominator and is not robust to its replacement. Applied to sex-specific cancers, and tested on nine national project portfolios recorded in the ICRP, the question of asymmetry receives a clear answer of the opposite sign: it is female cancers that are over-represented in project portfolios. This reversal calls for two precautions. On the one hand, it concerns one field, oncology, and not on health research as a whole. On the other hand, it is mainly driven by one cancer, breast cancer, which explains 86 % of the female group's gap. Section 6.2 examines the conditions of reconciliation and the point that does not reconcile.

This study first seeks to measure the gap without imposing a single metric, by making explicit the competing conceptions of the public objective, then to identify and measure the variables that order it instead of postulating them. It finally examines, through independent routes, whether the sex of patients contributes to explaining the observed structure of the allocation.

1.1 Hypotheses

H1. Funding follows mortality with a significantly positive elasticity.

H2. The allocation presents an asymmetry by sex. The hypothesis is posed symmetrically and without a priori direction: it is rejected if female cancers and the exclusively male cancer or cancers depart from their burden in the same proportion, whatever the sign of that departure.

H3. Holding disease burden constant, cancers associated with a socially disapproved behaviour receive less than the others.

H4. Funding follows the stock of survivors rather than the flow of deaths, survivors being the human resource of advocacy.

H5. The gap between observed funding and a burden-proportional allocation is ordered by the density of patient advocacy.

These hypotheses were formulated before the data were examined, with the exception of H5, introduced after the rejection of H4 and before the corresponding variable was collected. H1 to H4 are therefore confirmatory; H5 is explicitly exploratory and its results must be read as such, whatever the strength of the coefficients obtained. H1 and H5 are supported. H4 is rejected. H3 is not supported in its direct form: the relationship between stigma and funding is weak and not significant. An adjacent relationship appears, however, between stigma and patient advocacy, which was not the object of H3 and is reported as such. H2 is not settled using U.S. data alone, for lack of power; it is supported by the international panel built in section 5.6, and the direction of the gap is that of the female sex.

2. Theoretical framework

2.1 The optimality condition and its scope

Let a budget R be allocated among J cancers indexed by j . Let f_j denote the allocation to cancer j , B_j its disease burden, and g_j the function that converts research spending into a proportional reduction of burden, increasing and strictly concave. The public planner maximises the sum of burden reductions subject to the budget constraint:

$$\max \sum_j B_j g_j(f_j) \quad \text{subject to} \quad \sum_j f_j = R$$

The first-order condition of the associated Lagrangian gives $B_j g'_j(f_j) = \lambda$ for all j . The term $B_j g'_j(f_j)$ measures the absolute reduction of burden obtained from one additional euro allocated to cancer j : it is the product of burden and the marginal return to spending. The condition therefore equalises this product across cancers, the multiplier λ being its common value.

This result has a consequence that the applied literature often neglects: the optimal allocation is proportional to burden only in the special case where the returns functions are identical. The condition then reduces to $g'(f_j) = \frac{\lambda}{B_j}$, and the form of f_j depends on that of g' . As soon as scientific maturity differs, which is manifestly the case between a cancer whose five-year survival plateaus at 13.7 % and another where it reaches 98.2 %, the optimum departs from proportionality. A departure from proportionality therefore does not, on its own, demonstrate a poor allocation.

What the gap does demonstrate is more modest and nonetheless sufficient: it creates a burden of proof. If one cancer receives twice as much per death as another, it falls to the funder to document the difference in marginal returns that justifies it. In practice, that documentation does not exist. Under the usual assumption of logarithmic returns, $g_j(f) = a_j \ln f$, one obtains $g'_j(f_j) = \frac{a_j}{f_j}$, whence $f_j = \frac{a_j B_j}{\lambda}$: the optimal allocation is proportional to the product of burden and a returns factor specific to the cancer considered. This is the structure of the scenarios built in section 4, where scenario A sets a_j constant for lack of an available estimate, and scenario B proxies a_j by the residual therapeutic margin.

2.2 Which variables can ground a priority

Twelve candidate variables were examined. Four measure burden: mortality, incidence, years of life lost, morbidity. Three measure potential returns: residual therapeutic margin, recent mortality trend, intrinsic scientific difficulty. Three belong to economic or distributive considerations: cost of care, production losses, market failure on rare cancers. Two appear in the data without being able to legitimately ground anything: the sex of patients and the notoriety of the cause.

Two exclusions deserve a word. Incidence is not a neutral measure of burden, because it incorporates the intensity of screening: the prostate has 333,830 new cases for 36,320 deaths and a survival of 98.2 %, a configuration that reflects the practice of prostate-specific antigen testing as much as the disease itself. Grounding a key on incidence amounts to rewarding over-diagnosis. The mortality trend is excluded for another reason: its normative sign is indeterminate, a rapid decline possibly signalling an effort that is bearing fruit or a problem on its way to resolution.

The four burden measures retained are not equivalent, and they rank. Incidence rewards screening. Mortality counts a death at 45 as it counts a death at 90, although the former represents three times as many years of life lost. Years of life lost correct this by weighting each death by the residual life expectancy at the age at which it occurs. Composite burden finally adds the years lived with the disease, which neither mortality nor years of life lost see. This is why composite burden serves as the main benchmark, deaths as a first reading in section 5.1, and the other measures as robustness denominators in section 6.2, where moving from one to another will be seen to suffice to reverse the verdict on sex. Quality-adjusted life years, which measure the gain brought by an intervention and not the burden of a disease, are not used.

Measure	What it captures	What it misses or distorts	Use in this study
Incidence (new cases)	Size of the newly affected population	Incorporates screening intensity; rewards over-diagnosis	Excluded as a key; robustness denominator (Table 15)
Mortality (deaths)	Actual lethality, transparent and readable	A death at 45 counts as a death at 90	First reading (section 5.1); denominator (Table 15)
Years of life lost (YLL)	Deaths weighted by residual life expectancy at age of death	Ignores years lived with the disease; depends on the life table	Component of the benchmark; denominator; robustness to the GBD table (section 3.1)
Composite burden (YLL + YLD)	Premature mortality and morbidity, with published disability weights	Rests on published phase durations and weights; not a strict DALY (sex-specific tables)	Main benchmark (scenario A); denominator
QALY	Health gain brought by an intervention	Does not measure the burden of a disease	Not used

Table 1. Evaluation grid of candidate burden measures and the use adopted for each. The hierarchy runs from incidence to composite burden; Table 15 shows what moving from one measure to another does to the verdict on sex.

Intrinsic scientific difficulty is the decisive missing variable. If the pancreas plateaus at 13.7 % survival after decades of effort, it may be because it is harder, not because it is neglected. No available data make it possible to separate the two. This limitation is handled not by an assumption but by an interval. The key is written as the product of burden and the residual therapeutic margin raised to the power α , that margin being one minus five-year survival. The value $\alpha = 0$ cancels the margin and restores scenario A, where only the weight of the disease counts; the value $\alpha = 1$ restores scenario B, where the expected return is assumed proportional to the margin. Varying α between these two bounds sweeps the whole set of intermediate weightings without any value having to be postulated.

The result of this sweep is reported in section 5.2. The amount reallocated rises steadily from USD 613.4 to 1,199.2 million, but sixteen of the seventeen cancers keep the same verdict over the whole interval. The only exception is Hodgkin lymphoma, which switches between $\alpha = 0.25$ and $\alpha = 0.50$. The core of cancers over-funded whatever the value adopted reaches USD 537.1 million.

2.3 The positive benchmark

The reference model is that of competition among pressure groups (Becker, 1983), in which the share of public resources obtained by a group rises with the pressure it exerts, itself a function of its size, its ability to overcome free-riding, and the legitimacy of its claim. Applied to oncology, this framework suggests three determinants: the size of the population concerned, the duration of survival which determines the stock of available spokespersons, and the perceived legitimacy of the claim, which collapses when the disease is attributed to the patient's behaviour.

The second determinant implies increasing returns to success and hence a divergence, the allocation drifting progressively away from the most acute needs. It is testable and it is rejected in section 5.7. The third is at the centre of the results.

3. Data

3.1 Sources

Funding. Amounts imputed by the National Cancer Institute to each research area, as published in the Budget Fact Book. These amounts overlap across categories, a single project possibly being imputed to several cancers, and their sum does not equal the institute's total budget. The USD 2,953.4 million retained here are therefore a total of imputations and not an exclusive budget envelope. This distinction governs the reading of the scenarios: the gaps computed in section 5.2 are imputation simulations, indicating by how much the structure of imputed amounts departs from the one a given criterion would produce, and not budget redeployments directly executable dollar for dollar. The term envelope is used in the remainder of the text for convenience, always in the sense of a total of imputations.

Burden. Estimated incidence, estimated deaths, breakdown by sex, five-year relative survival and prevalence, taken from the SEER Cancer Stat Facts sheets, themselves based on American Cancer Society projections. Distribution of deaths by age band from the same sheets, section Who Dies From This Cancer, American mortality 2020-2024. Residual life expectancies from the 2023 American life tables published by the National Vital Statistics System, the male, female or total table being applied according to the cancer. The quantity thus obtained, the sum of years of life lost and years lived with the disease, is referred to in what follows as composite burden and not as DALY: a DALY in the sense of the Global Burden of Disease uses a single reference life table, identical for both sexes, precisely so that a year lost has the same value whatever the sex of the deceased. Using sex-specific tables mechanically introduces a gap between the two groups, since a man dying at 79 loses fewer years than a woman dying at the same age.

This gap works against the hypothesis of a female over-representation, and correcting it is a robustness test. Recomputed with the GBD 2019 reference life table, whose life expectancy at birth is 88.9 years for both sexes, years of life lost per death rise by 24 % on average for the four female cancers and by 49 % for the prostate, whose patients die older: the American male table values a prostate death at 10.2 years, the reference table at 15.1. Under the reference table, the elasticity of the gap to advocacy moves from 0.430 to 0.434 with a HC3-robust t-statistic of 3.50 instead of 3.20; the amount reallocated under scenario A moves from 20.8 to 21.8 %; the female excess in the international panel moves from 7.94 to 9.03 percentage points, nine countries out of nine, and the prostate gap from minus 0.63 to minus 1.06 percentage points, still not significant; and, among the seven denominators of Table 15, that of years of life lost, the only one favouring the prostate, moves from 0.77 to 0.92, while that of composite burden moves from 0.98 to 1.07. No result changes sign, and all strengthen slightly. The main construction keeps the American tables, which describe the mortality actually observed in the country whose allocation is studied, and the reference table is reported as a robustness check; the corresponding script is in the replication material.

Morbidity. Years lived with the disease are reconstructed according to the Global Burden of Disease phase model, which distinguishes diagnosis and primary treatment, the controlled phase, the metastatic phase and the terminal phase. The corresponding disability weights, 0.288, 0.049, 0.451 and 0.540, come from Salomon and coauthors (2015) and are published with their intervals. Phase durations come from GBD 2017. No parameter is calibrated by the author.

Sex specificity. The seventeen cancers are divided into three groups. The first comprises those whose affected population is exclusively or almost exclusively female: cervix, uterine corpus and ovary, which affect only women, and breast, 98.8 % of whose deaths are female and which is retained on that basis, the male form existing but accounting for 530 annual deaths out of 42,670. The second group is the prostate, exclusively male. The third comprises the twelve cancers common to both sexes. For convenience, the first group is referred to in what follows as that of female cancers, in the sense of this definition.

Patient advocacy. Number of American non-profit organisations, section 501(c)(3), whose name contains the name of the cancer, retrieved from the federal tax register through ProPublica's Nonprofit Explorer.

Public attention. Average Google search interest for the year 2024, United States geography. Since the interface returns only a relative index within a set of at most five terms, the seventeen cancers were split into four batches sharing a common anchor, which returned exactly the same value in all four batches.

3.2 Two caveats on the funding data

The first concerns the vintage. The 2024 column of the Budget Fact Book reproduces the 2023 column identically for all eighteen rows of the table, total budget included, USD 7,221.1 million in both cases. It is not an independent estimate but a carry-forward. The results therefore bear on fiscal year 2023.

The second concerns three discontinuities that appeared in 2023. Cervical cancer falls from USD 76.6 to 20.7 million, a 73 % drop; Hodgkin lymphoma loses 56 %; stomach gains 106 %. Simultaneous variations of this magnitude correspond to no ordinary budgetary evolution. They are compatible with a break in coding or in scope, whose nature has not been confirmed by the National Cancer Institute. The whole analysis was therefore redone on the 2022 base, the last fiscal year before the breaks.

Cancer	2018	2019	2020	2021	2022	2023	2024	Change
Uterine corpus	17.5	17.9	13.6	14.4	15.0	20.0	20.0	+33 %
Cervix	71.5	86.0	69.3	73.7	76.6	20.7	20.7	-73 %
Hodgkin lymphoma	13.3	12.2	14.3	15.9	16.5	7.3	7.3	-56 %
Stomach	14.2	14.8	10.6	15.4	16.0	33.0	33.0	+106 %

Table 2. The three series showing a discontinuity in 2023, and uterine corpus for comparison, in USD million. Full series for the seventeen cancers in sheet 3d of the workbook.

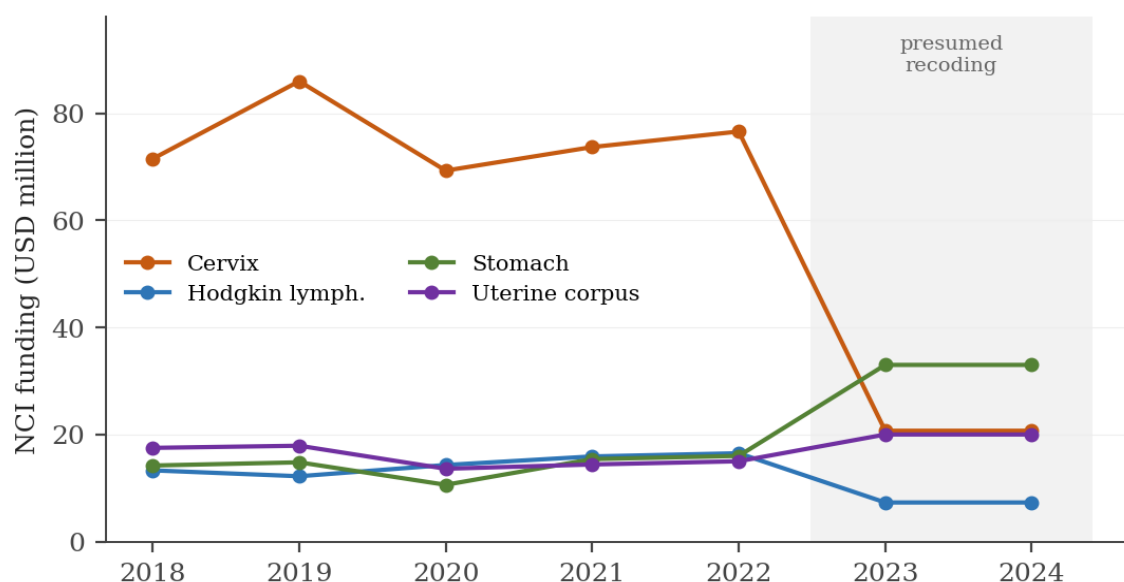


Figure 1. The three cancers showing a discontinuity in 2023 in the National Cancer Institute series, and uterine corpus, which shows none, for comparison. The 2024 column reproduces the 2023 column identically.

Fourteen verdicts out of seventeen are identical in both bases. Cervical cancer is the only case of complete reversal: with USD 76.6 million it is over-funded under the three scenarios built in section 4, with 20.7 it is under-funded under all three. Since its ranking depends entirely on a value the series flags as suspect, it is excluded from the conclusions. Uterine corpus, by contrast, shows no break: its funding oscillates between 13.6 and 20.0 million over seven fiscal years and rises in 2023. The two uterine cancers must therefore be treated separately.

4. Methodology

4.1 Three explicit scenarios

Rather than confronting the observed allocation with a single key, which would surreptitiously settle a political trade-off, three conceptions of the public objective are evaluated separately. Scenario A, called “today’s patients”, allocates in proportion to total burden, years of life lost and years lived with the disease. Scenario B, called “savable lives”, allocates in proportion to burden multiplied by the residual therapeutic margin, defined as one minus five-year relative survival. Scenario C, called “the population concerned”, allocates in proportion to prevalence in active disease.

On this last scope, the prevalence published by SEER counts every person diagnosed and still alive, including those cured for twenty years. Of 16.1 million prevalent persons, only 809,358 are in active disease, or 5.0 %, and this proportion varies by a factor of 27 across cancers: 41.1 % for the pancreas, 24.4 % for the liver, 20.5 % for the lung, against 3.6 % for the prostate, 3.1 % for the breast and 1.5 % for Hodgkin lymphoma. Allocating in proportion to total prevalence would amount to funding a cancer all the more because it has already been well treated, cure feeding the stock.

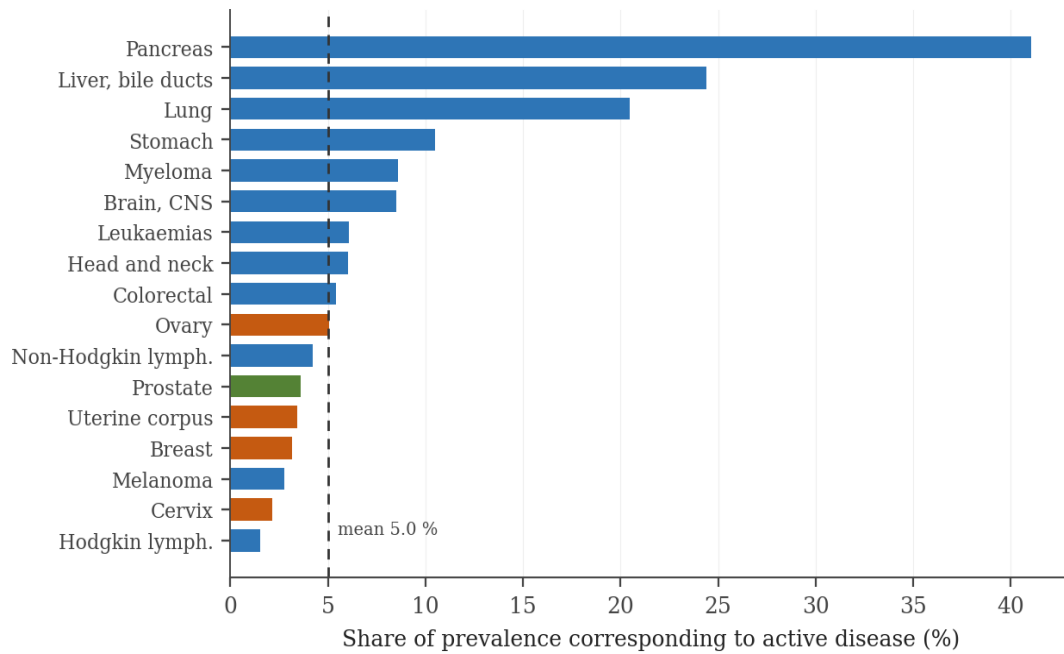


Figure 2. Share of prevalence corresponding to active disease, by cancer. Of 16.1 million prevalent persons, only 809,358 are in the diagnosis, primary treatment, metastatic or terminal phase.

4.2 The gap to the burden benchmark

The term benchmark is chosen deliberately. Section 2.1 establishes that the optimal allocation is proportional to burden only in the special case where the returns functions are identical across cancers, and section 2.2 that intrinsic scientific difficulty, which differentiates them, is not observed. Funding proportional to burden is therefore not what burden would justify in the sense of an optimum: it is an explicit point of comparison, normative in its construction but not in its claim, whose gap measures how far the observed allocation departs from a simple rule, not how far it departs from the best possible allocation. Nor is scenario B an estimate of the optimum: the complement of five-year survival proxies the marginal return there without being an established measure of it. The words used in what follows, gap to the burden benchmark and funding proportional to burden, are held to this scope.

The quantity analysed in section 5.3 is the logarithm of the ratio between observed funding and burden-proportional funding, that is, scenario A. This choice of dependent variable is central. Patient advocacy and public attention are not treated as control variables to be neutralised: they are the candidate explanatory variables for the deviation from the burden benchmark. Treating them as controls would amount to conditioning on the very channel of the mechanism under study, which produces a coefficient without causal interpretation.

4.3 Status of the analyses: formulated before the analysis, exploratory, robustness

With seventeen observations and a large number of constructions, a reader is entitled to ask which analyses answer a hypothesis posed before the data were examined, which were formulated along the way, and which serve only to test a result. The following table keeps the register. Hypotheses H1 to H4 were formulated before the data were examined; H5 was introduced after the rejection of H4 and before the advocacy variable was collected; everything else is exploratory or robustness, and is not presented as a confirmatory test.

Status	Analysis	Section
Formulated before analysis	H1, elasticity of funding to mortality	5.1
Formulated before analysis	H2, sex asymmetry, posed without direction; four-route American test, symmetric international test	5.5, 5.6
Formulated before analysis	H3, stigma and funding at equal burden; not supported in its direct form	5.3

Status	Analysis	Section
Formulated before analysis	H4, funding and survivor stock; rejected	5.7
Exploratory	H5, gap to burden benchmark and patient advocacy, formulated after the rejection of H4	5.3, 5.4
Exploratory	Adjacent relationship between stigma and advocacy	5.4
Exploratory	Decomposition by group, seven denominators, returns curve, greedy allocation	5.6, 6.2, 6.5
Exploratory	Uterine corpus case and stigma reclassification through obesity	6.4
Exploratory	2005-2023 fixed-effects panel, first differences, lags	5.9
Robustness	Three scenarios and exponent sweep; 2022 base against 2023 base; 2018-2023 smoothing	4.1, 5.2, 3.2
Robustness	HC3 standard errors, leverage, leave-one-out, permutation, bootstrap; unconstrained specifications; three advocacy measures; contemporaneous count year by year	5.4
Robustness	Country selection threshold, weighting, country-specific burden, de-duplicated counts, functional forms	5.6, 6.5
Robustness	External validation of stigma on five cancers, re-examination of Mirin (2021)	6.3, Appendix A

Table 3. Register of analyses by status. Only hypotheses formulated before the analysis are presented as tests; exploratory analyses generate hypotheses, robustness analyses test a result.

The full dataset, the extraction queries and the computation scripts are provided as supplementary material, so that every figure in the text can be reproduced from the public sources cited.

4.4 Limitations of the method

The scope is that of a single funder in a single country; industrial funding and universities' own funding are not covered. Funding categories overlap, so that a basic research project may be imputed to several cancers. With 17 observations, only very large effects are detectable at the conventional threshold, and section 5.5 explicitly quantifies this power limitation rather than invoking it. Three variables remain absent for lack of data of the same vintage: cost of care, production losses and industrial funding by cancer.

5. Results

5.1 Dispersion and size of the gap

The envelope studied covers 484,570 estimated deaths, or 77.4 % of expected cancer deaths in the United States. Average funding stands at USD 6,095 per death, with a dispersion of a factor of 13 between the extremes: USD 18,496 for melanoma, 1,384 for uterine corpus.

Regressing the logarithm of funding on that of deaths gives an elasticity of 0.933 with a standard error of 0.152 and a coefficient of determination of 0.715. The latter figure is largely a scale artefact, mortality ranging from 1,100 to 124,990 deaths. The relevant statistic is the residual dispersion, whose standard deviation is 0.663 in logarithm, a multiplicative factor of 1.94. The observed funding of a cancer taken at random typically departs by a factor of two, in either direction, from what its mortality would lead one to expect. The confidence interval of the elasticity moreover runs from 0.63 to 1.23, so that proportionality is not established but merely not rejected.

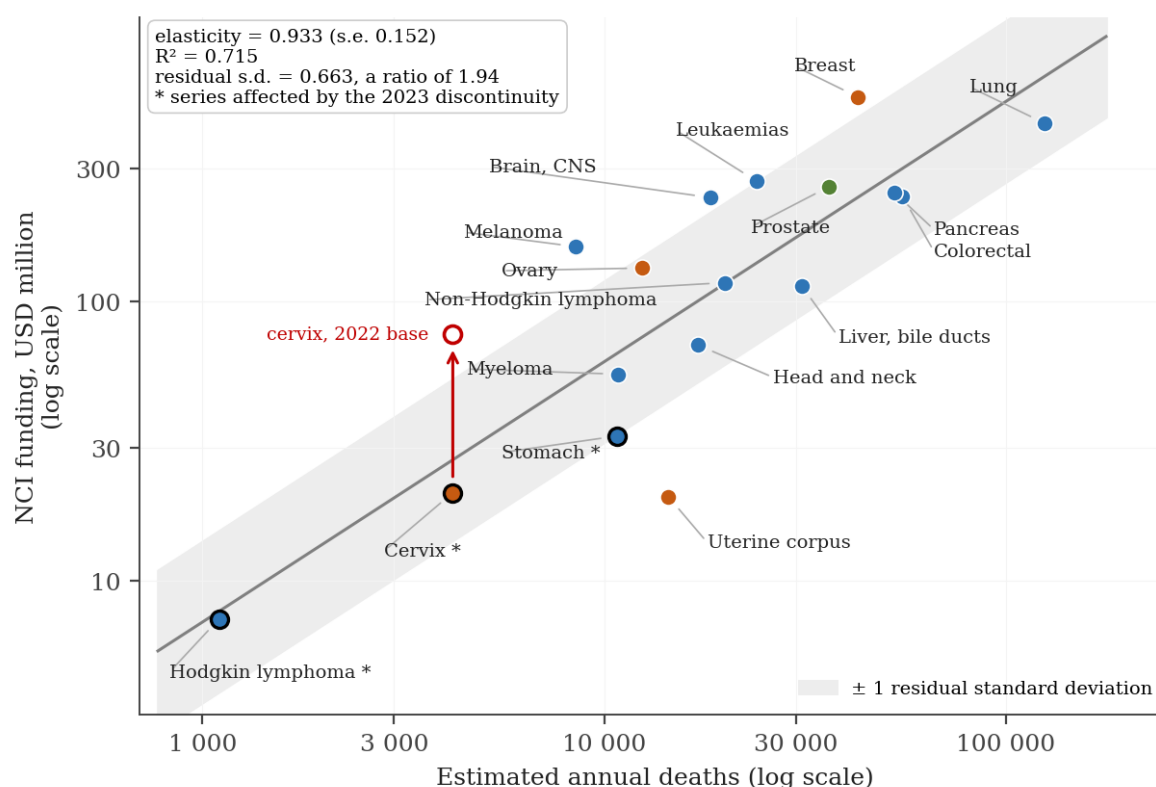


Figure 3. Funding and mortality, seventeen cancers, fiscal year 2023. The grey band covers one residual standard deviation on either group of the fit, a ratio of 1 to 1.94: eleven of the seventeen cancers lie within it. The three series affected by the series discontinuity that appeared in 2023 are marked with an asterisk. The arrow indicates the position cervical cancer would occupy on the 2022 base, at USD 76.6 million instead of 20.7.

The allocation is thus not random, since it is ordered by mortality. It does, however, show large gaps relative to an allocation that would be based on disease burden. The second statement does not say that the observed allocation would reduce burden less effectively than another, which section 2.1 forbids asserting in the absence of the returns function. What is at issue is not necessarily arbitrariness but a systematic gap of large amplitude to an explicit benchmark.

5.2 The three scenarios and the common core

Cancer	Current	Gap A (burden)	Gap B (returns)	Gap C (active disease)	Direction
Lung and bronchus	435.0	+225.4	+596.6	+59.1	increase under all three
Uterine corpus	20.0	+83.3	+23.7	+91.1	increase under all three
Colorectal	238.6	+106.2	+25.8	+54.0	increase under all three
Head and neck	69.9	+41.1	+6.6	+51.2	increase under all three
Stomach	33.0	+34.3	+56.8	+24.7	increase under all three
Cervix, 2023 base *	20.7	+22.8	+9.4	+3.4	increase under all three
Cervix, 2022 base *	76.6	-29.7	-44.2	-50.6	decrease under all three
Pancreas	246.0	+33.4	+288.2	-75.3	scenario-dependent
Liver and bile ducts	114.2	+62.8	+192.1	-10.5	scenario-dependent
Hodgkin lymphoma, 2023 base *	7.3	+4.1	-4.6	+6.0	scenario-dependent
Hodgkin lymphoma, 2022 base *	16.5	-4.2	-13.6	-2.2	decrease under all three
Multiple myeloma	55.0	-0.8	-11.4	+8.7	scenario-dependent

Cancer	Current	Gap A (burden)	Gap B (returns)	Gap C (active disease)	Direction
Non-Hodgkin lymphoma	117.0	-4.5	-52.9	+17.1	scenario-dependent
Melanoma of the skin	157.4	-79.0	-148.2	+0.8	scenario-dependent
Prostate	258.6	-54.0	-250.4	+230.3	scenario-dependent
Ovary	132.0	-50.6	-45.4	-85.2	decrease under all three
Brain and CNS	236.1	-99.0	-32.3	-175.1	decrease under all three
Leukaemias	270.6	-132.7	-174.7	-145.2	decrease under all three
Breast	542.0	-192.9	-479.3	-55.0	decrease under all three

Table 4. Gap to current funding under each of the three scenarios, in USD million. The two series affected by the series discontinuity that appeared in 2023, marked with an asterisk, appear in both bases: that of 2023 used throughout the study, and that of 2022, prior to the break, in which the seventeen cancers take their 2022 values, for an envelope of USD 3,189.7 million.

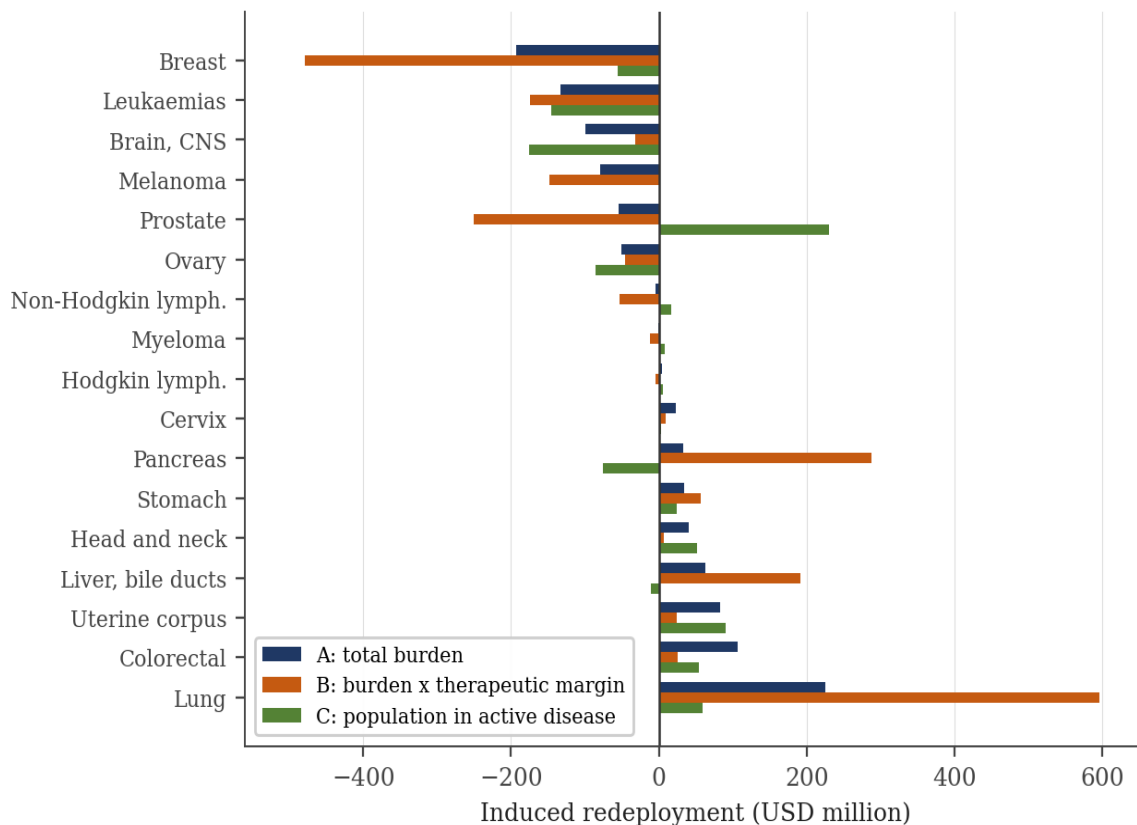


Figure 4. Redeployment induced by each of the three scenarios, in USD million. A positive value flags a cancer that should receive more.

The amounts reallocated stand at USD 613.4 million under scenario A, 1,199.2 under scenario B and 546.3 under scenario C, or 20.8, 40.6 and 18.5 % of the envelope. Ten cancers out of seventeen move in the same direction under the three scenarios, six upwards and four downwards. The corresponding core, obtained by taking for each the smallest of the three movements, corresponds to USD 265.5 million of imputations, or 9.0 % of total imputed funding. It indicates a direction of reallocation common to the three conceptions, not a budget amount that could be directly mobilised. Tested at the bounds of the published intervals of the disability weights, this core varies by less than 1.5 % and no cancer changes side.

The verdict for two cancers depends on the base adopted, and the table therefore reports them in both. Cervical cancer moves from under-funded under the three scenarios, with funding of USD 20.7 million in 2023, to over-funded under all three, with 76.6 million in 2022: it crosses the entire ranking. Hodgkin lymphoma switches likewise, from a scenario-dependent verdict to over-funding under all three. These two reversals are the direct consequence of the series discontinuity that appeared in 2023, documented in section 3.2, and that is why no conclusion is drawn on these two cancers.

The two other series affected by the break do not raise this problem. Stomach remains under-funded under the three scenarios in both bases, its gap moving from plus 34.3 to plus 56.7 million dollars under scenario A. Uterine corpus, which shows no break, remains under-funded under the three scenarios in both bases, with gaps of plus 83.3 and plus 96.5 million. The two uterine cancers therefore behave in opposite ways with respect to the base adopted, and confusing them would be a source of error.

The core of cancers over-funded under the three scenarios is affected accordingly: it comprises brain, breast, the leukaemias and ovary on the 2023 base, for USD 265.5 million, and adds to them on the 2022 base cervix, Hodgkin lymphoma and melanoma, for 327.9 million. Melanoma does not owe its presence to a break, its series shows none, but to the 16 % fall in its funding between 2022 and 2023, from 186.4 to 157.4 million, which is enough to make its gap under scenario C slightly positive, plus 0.8 million, where it was minus 15.5 in 2022. Its case illustrates the sensitivity of a three-scenario verdict when one of the three is close to zero. The four cancers of the 2023 core are common to both bases; they, and they alone, carry the conclusions of this study.

The correct treatment of prevalence is what distinguishes these results from the earlier literature. Measured in total prevalence, the population concerned would justify an increase of USD 235.1 million for breast cancer and would make it the main objection to the first two scenarios. Measured in active disease, it induces a decrease of 55.0 million. Melanoma moves from plus 131.1 to plus 0.8 for the same reason.

5.3 What the allocation follows when it departs from burden

The gap to the burden benchmark, defined in section 4.2, totals USD 613.4 million. It is regressed on each of the candidate variables, taken in isolation.

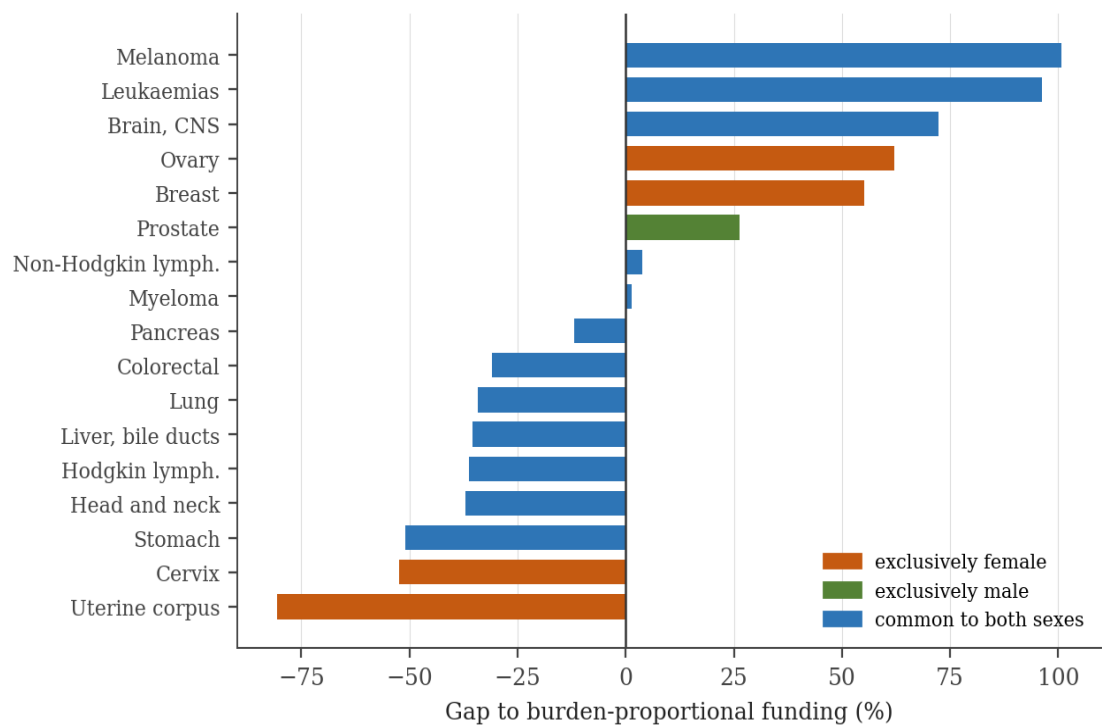


Figure 5. Gap between observed funding and a burden-proportional allocation, seventeen cancers, fiscal year 2023. The total mass of the gap amounts to USD 613.4 million, or 20.8 % of the envelope.

Explanatory variable, taken alone	Coefficient	Standard error	t	Share of variance
Patient advocacy, ln (organisations)	+0.430	0.080	5.36	65.7 %
Public attention, ln (Google searches)	+0.366	0.149	2.45	28.6 %
Behavioural stigma	-0.600	0.303	-1.98	20.8 %
Female-specific sex	-0.306	0.356	-0.86	4.7 %
Sex specificity, men and women	-0.161	0.337	-0.48	1.5 %

Table 5. Decomposition of the gap to the burden benchmark. $n = 17$. Each row is a separate univariate regression: the explanatory variables are not independent of one another and the variance shares do not add up.

The density of patient advocacy alone accounts for 65.7 % of the variance of the gap between what is funded and a burden-proportional allocation, and for 70.6 % once advocacy is itself residualised with respect to disease size, as section 5.4 establishes. The elasticity is 0.430: a doubling of the number of dedicated associations corresponds to a gap 35 % above burden-proportional funding. The association establishes that the gap has a statistical structure strongly tied to the density of patient advocacy, a quantity devoid of normative content; it does not suffice to establish a causal mechanism. Public attention explains 28.6 % of it taken in isolation, but the two indicators are not independent: their correlation, in logarithms, is 0.630. Entered together, the coefficient of the search index becomes nil while that of the organisation count remains unchanged. The two therefore largely measure the same thing, and it is organised advocacy that carries the information. For this reason they are never used simultaneously in what follows: the variance shares in Table 5 come from separate regressions and do not add up.

The same remark applies to the two measures of burden. The logarithm of deaths and that of incidence are correlated at 0.782, and each is correlated with the search index at around 0.73. A model stacking the five explanatory variables would show variance inflation factors from 1.06 to 3.36, acceptable values by the usual thresholds but not negligible on seventeen observations. The results reported in this study therefore rest on regressions with one or two explanatory variables, never more, and the coefficients are accompanied by heteroskedasticity-robust standard errors.

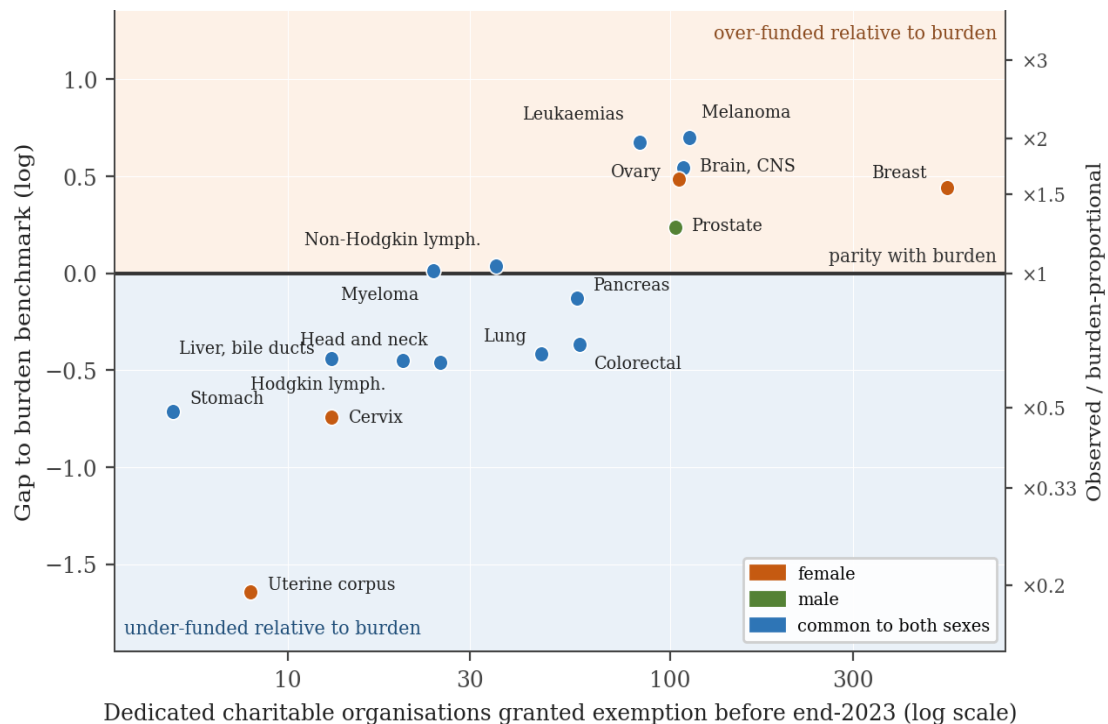


Figure 6a. Gap to the burden benchmark by cancer, plotted against the number of dedicated charitable organisations. The horizontal line is parity with burden: above it, the cancer receives more than a burden-proportional allocation would give, below it less. The right-hand axis gives the corresponding ratio.

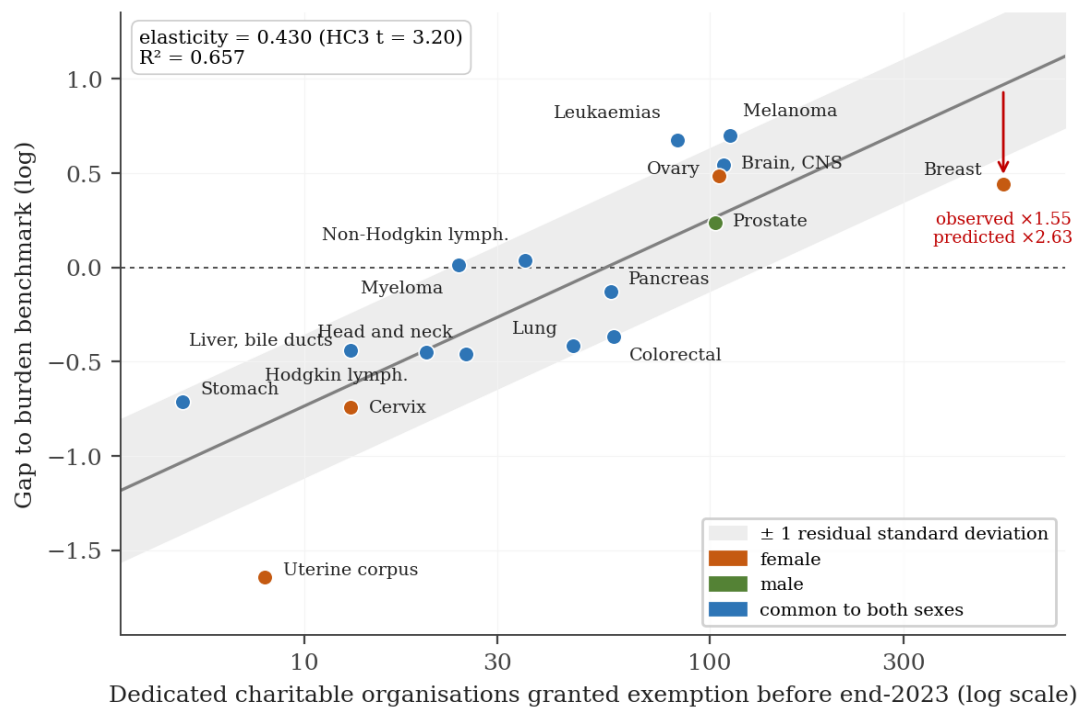


Figure 6b. The same relationship, with the least-squares fit and its one-residual-standard-deviation band. The line is the prediction of the gap by advocacy. Breast cancer, over-funded relative to its burden according to Figure 6a, lies below the line. This position depends on the functional form adopted, a constant elasticity; under saturating returns it lies on the curve, and section 6.5 shows that seventeen observations cannot discriminate between the two.

The magnitude of the underlying variation is considerable. Lung cancer, the leading cause of cancer mortality with 124,990 annual deaths, has 0.37 dedicated organisation per thousand deaths; breast has 12.40 and Hodgkin lymphoma, which kills 1,100 people a year, 18.18. The gap between the extremes reaches a factor of forty-nine, and this hierarchy was established independently of funding, from a tax register fed by private individuals who found associations after a diagnosis or a bereavement. The count is that of organisations whose tax-exempt ruling predates the end of 2023, the fiscal year of the funding compared, and not that of the register at the extraction date: of the 1,469 organisations identified in 2026, 150 were granted exemption after 2023 and are excluded.

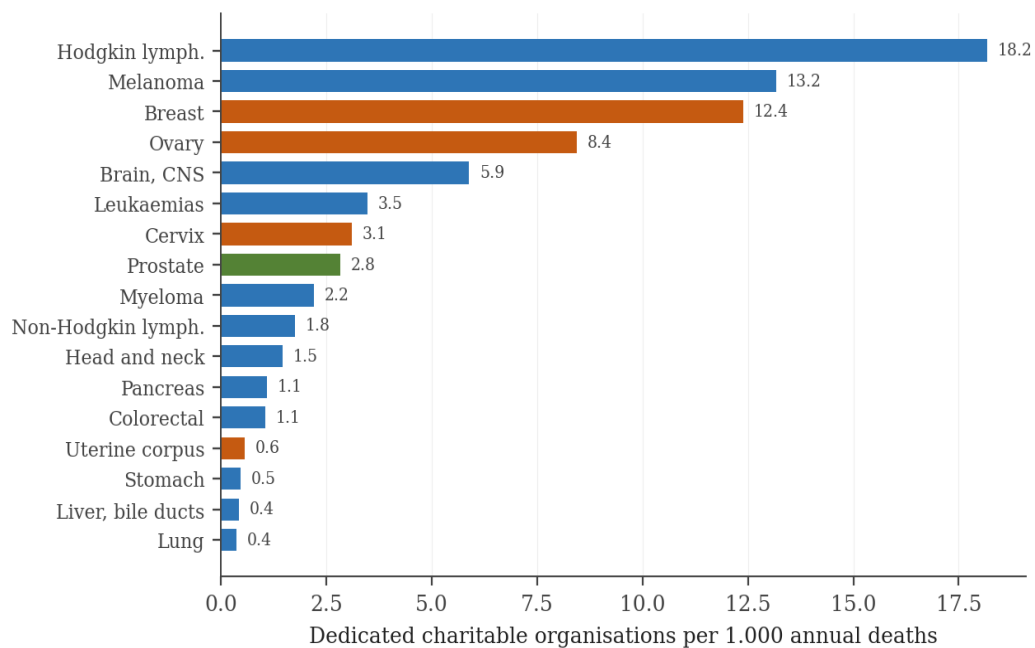


Figure 7. Density of patient advocacy by cancer. Source: American federal tax register via ProPublica Nonprofit Explorer.

One reservation on what the decomposition does not allow. Since the fit is logarithmic, its transposition into financial masses produces aberrant values for the extreme cancers: advocacy alone would predict for breast cancer a gap of USD 570 million above burden, against 193 observed. The shares reported are shares of variance and do not convert into millions. The proposition established is that advocacy orders the gap, not that it prices each of its components.

Advocacy residualised with respect to disease size

The specification retained so far regresses a funding already corrected for burden on an advocacy that is not. It moreover contains an implicit restriction: by constructing the dependent variable as the logarithm of the ratio between funding and burden-proportional funding, the coefficient of burden is set to one without having been tested. Three checks are therefore required.

Specification	Burden coefficient	Advocacy coefficient	t HC3	R2
A. Gap to burden benchmark on advocacy, burden constrained to 1	constrained to 1.000	+0.430	3.20	0.657
B. Funding on burden and advocacy, unconstrained	+0.827 (t = 7.88)	+0.492	3.52	0.924
C. Funding residuals on advocacy residuals, both purged of burden	removed	+0.492	3.74	0.706
D. Same exercise, advocacy measured by revenue	removed	+0.205	3.53	0.596

Table 6. Alternative specifications of the relationship between advocacy and funding. $n = 17$. Rows C and D apply the Frisch-Waugh-Lovell theorem: each variable is first regressed on burden, and it is the residuals that are confronted.

The result does not weaken, it strengthens. Once advocacy is also residualised with respect to disease size, the coefficient moves from 0.430 to 0.492 and the partial coefficient of determination from 0.657 to 0.706. The revenue measure, subjected to the same treatment, gives a coefficient of the same order, whose limitations the next section specifies.

The implicit restriction is moreover admissible. In the unrestricted specification, the coefficient of burden is 0.827 with a standard error of 0.105; the departure from unity gives a t-statistic of -1.65 and a p of 0.121, so that the hypothesis of a coefficient equal to one is not rejected at the 5 % level. The constrained form used in the rest of the study is therefore compatible with the data, and it has the advantage of bearing on a directly interpretable quantity, the gap to the burden benchmark.

Finally, the fear of a mechanical relationship between the two variables is not borne out. The correlation between the logarithm of burden and that of the number of organisations is 0.445, and burden accounts for only 19.8 % of the variance of advocacy. The latter therefore carries its own information for more than four fifths.

A point of vocabulary follows from the above. The figure of 65.7 % cited earlier is the coefficient of determination of the constrained specification. The partial coefficient of determination, which measures the share of the variance of funding explained by advocacy once burden is removed from both groups, is 70.6 %. It is this second figure that answers exactly the question posed.

Validation of the advocacy measure

The organisation count treats a large foundation and a local fundraising association alike. Two alternative measures were therefore built, by retrieving through ProPublica's interface the most recent tax return of each of the 1,469 distinct organisations identified, that is, 1,493 cancer-organisation pairings. Four hundred and fifty-seven of them report total revenue for fiscal year 2023, the others falling under the simplified filing regime that does not publish it or not having filed yet, for a cumulative revenue of USD 852.6 million over that year.

Advocacy measure	Coefficient	HC3 standard error	t HC3	R2
Number of dedicated organisations	+0.430	0.134	3.20	0.657
Reported revenue for fiscal year 2023	+0.205	0.058	3.53	0.596
Number of organisations with over USD 5 m revenue in 2023	+0.545	0.246	2.21	0.350

Table 7. Three measures of patient advocacy, regressed separately on the gap to the burden benchmark. $n = 17$.

The three measures lead to the same diagnosis and their mutual correlations, in logarithms, range from 0.70 to 0.84. The cumulative revenue measure is even the most robust of the three to heteroskedasticity, its HC3-robust t-statistic reaching 3.53 against 3.20 for the count. The result therefore does not depend on treating large and small structures alike. This measure does, however, have a fragility that the count does not: rerun on the revenues of each of the fiscal years 2018 to 2022, it is significant in none of them, whereas the count is in all six. The cause is cervical cancer, whose organisations report less than twenty thousand dollars of revenue a year over the whole period, while the cancer received 70 to 86 million dollars of funding until 2022. Without this observation, the revenue measure is significant in all six years, with HC3-robust t-statistics from 2.4 to 3.9.

The quality of the matching by legal name was checked on a random sample of fifty organisations. Forty-seven are correctly attached. Three cases are doubtful: an organisation whose name contains no oncological term, a cancer fund with no cancer specified, and a reconstructive surgery foundation attached to melanoma through the broader term skin cancer. The false-positive rate is therefore of the order of 6 % and it concentrates on the cancers for which several search terms were used. The variant built on a single canonical term, presented above, gives an elasticity of 0.373 instead of 0.430.

Diagnostics and robustness of the main relationship

With seventeen observations, the t-statistic alone is not enough. Five complementary diagnostics were conducted on the relationship between the gap to the burden benchmark and advocacy density.

Diagnostic	Result	Reading
Heteroskedasticity-robust standard errors, HC3	coefficient 0.430, standard error 0.134, $t = 3.20$, $p = 0.006$	The ordinary standard error, 0.080, is optimistic; the result remains significant at 1 %
Leverage and Cook's distance	Breast: leverage 0.360 and Cook 0.878; stomach: leverage 0.262	Breast is a high-leverage observation, conventional threshold $4/n = 0.235$
Leave-one-out	coefficient from 0.356 to 0.527; HC3 t from 2.59 to 3.87, lowest when stomach is removed	No single observation carries the result
Permutation test, 20,000 draws	$p < 0.0001$ (1 in 20,001)	None of the 20,000 permutations drawn produced a statistic as extreme as the one observed
Pairs bootstrap, 20,000 resamples	median 0.431, percentile interval [0.281; 0.692], no negative draw	The direction of the coefficient is stable

Table 8. Diagnostics of the relationship between the gap to the burden benchmark and the density of patient advocacy. $n = 17$.

The main lesson is corrective: the t-statistic of 5.36 obtained by the ordinary method overstates precision. Corrected for heteroskedasticity by the HC3 procedure, suited to small samples, it falls to 3.20, which leaves the result significant at the 1 % level but noticeably reduces its apparent strength. The other diagnostics are favourable. The coefficient ranges from 0.356 to 0.527 depending on the observation removed, and the HC3-robust t-statistic from 2.59 to 3.87, the lowest value corresponding to the removal of stomach. These ratios are computed with HC3 standard errors, like that of the full model, and their order of magnitude is therefore directly comparable with the latter's 3.20; the corresponding ordinary ratios, between 4.94 and 5.88, are higher for the same reason as in the full model. The permutation test, two-sided on the absolute value of the coefficient, gives a p below 0.0001, exactly 1 in 20,001 or 0.00005, under the convention , b being the number of permutations at least as extreme as the observation and m the number of permutations drawn, 20,000; no permutation reached

the observed value, and no bootstrap resample produces a negative coefficient. Breast cancer is a high-leverage observation, but its removal increases the coefficient rather than making it disappear, from 0.430 to $0.527 \cdot \frac{b+1}{m+1}$.

An additional check concerns the contemporaneity of the measure. The count used so far is that of organisations granted tax-exempt status before the end of 2023, the fiscal year of the funding analysed. The exercise was repeated for each of the years 2018 to 2023, each time confronting the year's funding with the count of organisations existing at the end of that same year, which the tax-exemption date published for each entity makes possible.

Fiscal year	Organisations at year end, total	Elasticity	t HC3	R2
2018	1,102	+0.422	3.68	0.604
2019	1,163	+0.418	2.90	0.533
2020	1,198	+0.503	2.79	0.505
2021	1,233	+0.441	2.77	0.523
2022	1,290	+0.438	2.78	0.486
2023	1,344	+0.430	3.20	0.657

Table 8bis. Relationship between the gap to the burden benchmark and the contemporaneous count of dedicated organisations, year by year, 2018 to 2023. $n = 17$ for each year.

The elasticity remains between 0.42 and 0.50 over the six years and remains significant at the 5 % level under robust standard errors in each of them. The coefficient of determination, for its part, ranges from 0.49 to 0.66 and reaches its highest value in 2023. This difference comes down to one observation: cervical cancer, funded at 70 to 86 million dollars until 2022 for thirteen dedicated organisations, constitutes over those years the most marked exception to the relationship, a heavily funded cancer with no advocacy. Its funding brought down to 20.7 million in 2023 aligns it with the others. Cervical cancer is thus the only cancer in which funding is decoupled from patient advocacy, which is consistent with a distinct funding channel, that of screening and human papillomavirus vaccination, and makes the 2023 break compatible with a transfer of this funding to another heading. The coefficient of 0.657 reported for 2023 is therefore the highest of the six and should not be presented as representative; the median value over the period is 0.51.

5.4 The first relationship: what advocacy is associated with

Establishing that funding follows advocacy does not close the analysis, since advocacy is itself determined. The dependent variable becomes the logarithm of the number of dedicated associations.

Explanatory variable	Coefficient	HC3 standard error	t	Reading
ln (composite burden)	+0.601	0.238	2.53	Grows more slowly than burden
Behavioural stigma	-1.408	0.426	-3.31	76 % fewer organisations
Female-specific	+0.253	0.949	0.27	No identifiable effect

Table 9. Determinants of the density of patient advocacy. $n = 17$, $R^2 = 0.533$. Heteroskedasticity-robust standard errors, HC3; ordinary standard errors give t -statistics of 2.55, -2.98 and 0.50.

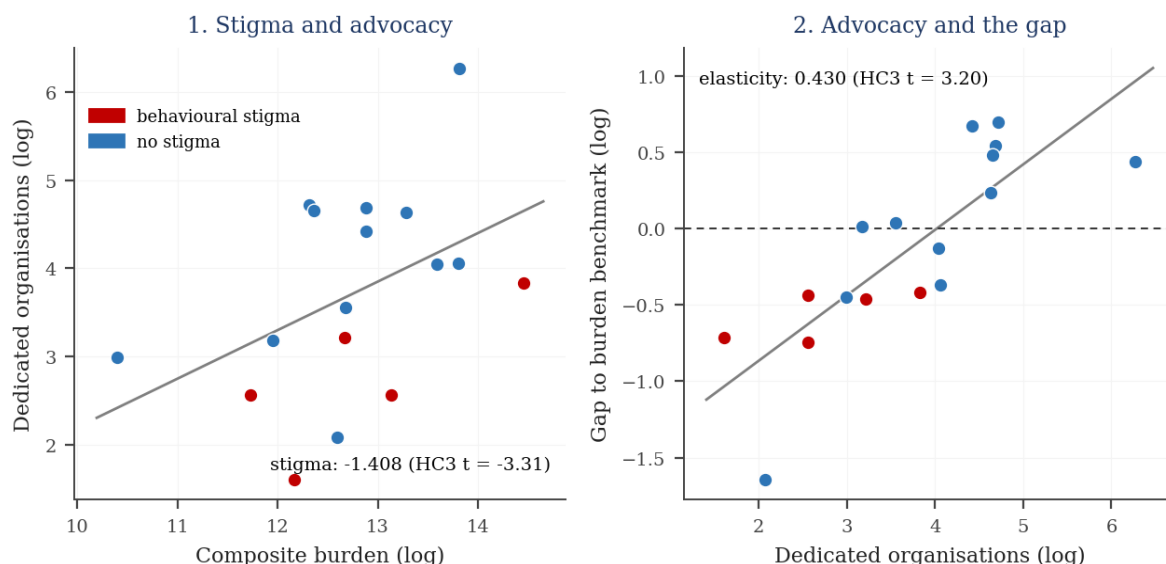


Figure 8. The two relationships. On the left, cancers with a behavioural stigma have fewer associations holding disease burden constant. On the right, advocacy density is associated with the gap to the burden benchmark.

Holding disease burden constant, cancers with a behavioural stigma have 76 % fewer dedicated organisations, with an HC3-robust t-statistic of -3.31. The partition by stigma explains 30.6 % of the variance of advocacy density, against 5.3 % for the partition by sex.

The empirical pattern can now be summarised as follows, bearing in mind that it is statistical and not causal. Behavioural stigma is negatively associated with the density of patient advocacy, coefficient -1.408 and HC3-robust t-statistic of -3.31. Advocacy is then strongly associated with the gap between observed funding and a burden-proportional allocation, with an elasticity of 0.430 and 65.7 % of the variance of that gap. No conversion of this variance share into a financial mass is proposed: the figure of 20.8 % measures the absolute magnitude of the gap to the burden scenario, not the fraction of that gap attributable to associations.

This estimate qualifies the usual interpretation of the role of stigma. Kamath and coauthors (2019) establish it on charitable funding; one might infer two parallel mechanisms, one private and the other public. The estimates presented here are rather compatible with a sequential relationship, from social judgement to the formation of associations and from these to public allocation, without the cross-sectional design making it possible to establish the causal direction. The observed fact is as follows: the stigma coefficient, negative as long as advocacy is not measured, ceases to be so once it is, which indicates that the two variables cover the same information and that advocacy is its finer measure.

5.5 Does the allocation present an asymmetry by sex? The American case

The question is posed without any directional hypothesis: is there, between female cancers and the exclusively male cancer, a difference in treatment relative to their respective burden? An affirmative answer requires that the two groups do not depart from their burden in the same proportion. This section examines the question using U.S. data, through four approaches based on different measures. Two are descriptive findings on all seventeen cancers; two rely on statistical inference whose scope is quantified at the end of the section. The status of these two registers is not the same and it is indicated each time.

A preliminary remark on the framework. The seventeen cancers do not constitute a sample drawn from a larger population: they correspond to the seventeen categories of cancer sites or types individualised in the Budget Fact Book table used here and cover 77.4 % of cancer deaths; they constitute neither the whole set of cancers nor the whole National Cancer Institute portfolio, whose page states that these headings are the most frequently requested and not the totality of its portfolio. The standard errors computed below describe a hypothetical resampling whose referent is doubtful. The descriptive statements, for their part, are exact on the set considered. It is on them that the conclusion rests, the inference tests being reported only to indicate what they do not allow one to assert.

First route, descriptive: funding per death

The group of female cancers receives USD 9,688 per death, or 1.59 times the average. This surplus disappears entirely once breast is removed: the group falls to USD 5,553, or 0.91 times the average, thus less than the prostate at 1.17. Uterine corpus, a female cancer, is the worst funded of the seventeen at 0.23 times the average, although it causes 14,450 deaths, 16 % more than ovary, for 6.6 times less funding.

Second route, descriptive: the symmetric comparison

Counting cancers is misleading, since it weights breast, 42,670 deaths, and cervix, 4,200, alike. The groups are therefore compared in aggregate, each relative to its own funding, and the prostate is included.

Group	Funding (USD m)	Deaths	Gap A	Gap B	Gap C
Female cancers (4)	714.7	73,770	-19.2 %	-68.8 %	-6.4 %
Exclusively male cancer, prostate (1)	258.6	36,320	-20.9 %	-96.8 %	+89.0 %
Cancers common to both sexes (12)	1,980.1	374,480	+9.7 %	+37.5 %	-9.3 %
Sex-specific, excluding breast (4)	431.3	67,420	+0.3 %	-60.9 %	+55.5 %
Breast alone	542.0	42,670	-35.6 %	-88.4 %	-10.2 %

Table 10. Aggregate gap by group, as a percentage of the group's funding. A negative gap indicates over-funding.

Female cancers are indeed over-funded in aggregate, by 19.2 % relative to burden. But the exclusively male cancer is over-funded by 20.9 %, that is, of the same order and if anything more, while the common cancers are under-funded by 9.7 %. There is therefore no female-specific premium relative to the male comparator. And the gap between sex-specific cancers and common cancers does not survive the removal of breast: plus 0.3 %, that is, exact parity.

Third route: variance decomposition

The partition by sex explains 0.8 % of the variance of the funding index across the seventeen cancers, against 19.8 % for the partition by stigma. The within-group standard deviation of the female group is 0.873, against 0.547 for the common group: female cancers differ more among themselves than they differ from the others.

The scope of this figure must be bounded. An exhaustive permutation of the four labels over the seventeen cancers, 2,380 combinations, gives a median share of 3.1 % and a ninety-fifth percentile of 24.3 %. The observed value of 0.8 % is therefore not abnormally low, 82 % of random labellings producing a higher value. Above all, a partition would have to explain more than 24 % of the variance to be distinguishable from chance on this sample. The decomposition indicates that sex does not order the observed dispersion; it does not rule out an effect of moderate size.

Fourth route: decomposition of the gap to the burden benchmark

On the normatively relevant variable, the coefficient of the female dummy is -0.306 with a standard error of 0.356, a t-statistic of -0.86, and the variable explains 4.7 % of the variance. Sex specificity, men and women together, explains 1.5 % of it.

Here again the scope must be bounded, and it is bounded widely. The 95 % confidence interval of the coefficient runs from -1.065 to +0.454, a ratio from 0.34 to 1.57. The test therefore rejects neither the hypothesis that female cancers receive 66 % less than a burden-proportional allocation would give, nor that they receive 57 % more. The minimum detectable effect at 80 % power corresponds to a factor of 2.81. This route settles nothing.

A complementary check deserves to be mentioned in order to be set aside: the correlation between the share of women among deaths and the funding index, measured on the twelve common cancers, is -0.13. It is inconclusive, the range of the explanatory variable being too narrow there, a little over twenty points.

Scope of the four comparisons

The first two comparisons are descriptive, the next two belong to statistical inference, and their scope is not the same. The first two are exact on all seventeen cancers. They establish four facts. The funding-per-death surplus of female cancers disappears entirely once breast is removed. The aggregate gap of this group relative to burden, minus 19.2 %, is of the same order as that of the prostate, minus 20.9 %, and it too does not survive the removal of breast, parity then being reached to within plus 0.3 %. The worst-funded cancer of the seventeen is a female cancer, uterine corpus. And the within-group dispersion of the female group exceeds that of the common group.

These four facts have a clear consequence: on the set studied, sex is not enough to account for the structure of the allocation, since cancers of the same sex are found at both ends of the ranking. They do not, however, constitute the refutation of a general hypothesis, because they bear on four female cancers one of which, breast, weighs 76 % of the group's funding.

The last two routes belong to inference and their intervals have just been given: from 0.34 to 1.57 for the coefficient of the gap to the burden benchmark, and a threshold of 24 % of explained variance for the decomposition. They are compatible with the absence of a sex effect; they are equally compatible with a substantial effect in either direction. Presenting them as convergent tests establishing an absence would be abusive, and the four routes are moreover not independent, since they rest on the same seventeen observations and the same four female cancers.

Limits of the inference

A causal reading of these results would exceed what the data allow, and this must be said precisely rather than concluded too quickly. The hypothesis that female cancers are more mobilised because they affect women, through the joint effect of advocacy organised on a sex basis and of a particular sensitivity of the public, is not refuted by Table 9. Nor is it supported there. The estimated coefficient is plus 0.253 with a standard error of 0.506, which leaves a confidence interval running from a ratio of 0.48 to a ratio of 3.47. The minimum detectable effect at 80 % power corresponds to a factor of 4.12. In other words, a sex effect tripling advocacy density holding disease burden constant would remain undetectable on this sample.

Two descriptive elements feed this hypothesis and two run against it. On the favourable side, female cancers have 3.66 organisations per thousand deaths in geometric mean against 1.90 for the common cancers, and the comparison of the two flagship sex-specific cancers gives 12.40 for breast against 2.84 for the prostate, a ratio of 4.4. On the unfavourable side, the within-group dispersion of the female group reaches a factor of twenty-two, from breast at 12.40 to uterine corpus at 0.55, with a within-group standard deviation of 1.20 close to that of the common group, 1.23; and the descriptive gap between non-breast female cancers and common cancers, 4.05 against 1.56, is entirely explained by the presence in the second group of the four most stigmatised cancers, which fall to 0.54.

The American case therefore does not settle the question posed. On seventeen cancers, none of the four routes has the power to distinguish a difference in treatment between the two groups, and the only solid statement is descriptive: the female group's surplus, minus 19.2 % relative to burden, is of the same order as the prostate's, minus 20.9 %, and it disappears when breast is removed. The question calls for a design with more independent replications. That is the object of section 5.6.

5.6 The symmetric test on nine national project portfolios

The limit of the American case is not the number of cancers but the number of replications. A sex indicator is invariant from one country to another: stacking country-cancer observations would create no information and would produce artificially low standard errors. What brings power is distinct national portfolios, built by funders applying distinct procedures to the same question. The International Cancer Research Partnership database provides nine.

The design is as follows. For each of the seventeen cancers and each of the countries with at least six hundred projects over all seventeen cancers for the period 2018 to 2022, a threshold that retains nine countries and

excludes all the others, the number of funded projects is recorded. The dependent variable is a count of projects and not an amount: what is measured is the structure of the portfolio of funded projects, not that of spending.

A project may be attached by its funder to several cancers, and it is then counted in each of them. The sum of the seventeen counts therefore exceeds the number of distinct projects, by a factor ranging from 1.25 in Belgium and France to 1.53 in Japan, and equal to 1.41 in the United States. The shares computed relate counts with overlap to a total also with overlap, so that the measure remains consistent; it does, however, implicitly give a higher weight to multi-labelled projects.

The effect of this choice was measured. For each country, the female share was recomputed on de-duplicated counts, obtained by querying directly the union of the four female cancers and the union of the seventeen, which the interface allows. The de-duplicated female share is higher than the share computed on sums in all nine countries, by 3.2 to 6.9 percentage points, because projects on a female cancer are less often multi-labelled than the others. Confronted with the same burden, the female gap then moves from 7.94 to 13.16 percentage points, with a t-statistic of 7.79, a p of 0.00005 and all nine countries above their burden. The treatment adopted in this study is therefore the more conservative of the two, and the overlap works against the reported result.

The share of burden serving as reference is computed separately for each country, from the national fact sheets of the Global Cancer Observatory of the International Agency for Research on Cancer, GLOBOCAN 2024 vintage, which provide incidence, mortality and five-year prevalence by cancer. The same construction as in section 4.1 is applied to them, with the same phase durations and the same disability weights. Two approximations remain: age at death by cancer is that observed in the United States, for lack of national distributions, and five-year prevalence is converted into complete prevalence by a uniform factor of 1.6. The section devoted to robustness shows that the results do not depend on them.

Each country thus yields a gap between its share of projects and its own share of burden, and the nine gaps form the sample of the test.

Country	Projects	Projects, female share	Burden, female share	Gap	Projects, prostate	Burden, prostate	Gap
United States	30,331	25.5 %	18.9 %	+6.6	8.1 %	5.9 %	+2.2
Canada	7,443	31.8 %	16.8 %	+15.0	8.7 %	5.5 %	+3.2
United Kingdom	5,157	22.4 %	17.7 %	+4.7	6.9 %	7.2 %	-0.3
Australia	1,737	30.9 %	16.1 %	+14.8	5.6 %	7.0 %	-1.4
France	1,569	22.6 %	18.7 %	+3.8	3.1 %	5.3 %	-2.2
Italy	1,285	22.4 %	17.1 %	+5.4	4.8 %	4.5 %	+0.3
Belgium	1,118	26.0 %	18.7 %	+7.4	2.8 %	6.6 %	-3.9
Netherlands	1,077	24.6 %	16.8 %	+7.8	4.0 %	6.5 %	-2.5
Japan	807	16.4 %	10.3 %	+6.1	2.4 %	3.4 %	-1.1

Table 11. Share of funded projects and share of burden, by sex group and by country, 2018-2022, in percentage points. Sources: International Cancer Research Partnership for projects, GLOBOCAN 2024 for burden, computed separately for each country.

Group	Mean gap	t (8 df)	two-sided p	Countries above	sign-test p
Female cancers	+7.94 pts	5.78	0.0004	9 of 9	0.004
of which breast alone	+6.84 pts	5.50	0.0006	9 of 9	0.004
of which the three others	+1.10 pt	2.58	0.033	7 of 9	0.180
Prostate	-0.63 pt	-0.83	0.432	3 of 9	0.508

Table 12. Symmetric test on the nine national gaps. The two-sided p is that of the t-test with eight degrees of freedom; the sign-test p is the exact two-sided binomial p on the number of countries above their share of burden.

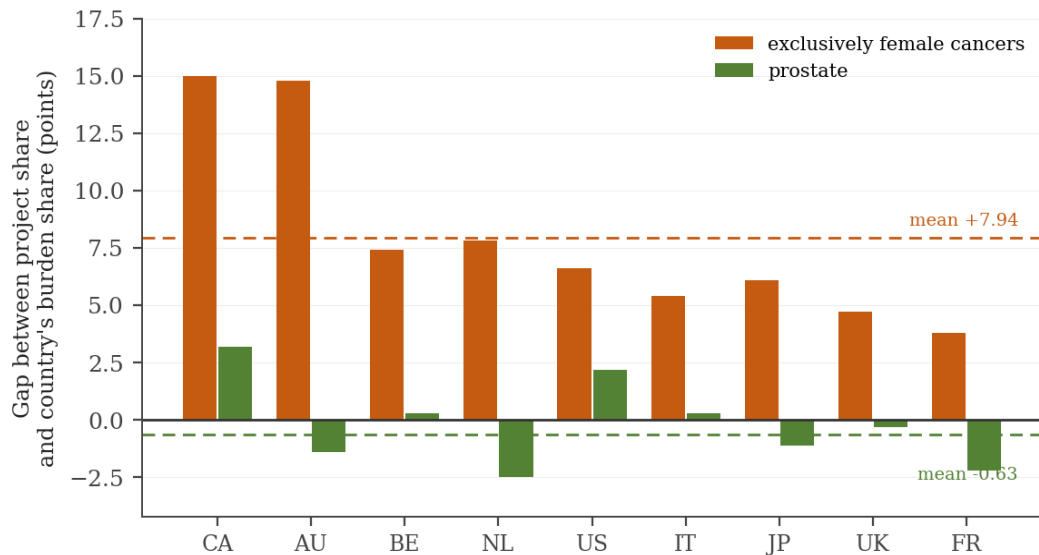


Figure 9. Gap between the share of funded projects and each country's own share of burden, nine countries, 2018-2022, in points. Dashes mark the mean gaps.

Hypothesis H2 is supported by the international panel, in one direction and one only. On the female-cancer group, the excess of 7.94 percentage points is significant at the one-per-thousand level in a two-sided test, p equal to 0.0004, and all nine countries without exception lie above their own share of burden, which gives an exact sign test at p equal to 0.004 and a Wilcoxon signed-rank test at the same value. The result therefore depends neither on the normality assumption nor on any particular country.

On the prostate, by contrast, no statistically identifiable deficit appears. The prostate gap is -0.63 percentage points with a t -statistic of minus 0.83, p equal to 0.432, and only three countries out of nine place it below its share of burden. This result corrects the earlier version of this study, which used a single American burden reference and concluded to a marginally significant prostate deficit of 1.78 percentage points. Correcting the reference makes it disappear: the observed asymmetry is one-sided, a female excess and not a male deficit.

Female cancers show an excess of nearly eight points of project share over their share of burden, in the nine national portfolios examined, without exception and at a high level of significance. For the prostate, no significant deviation from its share of burden is detected: the mean gap is -0.63 percentage points ($p = 0.432$). There is no transfer from one to the other: the counterpart of the female excess is spread over the cancers common to both sexes.

The contrast with the American case comes down to the number of national observations available: nine national project portfolios, built by funders subject to different procedures, administrative cultures and advocacy landscapes, produce the same gap, each measured against its own epidemiology. These nine observations do not, however, constitute nine independent replications in the statistical sense. They share the same cancer classification, that established by the International Cancer Research Partnership, and the same age-at-death structure, for lack of national distributions. They are nine convergent national observations, which rules out an explanation by the peculiarities of one agency or by the epidemiological profile of one country, not nine independent experiments.

An immediate objection is that the result could be driven by the United States, which alone supplies 30,331 of the panel's 45,524 projects. The matrix of gaps by cancer and by country allows one to judge.

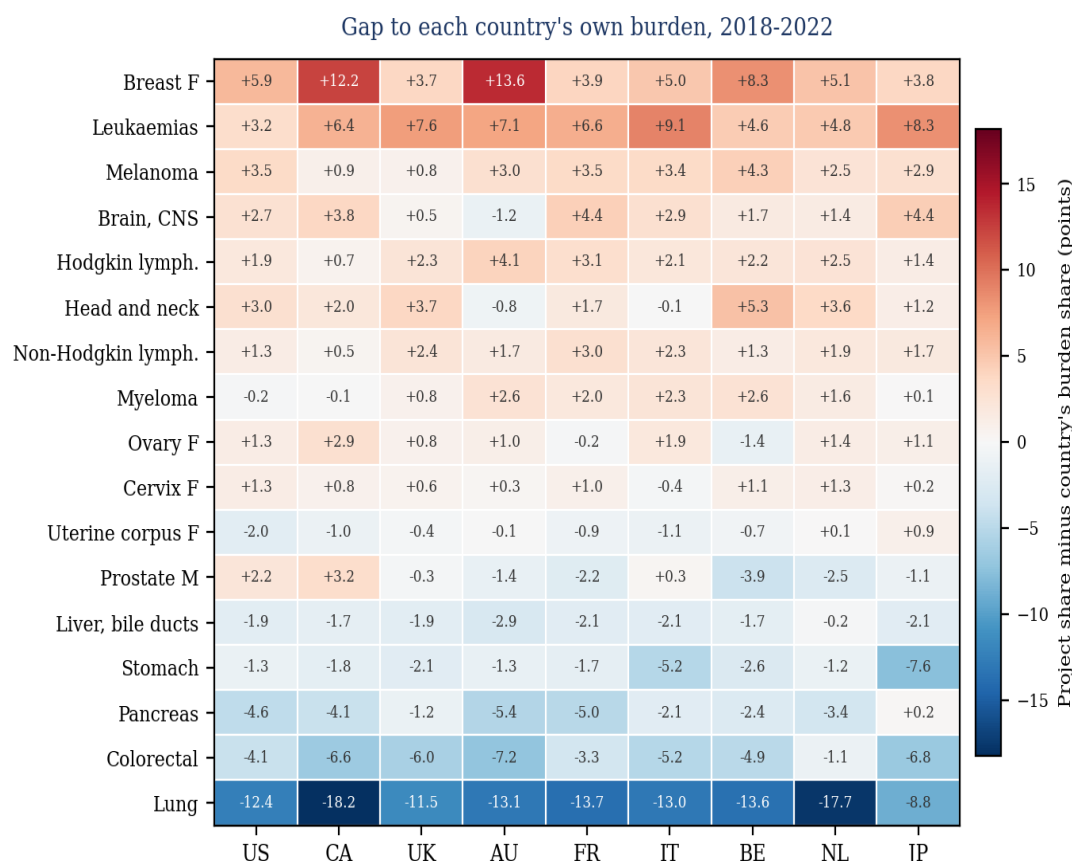


Figure 10. Gap between the share of projects and each country's own share of burden, by cancer, 2018-2022, in points. Cancers are ranked by mean gap. Red ones receive more than their burden, blue ones less.

The hierarchy is remarkably stable once each country is confronted with its own burden. Four cancers are in deficit in all nine countries without exception: lung, colorectal, liver and stomach. Five are in surplus in all nine: breast, melanoma, the leukaemias, Hodgkin lymphoma and non-Hodgkin lymphoma. None of these nine cancers changes side from one country to another.

The rank correlation between the American profile and that of each other country confirms this reading: 0.90 for Canada, 0.84 for Italy, 0.83 for France, 0.82 for the Netherlands, 0.80 for Belgium, 0.79 for the United Kingdom and Japan, 0.73 for Australia, or 0.81 on average outside the United States. The result is therefore not an American artefact: the eight other national portfolios observed rank the cancers in a very similar order, with different envelopes, procedures and advocacy landscapes.

Japan deserves a mention because it was the anomaly of the earlier version of this study. Measured against an American burden reference, its profile showed a rank correlation of only 0.24 with that of the United States, stomach appearing in surplus there and breast in deficit. Measured against its own burden, the correlation rises to 0.79 and the country joins exactly the eight others. The anomaly was an artefact of the reference, not a peculiarity of preference, and its disappearance is the best argument for the correction made.

Sensitivity to the country selection threshold

The threshold of six hundred projects retains nine countries. It must be checked that the result does not depend on it. The distribution of volumes makes this check simple: between Germany, tenth country with 300 projects, and Japan, ninth with 807, no country lies. The threshold could therefore have been set anywhere between 301 and 807 without changing the sample. Four additional countries were nonetheless collected to go below it, Germany, Spain, China and Switzerland, with their respective burden sheets.

Project threshold	Countries retained	Mean female gap	t	two-sided p	Positive countries	Prostate gap	p
150	13	+7.72	6.80	< 0.0001	13 of 13	-0.41	0.519
200	11	+7.19	5.70	0.0002	11 of 11	-0.55	0.416
300	10	+7.29	5.24	0.0005	10 of 10	-0.72	0.324
600 (adopted)	9	+7.94	5.78	0.0004	9 of 9	-0.63	0.432
900	8	+8.18	5.32	0.0011	8 of 8	-0.57	0.528
1,100	7	+8.23	4.64	0.0035	7 of 7	-0.29	0.768
1,300	5	+8.98	3.66	0.0215	5 of 5	+0.30	0.786
1,600	4	+10.27	3.81	0.0317	4 of 4	+0.94	0.444
2,000	3	+8.77	2.77	0.1091	3 of 3	+1.72	0.241

Table 13. Sensitivity of the symmetric test to the volume threshold used to select countries. The four countries added below six hundred projects are Germany, Spain, China and Switzerland, each confronted with its own burden.

The female gap remains between 7.19 and 10.27 percentage points over the whole range, and it is positive in every country retained at each of the nine thresholds tested, including at 150 where thirteen countries enter the computation. Its significance holds at the 5 % level up to 1,600 projects and is lost only at 2,000, where only three countries remain and power vanishes. The prostate gap, for its part, is significant at no threshold and even changes sign from 1,300 projects. The choice of six hundred therefore carries no consequence.

The weight given to each country is a second convention to be made explicit. The test retains nine national sets of projects recorded in the ICRP and gives each the same weight, which is the choice consistent with the question posed, that of a convergence across systems, but also the one that gives the least weight to the United States, which supplies 60 % of the panel's projects. Weighted by each country's project volume, the nine gaps give a female excess of 7.84 percentage points instead of 7.94; weighted by the square root of volume, 8.12; outside the United States and weighted by volume, 9.70. The prostate gap remains in all cases between minus 1.0 and plus 1.5 percentage points. The result therefore depends neither on the weighting nor on the American weight. Weighting by spending is not possible, the database not publishing amounts.

An interpretive reservation remains and it is more serious than that of weighting. The nine countries are not nine independent experiments. Oncology research is internationalised: the same journals, the same scientific priorities, the same multicentre trials, the same patient movements and the same symbols, the pink ribbon having crossed every border. Part of the observed convergence may reflect this community of influences rather than nine distinct judgements on the same question. The finding of nine identical signs is not weakened by this, but reading the reported p-values as those of nine independent replications is probably optimistic, which is why the text speaks of convergent national observations.

The direction and its origin

The decomposition immediately imposes a restriction. Breast cancer explains 86 % of the over-representation, that is, 6.84 of the 7.94 percentage points, with all nine countries above their burden and a p of 0.0006; but the three other female cancers also contribute positively to the remaining 14 %, with together an excess of 1.10 percentage points, a small but positive gap, significant at the 5 % level in a t-test, p equal to 0.033, and present in seven countries out of nine. This last point also corrects the earlier version of this study, where the American reference gave minus 0.25 percentage points, not significant. The non-breast female surplus therefore exists, but it is seven times smaller than that of breast cancer.

The exact statement is therefore the following. International oncology research portfolios show an over-representation of the female group relative to its burden, of the order of eight points of project share, and this asymmetry is essentially, but not exclusively, due to breast cancer. It is not a property of the female sex applied to its four cancers, but, essentially, a property of a single cancer, which happens to be female and which alone concentrates 17.26 % of all oncology projects funded in the nine countries.

What distinguishes this formulation from a broader version is not rhetorical. A statement about a uniform priority given to female cancers would be ill-fitted to these data: the surplus of the three other female cancers is seven times smaller than that of breast, and one of them, uterine corpus, remains the worst funded of the seventeen using U.S. data. The statement retained, that of an over-representation of the female group relative to its burden, mainly but not exclusively driven by breast cancer, withstands all the tests conducted here and rests on nine convergent national observations.

Three reservations

The burden reference is now specific to each country, which lifts the main reservation of the earlier version. The effect of the correction is clear: Japan, the only country in apparent deficit when the reference was American, moves to plus 6.1 percentage points once its own epidemiology is taken into account. Its singular profile was indeed epidemiological and not preferential, as the weight of stomach and liver in that country suggested. Two approximations nonetheless remain: age at death by cancer is still that observed in the United States, and the five-year prevalence published by GLOBOCAN is converted into complete prevalence by a uniform factor.

This last parameter was tested from 1.0 to 2.5: the female gap ranges from 7.68 to 8.12 percentage points and its p remains below 0.0005 over the whole range, the prostate gap remains not significant, and the non-breast female gap remains at 1.10 percentage points. A more radical variant, which removes all morbidity and keeps only years of life lost, gives a female gap of 8.49 percentage points with a p of 0.0003 and nine countries out of nine. The international result therefore depends on none of the choices made in constructing burden.

The variable is a number of projects and not an amount. An Australian project and an American project have neither the same size nor the same duration. The result concerns the structure of research effort, not the structure of spending.

The nine gaps no longer share the same burden denominator now that burden is computed country by country, but they rest on the same age-at-death structure and the same cancer classification. The finding of the same sign in nine countries out of nine depends, for its part, on no normality assumption. The binomial p of 0.004 is, however, computed under the assumption of independent signs; the common dependencies among national portfolios lead one to interpret it with caution, and the term exact test holds only under that assumption. The same goes for the signed-rank test, which rests on the same nine observations as the t -test. The three procedures therefore do not constitute three independent confirmations, but three readings of the same sample of nine national gaps.

A paired comparison and what it shows

One might hope to settle the matter more simply by comparing two gonadal cancers, ovary and testis. The comparison is instructive but not conclusive. Relative to deaths, the two are at parity: 109.5 projects per thousand deaths for testis against 103.4 for ovary. Relative to total burden, ovary moves ahead by a factor of 3.1. But testis kills 630 people a year with a survival of 94.6 %, which makes it a largely solved problem, and an allocation based on the therapeutic margin would grant it little without any sex effect being needed. Advocacy density moreover contradicts the sex interpretation: testis has 17.5 dedicated organisations per thousand deaths against 9.0 for ovary. Paired comparisons confound sex and lethality; that is why the aggregate test on nine countries is preferred to them.

5.7 Rejection of the survivor-stock hypothesis

Hypothesis H4 predicts that a survivor-stock indicator, built as the product of incidence and five-year survival, improves the fit obtained from mortality alone. The test is negative. Taken in isolation, this indicator explains only 25 % of the variance of funding, against 71.5 for mortality. Added to mortality, it raises the coefficient of determination from 0.715 to 0.730, a negligible improvement, and its own coefficient is 0.132 with a standard error of 0.150. The feedback-loop mechanism remains theoretically plausible but is not identifiable in cross-section.

5.8 The price of cure

A last result sheds light on the nature of the gap. The sensitivity of each key to survival, measured by regressing the logarithm of funding on five-year relative survival, is -11.3 % per ten points of survival under scenario A and -37.9 % under scenario B. The observed allocation, for its part, shows -9.0 % with a standard error of 1.152, a coefficient indistinguishable from zero, with a coefficient of determination of 0.04. The American allocation is therefore practically indifferent to survival, where every normative conception of the optimum lowers funding as the cancer becomes curable.

5.9 The 2005-2023 panel: the relationship is a state, not a dynamic

The cross-section left open the question of whether the relationship between advocacy and funding describes a response of the funder to advocacy, or a long-run equilibrium state whose two terms stem from common causes. The National Cancer Institute's Fact Book archives publish the same series for the same seventeen cancers since 2003, in five-year windows, and the tax-exemption date of each organisation makes it possible to reconstruct the number of organisations existing at the end of each fiscal year. A panel of seventeen cancers over nineteen fiscal years, 2005 to 2023, or 323 observations, results; fiscal year 2024, a copy of the previous one, is excluded.

This panel makes it possible to estimate the relationship in within-cancer variation, with cancer and year fixed effects. The cancer fixed effect absorbs everything that, within a cancer, does not change over the period, its burden, its tractability, its image; the year fixed effect absorbs the common growth of the budget and of the non-profit sector. What remains is the relationship between the differential growth of organisations and the differential growth of funding.

Specification	Elasticity	Standard error
Between cancers, 2005-2023 means	+0.671	0.117 (t = 5.72); HC3 0.069 (t = 9.79)
Cancer fixed effects only	+0.169	0.082 (t = 2.06)
Cancer and year fixed effects	+0.237	0.184 (t = 1.29)
First differences, year fixed effects	+0.124	0.085 (t = 1.46)
Lags of 1 to 5 years on organisations	+0.21 to +0.26	t from 1.18 to 1.70
Long-run growth 2005-2023, 17 cancers	+0.463	correlation 0.28

Table 14. Relationship between funding and patient advocacy on the 2005-2023 panel, 17 cancers, 323 observations. Standard errors clustered by cancer account for the correlation of residuals within the same cancer.

The result is clear and it tempers the reading of the cross-section. The within-cancer elasticity is positive, from 0.12 to 0.26 depending on the specification and the lag, and stable in sign; it is significant in none of them once standard errors are clustered by cancer. The reason is the nature of the variation available. Organisations were multiplied by two to seven in all cancers between 2005 and 2023, but this growth is largely common, and its differential component, the one that identifies the relationship, has a standard deviation of only 0.19 in logarithm, against 1.39 for the between-cancer variation. The panel does not contain enough variation of its own to settle the question.

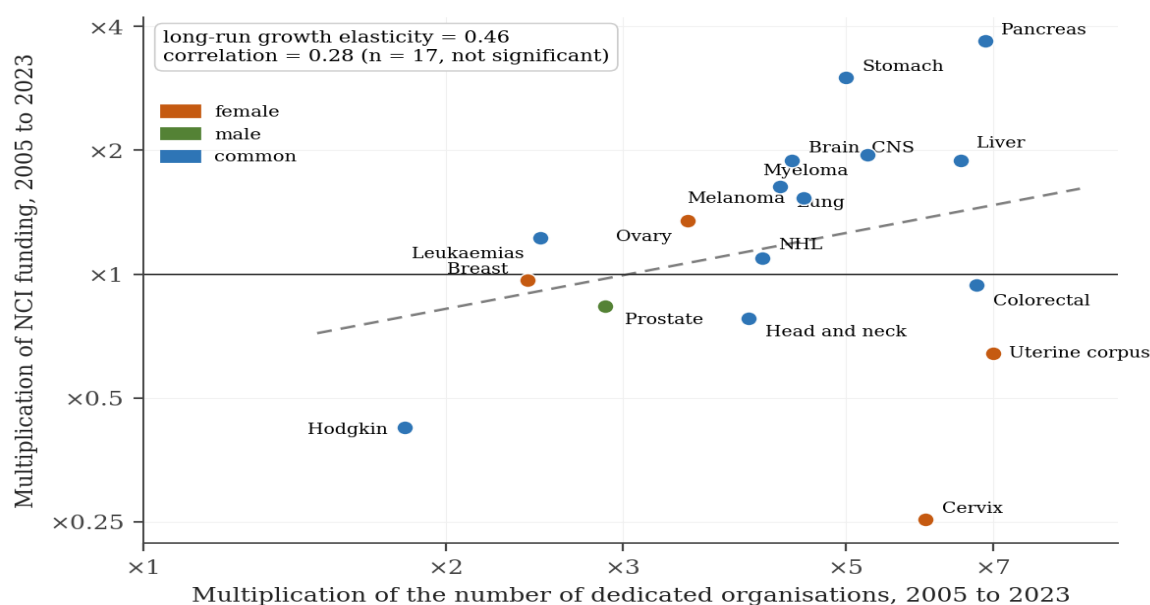


Figure 11. Multiplication of the number of dedicated organisations and multiplication of National Cancer Institute funding between 2005 and 2023, seventeen cancers, logarithmic scales. The line is the least-squares fit.

What the panel establishes is therefore more precise than what the cross-section suggested. The relationship between advocacy and funding is a relationship of levels, across cancers, describing a long-run state: a heavily mobilised cancer is a well-funded cancer, and this has been true since at least 2005. It is not, over the period observed, a relationship of flows: a cancer whose advocacy grows faster than the others does not see its funding grow significantly faster. The pancreas, whose organisations went from 8 to 55 and whose funding from 67 to 246 million, illustrates what a response would look like; colorectal, from 8 to 54 organisations for unchanged funding, and uterine corpus, from 0 to 7 for funding down by a third, show that such a response is not the rule.

The panel does not make it possible to discriminate between two interpretations. The relationship may reflect a slow adjustment of the funder to a stock of advocacy accumulated over several decades, which nineteen fiscal years are not enough to reveal; it may also stem from a durable common cause, such as the social visibility of the cancer or the characteristics of its population, which generates both advocacy and funding and which the cancer fixed effect absorbs along with the relationship itself. The cross-sectional estimate of section 5.3 must therefore be read as the description of an equilibrium and not as the measurement of a lever. Section 6.5, which reasons on that lever, is all the more conditional for it. What would discriminate between the two readings is an exogenous shock to the advocacy of one cancer, such as a publicised diagnosis or a campaign produces, whose effect on funding would be measured by an event study.

6. Discussion

6.1 Interpretation

The overall picture is that of an allocation mostly ordered by burden, whose residual gap is in turn ordered by two measured quantities, the density of patient advocacy and, upstream of it, the social judgement attached to the disease. The residual of USD 613 million indicates that burden is only partially taken into account, and its structure indicates that the distortion is not random. What follows proposes a reading of that structure; it is compatible with the data without being established by them, the cross-section not allowing any causal direction to be identified, and the panel of section 5.9 showing that the relationship describes an equilibrium of levels rather than a response to variations.

On the premium side, the cancers that have a recognisable symbol, a dedicated month, a charitable industry and a mobilised constituency are also those that receive beyond their burden. Breast cancer is the extreme case, with 529 dedicated organisations at the end of 2023; the leukaemias and brain tumours present the same configuration, their visibility owing largely to their paediatric component. On the deficit side, the cancers whose

disease is attributed to the patient's behaviour are also those whose advocacy fabric is the least dense and whose funding departs furthest below their burden.

One objection must be dealt with. One might argue that the premium of breast, melanoma and the leukaemias reflects a higher marginal return, that is, a scientific maturity allowing spending to be efficiently converted into survival. The objection is admissible in theory but hard to sustain in practice. Melanoma and the prostate already show survivals of 94.7 and 98.2 %, which leaves little room for progress, whereas the pancreas plateaus at 13.7. And if the marginal-return argument were the principle actually applied, it should be documented and published, which it is not. What is at issue is not only the level of the allocation, it is the absence of explicit justification.

One may also object that patient advocacy reflects collective preferences which a public funder could legitimately take into account. The argument runs into two difficulties. The first is institutional: the National Cancer Institute is not a representative body, its mandate is scientific, and no text instructs it to weight cancers by the intensity of the advocacy they attract. The second is substantive: advocacy is not the neutral expression of preferences, it is shaped by the disapproval attached to certain diseases, as Table 9 establishes. Following advocacy therefore amounts to indexing public research spending on the degree of responsibility that society attributes to the patient, which is not a public health criterion.

6.2 Confrontation with the literature

Our results agree with Carter and coauthors (2012 and 2015) on the identification of breast and the leukaemias among the best-funded cancers, and of stomach, head and neck and uterus among the worst funded. The stability of this diagnosis over fifteen years, two countries and different nomenclatures is a strong argument for its robustness. One point of divergence must be noted: those authors explicitly recommend reducing the funding of breast, prostate and the leukaemias. We do not make that recommendation for the prostate, whose ranking reverses under scenario C.

Our results agree with Kamath and coauthors (2019) on the role of stigma. They suggest that the private and public channels do not constitute two parallel mechanisms but an ordering, private advocacy fully absorbing the stigma coefficient in the public model. This reading remains an interpretation, the cross-section not making it possible to discriminate it from an unobserved common cause.

Confrontation with the female-disadvantage thesis

The result of section 5.6 runs counter to a widely circulated thesis, according to which health research favours diseases in which men are the majority. This thesis rests on a statistic bearing on the share of the global biopharma pipeline devoted to specifically female conditions, on the under-representation of women in clinical trials, and on the estimates of Mirin (2021). In the field of oncology, measured by the number of funded projects in nine countries, the asymmetry runs the other way: it is the female-cancer group that receives beyond its burden, while the prostate does not depart from it significantly. It would be incomplete to present this result without setting out what it contradicts and on what conditions it holds.

This result does not on its own refute the literature on women's health, because the objects and the units of measurement differ. The 5 % statistic concerns the share of specifically female conditions among drug candidates in clinical development in the pharmaceutical industry (McKinsey, 2023), all conditions combined, female cancers for four points and maternal health, contraception, fertility, endometriosis and menopause for the fifth. Our result concerns the internal distribution of an oncology envelope across cancers. One and the same reality may comprise an under-funding of female conditions at the scale of medicine and an over-representation of the female-cancer group within oncology.

The second is that the literature cited itself supplies the key to the reversal: of the five points of biopharma pipeline share devoted to female conditions, four go to female cancers and only one to everything else. In this pipeline measure, oncology accounts for four of the five points attributed to specifically female conditions, and within it breast cancer. The low share observed in the pipeline concerns mainly non-cancer female conditions, and our result is its counterpart: where women are well funded, they are so through a single channel.

The third is that the units of measurement differ: we count projects funded by partner agencies of the International Cancer Research Partnership, whereas the literature cited most often reasons in dollars and on scopes which, for the 5 % statistic, are confined to industrial funding, where the structure is different.

Direction, magnitude and robustness to the metric

Two clarifications are needed before concluding, one on magnitude and the other on robustness.

On magnitude, the comparison is possible because Mirin (2021) quantifies his result: diseases favouring men depart from burden-proportional funding by a factor of five to six, those favouring women by a factor of two to three, and the ratio between the two is 2.49 at the start of the period and 1.84 at the end. Our international asymmetry gives 1.265 for the female-cancer group and 0.743 for the prostate, a ratio of 1.70. The difference is therefore in direction rather than magnitude: the latter is of the same order and slightly lower. The two quantities are moreover not homogeneous, Mirin relating dollars to disability-adjusted years over a whole portfolio, and we projects to a share of burden over one field.

On robustness, the asymmetry was recomputed on seven different denominators, each time relating the funding of the female group and that of the prostate to the same measure of need.

Denominator	Female group	Prostate	Ratio	Direction
Per new case	1,672 \$	775 \$	2.16	female
Per person in active disease	3,899 \$	1,930 \$	2.02	female
Per prevalent person	126 \$	70 \$	1.80	female
Project share over burden share, nine countries	1.265	0.743	1.70	female
Per death	9,688 \$	7,120 \$	1.36	female
Per year of composite burden	433 \$	442 \$	0.98	parity
Per year of life lost	540 \$	700 \$	0.77	male

Table 15. Ratio of the female group's funding to that of the prostate, by denominator. Six rows are built using U.S. data, fiscal year 2023; the row relating project share to burden share uses the international panel, period 2018-2022.

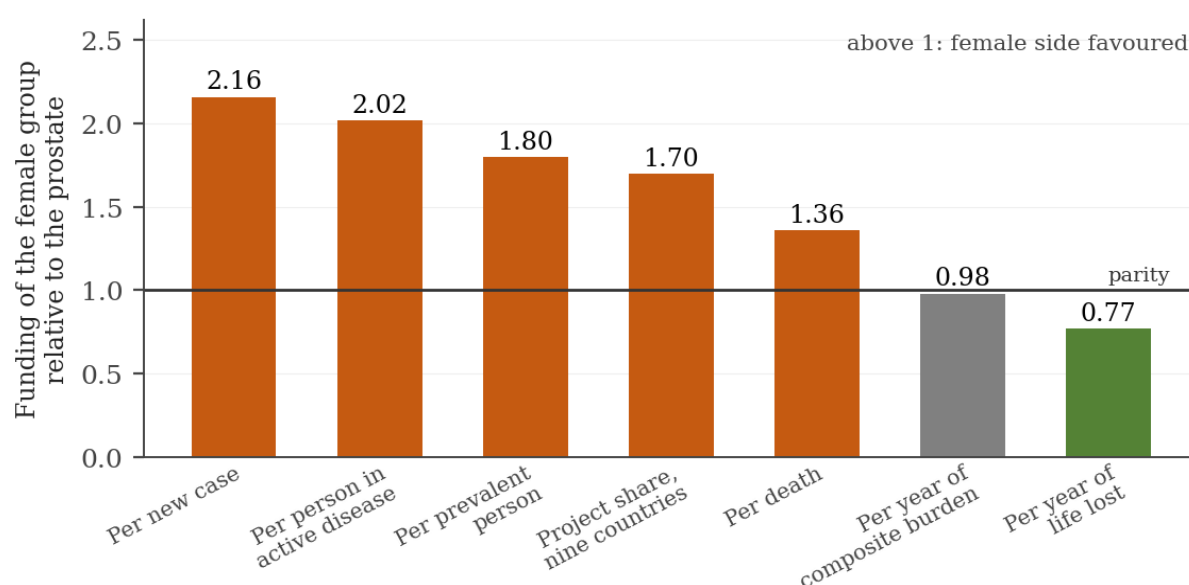


Figure 12. Ratio of the female group's funding to that of the prostate, by denominator.

Five denominators out of seven favour the female-cancer group, with ratios between 1.36 and 2.16. One gives parity. Only one reverses it, that of years of life lost, and the reversal there is mechanical: prostate cancer kills at a median age of 79, which gives it 10.17 years of life lost per death, the lowest value of the seventeen cancers.

Its denominator is therefore small and its funding per year of life lost mechanically high, without any particular generosity being at issue.

This observation has a scope beyond our subject. The analysis from which Mirin draws his oncology finding, the one ranking the prostate first and the gynaecological cancers tenth, twelfth and fourteenth, rests precisely on funding relative to years of life lost. It is the only one of the seven denominators tested here that produces this ranking, and it produces it through the age structure of prostate mortality. The finding of a male advantage in oncology is therefore not robust to the choice of denominator: of the seven measures tested, five favour the female-cancer group, one gives parity and only one the prostate.

One restriction remains, and it is the same as everywhere else in this study. With breast cancer removed from the female group, the picture flips: three denominators out of five then favour the prostate, and the gap becomes large on years of life lost, 304 dollars against 700, as on composite burden, 265 against 442. What this flip means and does not mean must be made clear. The three remaining female cancers, cervix, uterine corpus and ovary, remain over-funded or at parity relative to their own burden, never below it: using U.S. data, their aggregate gap to the burden benchmark is plus 0.3 %, that is, parity, and in the international panel they keep an excess of 1.10 percentage points of project share, positive in seven countries out of nine. What disappears with breast cancer is the female-cancer group's advantage over the prostate, not the coverage of the female burden. And this residual group is itself heterogeneous, ovary receiving 1.6 times its burden, cervix a fraction that depends on the base, uterine corpus 0.23 times. The female advantage is therefore real and robust to the choice of metric, but it remains very largely driven by breast cancer; excluding breast, the female-cancer group is at parity with its burden in the United States and slightly above it in the international portfolios, without any longer exceeding the prostate.

The point that does not reconcile concerns the ovary. The frequently cited analysis that ranks it fifth for lethality and twelfth for the ratio of funding to lethality directly contradicts our estimates, which place it among the over-funded cancers under the three American scenarios. The international panel points the same way as our estimates: relative to its national burden, the share of projects devoted to ovary is in surplus in seven portfolios out of nine, from plus 0.8 percentage points in the United Kingdom to plus 2.9 in Canada, at parity in France, minus 0.2, and in deficit in Belgium only, minus 1.4. A cancer under-funded at twelfth rank should not find itself on the surplus side in nearly all portfolios. The divergence most likely stems from the metric, that analysis relating funding to years of life lost alone whereas we add morbidity and prevalence in active disease, and from the vintage. We cannot settle it here and we flag it as a reconciliation to be carried out.

6.3 Limitations

The stigma variable is an author's coding, and it was the point most exposed to challenge. Its scope must first be circumscribed: it does not affect the relationship between advocacy and funding, which does not involve this variable, but only the adjacent proposition that advocacy is lower for cancers whose disease is attributed to the patient. It has moreover been confronted with an external measure, which the end of this section reports, and the two cases that seemed questionable are thereby strengthened. Stomach cancer is as much a matter of *Helicobacter pylori* infection as of a disapproved behaviour. Symmetrically, melanoma is largely attributable to a sun-exposure behaviour and is nonetheless classified outside the stigmatised group, where it appears as the best-funded cancer. The following paragraphs quantify this asymmetry, then confront it with an external measure with which it agrees.

The stigma variable would gain from being replaced by a continuous, published quantity rather than an author's binary coding. The population attributable fraction, as estimated by Islami and coauthors, provides one. The complete vector could not be reconstructed: the 2024 article is under an open licence according to its metadata, but its full text is accessible neither from the publisher for automated extraction nor in public repositories. Seven values were obtained from secondary sources, five of which concern cancers in the sample.

Cancer	Share of cases attributable to modifiable factors	Rank of funding per death
Melanoma of the skin	92.2 %	1st of 17
Lung and bronchus	88.2 %	15th of 17

Cancer	Share of cases attributable to modifiable factors	Rank of funding per death
Uterine corpus	59.2 %	17th of 17
Colorectal	54.2 %	12th of 17
Breast	31.2 %	3rd of 17

Table 16. Population attributable fraction, incidence, United States 2019. Source: Islami and coauthors (2024), values reported in a presentation to the American National Academies. The same author's 2017 review moreover places cervix and larynx above 80 %, and Hodgkin lymphoma and ovary at 5 % or less.

These five values suffice to rule out the hypothesis that the fraction attributable to modifiable factors alone would explain the ranking of cancers. Melanoma has the highest attributable fraction of the five, 92.2 %, more than lung, and it is the best-funded cancer per death of the seventeen. Lung, at 88.2 %, is fifteenth. Attributing a cancer to a modifiable behaviour therefore depresses nothing by itself: two cancers four points of attributable fraction apart occupy the two ends of the funding ranking.

What distinguishes them is not the avoidability of the disease but the nature of the behaviour involved: tobacco, alcohol and chewing tobacco belong to a socially situated category, sun exposure does not. The defensible hypothesis is therefore not that of a behaviour penalty, but that of a penalty attached to a behaviour associated with a given social status. Substituting the full vector of attributable fractions for the binary coding would make it possible to test this directly, by crossing the size of the avoidable share with the nature of the risk factor. This extension presupposes access to the full text, which could not be obtained here. A third route, less costly than the two previous ones, was adopted: confronting the coding with an external measure of one component of the construct, published independently of any funding data.

Marlow, Waller and Wardle (2010) asked a representative sample of 1,620 British women to what extent they would hold a person with each of five cancers responsible, comparing the answers with two conditions serving as yardsticks. Their Friedman analysis provides a mean blame rank per cancer, all pairwise differences above 0.182 being significant at the 5 % level. Two reservations of scope are required: the sample is exclusively female, and the quantity measured is the attribution of responsibility, which is only one component of social stigma. The 2015 study, reported below, provides the multidimensional measure missing here.

Cancer	Mean blame rank	Share attributing at least some responsibility	Coding adopted here
Lung and bronchus	4.87	70 %	stigma = 1
Cervix	3.26	37 %	stigma = 1
Colorectal	2.86	23 %	stigma = 0
Breast	2.67	15 %	stigma = 0
Leukaemias	2.50	9 %	stigma = 0
For reference: chlamydia infection	5.58	87 %	outside sample
For reference: obesity	6.26	96 %	outside sample

Table 17. Attribution of responsibility by cancer. Source: Marlow, Waller and Wardle (2010), representative sample of British women, 1,620 respondents, Friedman analysis on 1,307 complete questionnaires. The quantity measured is the attribution of responsibility, a component of social stigma and not its complete measure.

The agreement is complete on the five cancers for which a measure exists. The two that the coding classifies as stigmatised occupy the first two ranks, and the gap separating them from the other three is significant. The three classified as non-stigmatised occupy the last three ranks, and their mutual gaps are small. The binary coding therefore reproduces the partition established by an external measure, on the five cancers, a little under a third of the sample, for which such a measure exists. The agreement is complete on this subset; it does not prejudge the twelve others.

The later study by Marlow, Waller and Wardle (2015) brings a complementary element on melanoma. It administered the cancer stigma scale to 1,205 people spread over five cancers, including skin cancer. Lung cancer obtains higher scores there than breast and cervix on all six subscales. But it is at the same level as skin

cancer on personal responsibility, avoidance and opposition to support policies, while exceeding it on felt awkwardness, perceived severity and tolerance of financial discrimination.

This result agrees with the distinction that section 6.3 formulated as a hypothesis. Skin cancer attracts as much attribution of personal responsibility as lung cancer, which is consistent with its attributable fraction of 92.2 %, but it does not attract the awkwardness, the distancing or the tolerance of discrimination that accompany the latter. The coding adopted here measures the second set of dimensions and not the first, and the classification of melanoma outside the stigmatised group, which might have seemed arbitrary, is thereby supported by an independent measure.

It remains that twelve cancers out of seventeen have no published external measure, and that the number of observations covered, five and then five, allows no estimation. Coding by several raters kept away from the funding data, with a Cohen or Fleiss agreement coefficient, remains the way forward for the remaining twelve.

The advocacy indicator had a weakness of its own, dealt with in section 5.4. The organisation count puts a large foundation and a small local fundraising association on the same footing, which probably overstates the effective advocacy of breast cancer, whose 529 structures include a very large number of small entities. Weighting by revenue, built from the tax returns of the 1,469 organisations, gives the same diagnosis with a higher HC3-robust t-statistic. The result is moreover robust to the removal of breast cancer, the elasticity moving from 0.430 to 0.527.

Statistical power, finally, requires that the coefficients not be presented as proofs but as elements convergent with the descriptive results, which for their part depend on no specification assumption. Section 5.5 quantifies this limitation instead of invoking it, and that is the practice we recommend for this type of sample.

6.4 The case of uterine corpus cancer

Uterine corpus cancer is the worst-funded cancer of the seventeen, at 0.23 times the average funding per death, although it causes 14,450 annual deaths, more than ovary, which receives 6.6 times as much. This position owes nothing to any artefact: the National Cancer Institute series is stable from 2018 to 2024, from USD 13.6 to 20.0 million, without any break, and Mirin (2021) finds over the whole National Institutes of Health a funding equal to 0.31 times the amount commensurate with burden. The deficit is real and long-standing. It deserves separate examination, because it brings together each of the mechanisms this study identifies, and because it reveals one that the adopted coding had missed.

The first mechanism is that of nominal survival. At 80.9 % five-year survival, this cancer passes for solved, and that statistic is precisely the one that justifies its low priority. It is misleading. The disease is bimodal: endometrioid tumours, hormone-dependent and linked to obesity, are cured by surgery; non-endometrioid tumours, serous, clear-cell and carcinosarcomas, account for 5 to 10 % of cases but nearly 40 % of deaths, and their mortality is rising by 2.7 % a year (Clarke and coauthors, 2022). As a result, uterine corpus is the only major cancer whose incidence and mortality are both rising in the United States, by 0.7 and 1.6 % a year over the past decade, while almost all the others are receding. It has become the leading cause of gynaecological cancer death and overtakes ovary in the 2026 estimates used here.

The second mechanism is that of attributed responsibility, and it appears only once one leaves the binary coding. More than half of cases are attributed to excess weight and physical inactivity, the attributable fraction of 59.2 % reported in Table 16 being essentially of that nature. Yet the survey by Marlow, Waller and Wardle (2010) measures that obesity attracts the highest attribution of responsibility of all the conditions tested: 96 % of respondents attribute some responsibility to it, for a blame rank of 6.26, above chlamydia infection and far above lung cancer. On the dimension of attributed responsibility, uterine corpus is therefore most likely the most stigmatised cancer in the sample, and the coding used in this study, built on tobacco, alcohol and papillomavirus, had classified it among the non-stigmatised cancers.

The consequence of this reclassification can be measured. Coded as stigmatised, uterine corpus moves the stigma coefficient on patient advocacy from -1.408, HC3-robust t-statistic of -3.31, to -1.792, corrected ratio of -4.53, and the coefficient of determination of the relationship from 0.533 to 0.768. A single miscoded observation masked a substantial part of the relationship. This result is not incorporated into the main estimates,

whose coding was fixed before the analysis and confronted with an external measure in section 6.3; it is reported as a variant, and it constitutes the strongest argument for replacing the binary coding with a continuous measure of attributed responsibility, in which obesity would take its rank.

The third mechanism is that of advocacy capital. The patients are post-menopausal, elderly, and disproportionately Black: the mortality rate of Black women is double that of the other groups, and the five-year survival gap between Black and white women, 63 against 84 %, is the largest of all cancers (Clarke and coauthors, 2019 and 2022; Giaquinto and coauthors, 2022). This is, potentially, the population whose capacity to found associations, to obtain a ribbon and a month, and to weigh on a funder is the lowest; the present study does not measure that capacity, it observes its result. The model predicts what is observed: eight dedicated organisations, 0.55 per thousand deaths, fourteenth rank out of seventeen.

The fourth mechanism is that of symbolic capture. In the public mind, uterine cancer is confused with cervical cancer, which has the papillomavirus, the smear test, a vaccine and an elimination target set by the World Health Organization. Ovary has the teal ribbon and the narrative of the silent killer. Uterine corpus has neither symbol, nor month, nor narrative, and its two gynaecological neighbours occupy the advocacy space that its burden, higher than that of either of them, should have earned it.

Uterine corpus is therefore not the anomaly of the picture, it is its textbook case: a high nominal survival that masks a rising lethal subtype, the most blamed risk factor there is, a population without advocacy capital, and an identity captured by its neighbours. Each of these traits taken in isolation would suffice to explain a deficit; together they explain the largest deficit of the seventeen. It must nonetheless be made clear that this textbook case is, in its magnitude, American. In the international panel, relative to its national burden, the share of projects devoted to uterine corpus is slightly in deficit in seven portfolios out of nine, from minus 0.1 percentage points in Australia to minus 1.1 in Italy, and at parity or slightly in surplus in the Netherlands and Japan; its rank there runs from ninth to twelfth out of seventeen, never last. The American deficit, minus 2.0 percentage points and fourteenth rank on the same criterion, seventeenth on funding per death, is therefore the most marked of the nine. The mechanism of attributed responsibility and symbolic capture is most likely common, but it is in the United States, where patient advocacy weighs most on the allocation, that it produces its clearest effect.

6.5 The diminishing returns to advocacy and the allocation they suggest

The relationship estimated in section 5.3 lends itself to an economic reading, provided its assumption is stated: what follows treats the association between advocacy and funding as if it were causal and stable, which the cross-section does not establish. Under this assumption, the fitted relationship is written, denoting by F a cancer's funding, by K the funding proportional to its burden and by N the number of organisations dedicated to it, $\frac{F}{K} = 0,178 \times N^{0,43}$. Two properties follow.

The first is a parity threshold. The ratio F/K equals one for $N^* = 55.5$ organisations according to the regression: below it, a cancer is under-funded relative to its burden whatever that burden, above it it is over-funded. This threshold does not depend on the size of the cancer, because the relationship concerns a ratio and not on an amount. It is, however, poorly determined. Pairs bootstrap gives it a 95 % interval from 37 to 85. A direct reading of the scatter, looking for the crossing between the last under-funded cancer, colorectal with 58 organisations, and the first clearly over-funded one, the leukaemias with 83, places it around 70. A logistic regression on the sign alone puts it at 46, and the regression without the two cancers that are at near-parity, myeloma and non-Hodgkin lymphoma, at 60. The defensible range is therefore 45 to 85, and the transition zone, between 24 and 83 organisations, contains cancers on both groups. Nine cancers out of seventeen are below 55 at the end of 2023; breast exceeds the upper bound by a factor of six.

The second is a diminishing marginal return. The derivative of F with respect to N is $\frac{dF}{dN} = 0,43 \times \frac{F}{N}$: one additional organisation brings all the less the more the cancer already has. The exponent of 0.43 means that doubling the number of organisations raises the ratio F/K by only 35 %, and that multiplying it by ten raises it to only 2.7 times its value. Expressed in dollars per hundred million of burden-proportional funding, the marginal gain of one organisation ranges from 3.1 million for stomach, which has five, to 0.2 million for breast, which has 529.

The shape of this decline is itself uncertain, and breast cancer is the reason. The log-linear relationship imposes a constant elasticity over the whole range of N , whereas breast, with 529 organisations, is extrapolated five times beyond the next point, melanoma with 112. Three forms were confronted.

Functional form	R2	Prediction for breast	Breast observed	Gap
Log-linear, constant elasticity 0.43	0.657	$\times 2.63$	$\times 1.55$	41 % below
Quadratic in $\ln N$, decreasing elasticity	0.688	$\times 1.94$	$\times 1.55$	20 % below
Saturation, $F/K = 1.79 \times N/(N+31)$	0.669	$\times 1.69$	$\times 1.55$	8 % below

Table 18. Three functional forms of the relationship between advocacy and the gap to the burden benchmark, and position of breast cancer under each. $n = 17$.

Under the saturating form, breast cancer is practically on the curve, and that curve has a ceiling: advocacy cannot carry funding beyond 1.8 times burden, whatever the number of organisations, and breast, at 1.55, is close to it. The data do not make it possible to choose among the three forms. The curvature test of the quadratic form against the linear form gives an F of 1.40 and a p of 0.256, and the curvature changes sign when breast is removed: it is the only observation beyond 112 organisations, hence the only point that can identify a saturation, and it cannot be both what identifies it and what it is tested against. Estimated without it, the log-linear form gives for $N = 529$ a 95 % prediction interval running from 1.4 to 8.9 times burden, within which breast lies.

The statement that breast cancer receives less than its advocacy predicts therefore holds only under constant elasticity. An economic reason argues for saturation: the funder's total is fixed and no cancer can capture an indefinitely growing share of it. Under this form, the marginal return to advocacy declines even faster than under the log-linear form, and the optimal allocation examined below is even more concentrated on the least mobilised cancers. The figures that follow, computed under the log-linear form, are in this respect conservative.

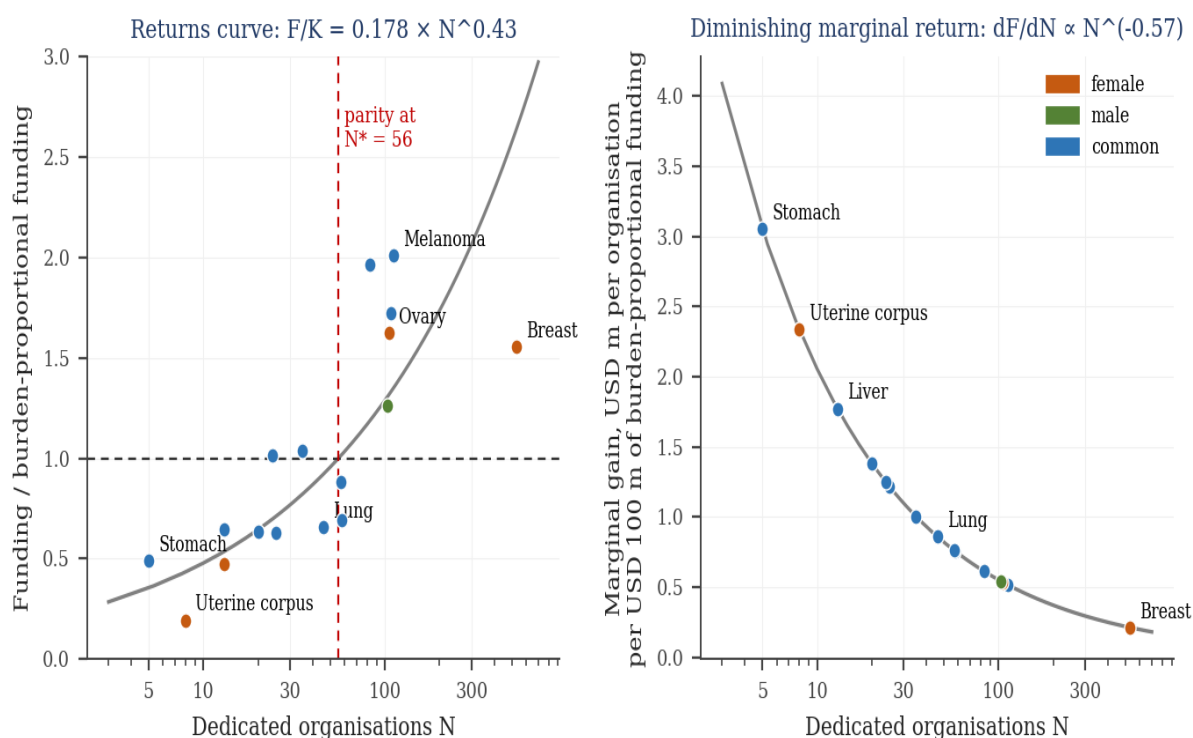


Figure 13. On the left, the returns curve $F/K = 0.178 \times N^{0.43}$ with the seventeen cancers and the regression's parity threshold, whose 95 % interval runs from 37 to 85. On the right, the marginal gain of one additional organisation, per hundred million dollars of burden-proportional funding. Both readings assume the relationship to be causal and stable.

The consequence for an actor wishing to act on the allocation through advocacy, a patient federation, a foundation or a public authority, is direct. Since returns decline with N and the gap to be corrected is largest

where N is small, the most profitable advocacy is that of the least mobilised cancers. A greedy allocation, which creates organisations one at a time where each most reduces the total size of the gap to the burden benchmark, places the first twenty-five on lung, then the following ones on colorectal, liver, pancreas and uterine corpus.

Organisations created	Residual gap (USD m)	Share of total imputed	Cumulative distribution
0	531.4	18.0 %	2023 situation according to the model
50	443.6	15.0 %	lung 42, liver 6, colorectal 2
100	400.3	13.6 %	lung 50, colorectal 30, liver 14, pancreas 3, uterine corpus 3
200	341.7	11.6 %	lung 62, colorectal 50, pancreas 43, liver 32, uterine corpus 10, stomach 3
400	292.4	9.9 %	liver 84, lung 82, pancreas 71, colorectal 70, uterine corpus 30, prostate 23
200 in proportion to existing	531.4	18.0 %	no effect: the relationship is invariant to uniform multiplication

Table 19. Greedy allocation of additional organisations minimising the size of the gap to the burden benchmark, under the assumption of a causal and stable relationship. The last row shows that advocacy increased everywhere at the same pace changes nothing.

Two findings hold whatever the precision of the model. A uniform increase in the number of organisations does not change the gap: two hundred organisations distributed in proportion to the existing ones leave the gap exactly unchanged, because the relationship is invariant to a uniform multiplication. Only their distribution across cancers matters, and the return to this redistribution declines quickly: the first hundred well-placed organisations reduce the gap from 18.0 to 13.6 % of total imputed funding, the next hundred from 13.6 to 11.6, and the next two hundred from 11.6 to 9.9. Bringing all under-funded cancers to parity would require between 255 organisations, if the break-even point is at 55, and 520, if it is at 85, that is, between one fifth and two fifths of the current stock, concentrated on five cancers that today have only 154. The uncertainty on the break-even point is therefore transmitted in full to the scale of the lever.

These orders of magnitude hold only under the assumption stated at the head of the section. They indicate the direction and scale of a lever, not its effectiveness, which only a longitudinal design can establish.

7. Conclusion

A methodological result precedes the contributions of this study, and it holds for the whole literature on funding inequalities. The question of which side is over-represented relative to its burden has no answer until the denominator is chosen, and seven legitimate denominators give three different answers.

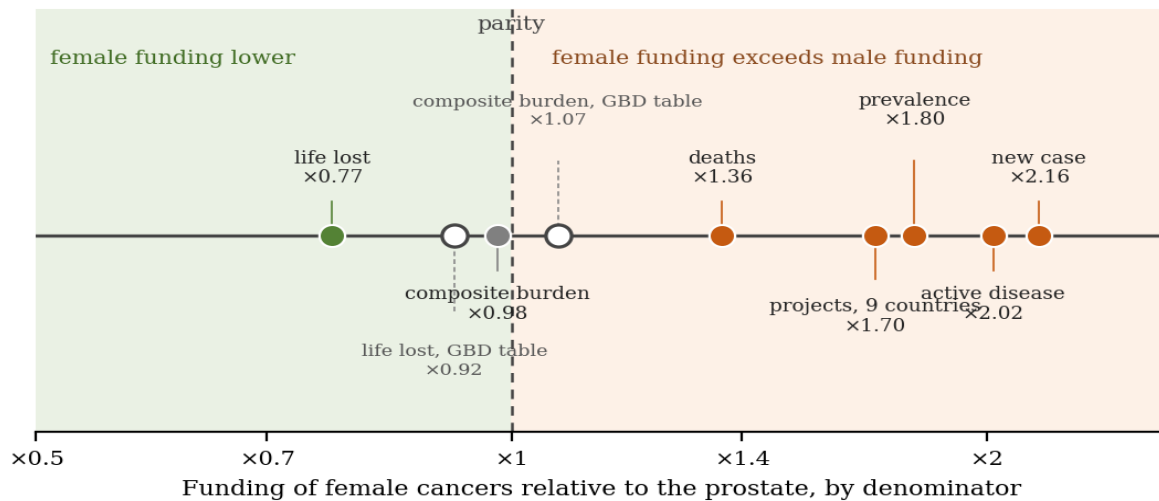


Figure 14. Funding of female cancers relative to that of the prostate, using 2023 U.S. data for six denominators and on the international panel for the seventh. Five denominators place the female-cancer group above, one at parity, one below. The hollow markers give the position of the two years-of-life denominators when those years are computed with the GBD 2019 reference life table, identical for both sexes.

Relative to new cases, to persons in active disease, to prevalent persons, to funded projects or to deaths, the funding of female cancers exceeds that of the prostate, by 36 to 116 %. Relative to years of burden, it is at parity. Relative to years of life lost, it is 23 % lower, because the prostate kills at a median age of 79 and loses few years per death. The literature that concludes that there is a female disadvantage in oncology reasons on this single denominator, and this denominator is the only one that reverses as soon as years of life are counted with a reference life table common to both sexes, six denominators out of seven then placing the female-cancer group above. Any statement about asymmetry that does not begin by naming its denominator is therefore not yet a statement.

Once the denominator is named, the overall finding is clear. Female cancers receive, almost systematically, funding above the burden-proportional benchmark: under five denominators out of seven using U.S. data, under the three scenarios of section 5.2 for breast and ovary, and, relative to its own epidemiology, in each of the nine national project portfolios recorded in the ICRP, where their share of projects exceeds their share of burden by 7.94 percentage points on average. This last result concerns the structure of project portfolios, not on amounts, and it answers the thesis, widely circulated but resting on a single quantitative study, that health research favours diseases in which men are the majority. The prostate shows no robust over-representation: its position varies with the denominator and the scenarios, and its mean gap in the panel is not significant. In the international portfolios studied, the over-representation of the female group is by contrast observed in all nine countries. It could be described as systemic. It is driven mainly by breast cancer, which explains 86 % of it, that is, 6.84 of the 7.94 percentage points, and which is also the most mobilised cancer in the world, with 529 dedicated charitable organisations in the United States alone at the end of 2023; it persists outside breast cancer, at a markedly lower level, 1.10 percentage points, in seven countries out of nine; and it coexists with a female cancer, uterine corpus, which remains the worst funded of the seventeen using U.S. data. The two results, American and international, are compatible with a common mechanism of flagship cause, without the cross-sectional design making it possible to establish the causal direction, and the data point more towards differences in advocacy across cancers than towards a general effect of patients' sex.

The gap itself is the first contribution. The allocation of American oncology funding is not random, since it is ordered by mortality, but it shows large gaps relative to an allocation based on disease burden, observed funding typically departing by a factor of two from what its mortality would lead one to expect. The term sub-optimality is deliberately avoided: establishing it would require knowing the marginal return to research by cancer, which section 2.1 identifies as the decisive missing variable. Rather than confronting the observed allocation with a single key, this study makes explicit three competing conceptions of the purpose of public research and evaluates them separately, without any parameter being calibrated by the author. A common core of USD 265.5 million

of imputations emerges, whose direction of reallocation is common to the three conceptions and therefore does not presuppose that the debate of principle has been settled.

The density of patient advocacy is the variable that most clearly orders the residual: it accounts for 65.7 % of its variance, and for 70.6 % once funding and advocacy are both residualised with respect to disease size. Responsibility attributed to the patient is not directly associated with funding once advocacy is taken into account; it is, however, associated with advocacy density, stigmatised cancers having 76 % fewer organisations holding disease burden constant. The nineteen-year panel specifies the nature of this relationship: a long-run state, not a response to recent variations in advocacy.

Three extensions emerge. The panel of section 5.9 does not contain the exogenous variation that would discriminate between slow adjustment and common cause; an event study around identifiable shocks to one cancer's advocacy, a publicised diagnosis or a national campaign, would measure the effect on the funding obtained. Exploiting the International Cancer Research Partnership database at the project level, and no longer only at the level of counts, would provide the institutional variation needed to separate the procedural effect from the social-judgement effect, as an extension of the test of section 5.6. Finally, extending the external measure of stigma to the twelve cancers that lack one, through a general-population survey following the protocol of Marlow and coauthors, would make it possible to replace the binary coding with a continuous variable and to make it a result in its own right rather than an adjacent proposition.

A final word on the French case. The question examined here cannot currently be addressed in France given the available data, the Institut national du cancer breaking down its funding by scientific category and by programme type but not by cancer. This is not a technical detail: it is a prerequisite for democratic oversight of public spending devoted to the country's leading cause of death.

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Appendix A. Re-examination of Mirin (2021) from the published data

The study plots the National Institutes of Health funding of each disease against its disease burden expressed in disability-adjusted life years, on a double logarithmic scale, fits a power law to the scatter, then qualifies as under-funded any disease lying below the curve and as over-funded any disease lying above it. The deviation thus obtained is crossed with the dominant sex, a disease being deemed sex-dominant when at least 60 % of patients are of the same sex. Tables 1 to 5 of the article give, for 74 diseases, the ratio of actual funding to so-called commensurate funding for 2015, 2017 and 2019, as well as the 2015 burden. Everything that follows is computed from those tables.

Six reservations limit what this construction can establish.

The first is that the reference is fitted on the sample itself: the so-called burden-commensurate funding curve is not an external norm, it is the average relationship observed in these 34 diseases, and about half of them lie below it by construction. What is measured is a residual, and calling it under-funding presupposes that the fitted curve has normative value, which it does not.

The second concerns the choice of burden metric, which is not neutral with respect to the hypothesis tested. Disability-adjusted life years add years of life lost and years lived with disability. Conditions that disable without killing, migraine, endometriosis, anorexia, myalgic encephalomyelitis, that is, the very examples the author puts forward, weigh heavily through their second component while mobilising little funding, for lack of a mortality endpoint and of identified therapeutic targets. Yet these conditions are predominantly female. The metric adopted therefore tends to produce the result obtained: the study thus presents a construction bias. The present study establishes the symmetric proposition on its own field: in section 6.2, replacing the denominator moves the oncology asymmetry from a male advantage to a female advantage for five measures out of seven.

The third concerns the unit of observation, and it is the most concrete. Mirin relates a funding level to a disease burden, but the two quantities do not bear on the same object. Burden is measured by disease, an entity whose boundaries are defined by nosology. Funding, for its part, is measured by category of the Research, Condition, and Disease Categorization, which is an accounting system internal to the National Institutes of Health. These categories do not partition the budget. The institute writes it itself on the page that publishes them: they are not mutually exclusive, a single project may be counted in several of them, and the amounts in a column do not add up to 100 % of funded research. A grant on breast cancer prevention in women is thus imputed at once to the headings breast cancer, cancer, women's health and prevention. The amount attributed to a category is therefore not the share of the budget that accrues to it, and relating it to a disease burden amounts to dividing two quantities built on different scopes. A second difficulty concerns the absences. The 2023 Nature editorial notes that some women's health issues have no heading of their own in this nomenclature, so that the corresponding funding cannot be isolated. A disease without a category is invisible in the exercise, whatever the amount devoted to it.

The fourth concerns the thresholds adopted and the absence of any sensitivity test. The study publishes its data by disease, which makes it possible to redo the exercise and move those thresholds, an operation conducted here. The published values for 2019 are reproduced exactly, 25 diseases whose funding profile favours men against 9 whose profile favours women, or 73.5 %, with mean deviations of 5.19 and 2.82 and a ratio of 1.84. This reproduction incidentally reveals a third, unmentioned threshold: the classification as over- or under-funded assumes a 5 % tolerance band around unity, without which the published figures do not come out. The ratio of 1.84 between the two groups' mean deviations falls to 1.36 if the median is used rather than the mean, to 1.33 after removing the three most extreme observations, and to 1.05, that is, parity, after removing the five most extreme. These five diseases are HIV/AIDS, myalgic encephalomyelitis, tuberculosis, migraine and headaches; they are split between the two groups, but their deviations, between 10.6 and 17.8, swamp those of the 29 others. The claim that the gap to commensurate funding would be nearly twice as large on the male side therefore rests on five observations out of thirty-four and on the choice of an arithmetic mean applied to ratios.

The fifth is a construction defect in the tables, which had not been noted and which bears directly on the count. The study counts separately categories nested within one another, as if they were distinct diseases. On the female side, migraine and headaches, anorexia and eating disorders, depression, anxiety and mental illness, prematurity and conditions of the perinatal period are each counted twice. On the male side, hepatitis B and hepatitis, drug abuse, alcoholism and substance abuse are likewise. A migraine is a headache, an anorexia an eating disorder, and the funding of the enclosing category includes that of the enclosed one: counting both amounts to counting the same under-funding twice. Keeping only one entry per family brings the 34 dominant diseases down to 27, 18 female and 9 male, and changes the results in the proportions that counterfactual A of Table A2 reports below.

The 60 % threshold moreover calls for a logical objection, independent of statistical sensitivity. A disease classified as female-dominant at this threshold has 40 % men among its patients. A funder seeking to disadvantage women by under-funding it would in the same move disadvantage those 40 % of men, and would produce only a twenty-point difference in treatment between the sexes at the cost of almost equal harm on both sides. The mechanism invoked, a sex-biased allocation, is operative only to the extent that the disease is sex-specific; at 60 %, it is almost inoperative.

The study's tables confirm that it is not sex-specific diseases that carry the result. The most over-funded male-dominant diseases are HIV/AIDS, at 17.8 times commensurate funding, tuberculosis, 13.1 times, hepatitis, 6.9 times, and the addictions, from 2.3 to 4.4 times. None is male beyond a ratio of three to one, and all come under a funding logic of their own, that of contagion and public health for the first three, that of dedicated National Institutes of Health institutes for the addictions. The most over-funded female-dominant diseases, herpes and sexually transmitted infections at 5.4 times, Alzheimer's disease at 4.5, mental illness at 3.9, are no more female in the strict sense.

Restricted to conditions that are truly sex-specific, the comparison that these same tables allow gives, on the male side, the prostate at 1.10, and on the female side breast at 2.12, ovary at 1.02, cervix at 0.89, uterine corpus at 0.31, uterine fibroids at 0.22 and endometriosis at 0.18. This subset, the only one in which a sex bias could operate without collateral damage, does not say what the general conclusion says: it shows a strongly over-funded breast cancer, a slightly over-funded prostate, and four under-funded gynaecological conditions. That is exactly the configuration the present study establishes in the field of oncology, an over-representation driven mainly by breast cancer and a uterine corpus in deficit, and not a uniform disadvantage of diseases in which women are the majority.

The link with sex can be tested directly, since the tables provide the ratio for each of the study's 74 diseases, dominant, semi-dominant and neutral. A regression of the logarithm of that ratio on two sex dummies, neutral diseases serving as reference, gives a coefficient of -0.19 for female-dominant diseases, t-statistic of -0.57, and of +1.10 for male-dominant diseases, ratio of 2.90. Female-dominant diseases are therefore not under-funded relative to neutral diseases; it is male-dominant diseases that are over-funded. The study's result is a male over-funding, not a female disadvantage, and the two statements are not equivalent.

This male over-funding stems from characteristics that are not sex. Adding two dummies, one for transmissible diseases and the other for addictions, the male coefficient falls from +1.10 to +0.80 and ceases to be significant under robust standard errors, while transmissibility takes +0.96. The gap between male-dominant and female-dominant diseases moves from a ratio of 3.6, p equal to 0.002, to a ratio of 2.6, p equal to 0.035. Of the study's eleven over-funded male-dominant diseases, seven are transmissible or addiction-related, and all are funded by dedicated institutes with their own appropriations, the Institute of Allergy and Infectious Diseases, that of Drug Abuse and that of Alcohol Abuse. The remaining four show modest ratios, autism 1.96, Parkinson's 1.43, attention deficit disorder 1.35, prostate 1.10.

Specification, 74 diseases	Female	Male	Transmissible	Male / female ratio, p
A. Sex dummies only	-0.19 (t = -0.57)	+1.10 (t = 2.90)		3.62 ; p = 0.002
B. With transmissible and addiction	-0.15 (t = -0.46)	+0.80 (t = 1.91 ; HC3 1.78)	+0.96 (t = 1.91)	2.58 ; p = 0.035

Specification, 74 diseases	Female	Male	Transmissible	Male / female ratio, p
C. B with log of burden	-0.06 (t = -0.18)	+1.03 (t = 2.41 ; HC3 1.95)	+1.30 (t = 2.46)	2.98 ; p = 0.016

Table A1. Logarithm of the ratio of actual to commensurate funding, regressed on disease characteristics, from Tables 1 to 5 of Mirin (2021), fiscal year 2019, n = 74. Reference: sex-neutral diseases. Transmissible diseases and addictions coded from their names.

The universe retained is not neutral either, and the bias lies in the nomenclature before it lies in the selection. The study retains 74 diseases out of the roughly three hundred categories of the National Institutes of Health accounting system. Non-lethal female conditions have headings of their own there: endometriosis and uterine fibroids each have their category and appear in the female list. The equivalent male conditions do not. A query of the funded projects database shows that erectile dysfunction and prostatic hyperplasia are attached to the urologic diseases category, and testicular cancer to the general cancer category, with no heading of their own. They therefore cannot appear in a list of male-dominant diseases, and urologic diseases in fact appear in the study's list of neutral diseases. An X-linked condition, almost exclusively male and endowed with its own heading, Duchenne muscular dystrophy, does not appear there either.

It follows that the asymmetry of the study's counts, 22 female-dominant diseases against 12 male-dominant, reflects not a property of biology but a property of accounting: female conditions are individualised, male conditions aggregated. A list built on a nomenclature that distinguishes the diseases of one sex more finely than those of the other does not allow the two to be compared, whatever the quality of the computation that follows.

These biases can be corrected, and the counterfactual is built on the study's own tables. The first defect to correct is the double counting of nested categories, set out in the fifth reservation, which brings the 34 dominant diseases down to 27. The second is that of diseases whose determining characteristic is not sex, transmissible diseases and addictions, which come under institutes with their own appropriations.

Counterfactual	Favouring men	Favouring women	Male share, p	Ratio of deviations, mean / median
Published values, 34 diseases	25	9	73.5 % ; p = 0.009	1.84 / 1.36
A. One entry per family, 27 diseases	19	7	73.1 % ; p = 0.029	1.65 / 1.13
B. A, excluding transmissible diseases and addictions, 22 diseases	15	6	71.4 % ; p = 0.078	1.38 / 0.95
C. Sex-specific conditions only, 7	5	1	83.3 % ; p = 0.219	1.46 / 1.52

Table A2. Counterfactuals built on Tables 1 to 5 of Mirin (2021), fiscal year 2019, 5 % tolerance band. The p is that of the exact two-sided binomial test on the number of diseases favouring men.

The count survives, significance and magnitude do not. The share of diseases whose profile favours men remains between 71 and 73 % under counterfactuals A and B, but its p moves from 0.009 to 0.029 and then 0.078, and the ratio of deviations, which carried the claim of a gap nearly twice as large on the male side, falls to parity in the median, 0.95. The count is stable because it counts categories and because the nomenclature individualises chronic non-lethal female conditions, migraine, endometriosis, fibroids, chronic fatigue, all low-funded: it measures the structure of the nomenclature, not a differential treatment.

The direct test of the statement completes the demonstration. Female-dominant diseases, once de-duplicated, show a geometric mean ratio of 0.75 against 0.81 for sex-neutral diseases, Welch test at p equal to 0.84: they are not disadvantaged. Male-dominant diseases show a ratio of 2.48, p equal to 0.016; with transmissible diseases and addictions removed, it falls to 1.39, p equal to 0.24. The two halves of the study's conclusion thus each receive their answer. A disproportionate share would go to diseases in which men are the majority: that holds for HIV/AIDS, tuberculosis, hepatitis and the addictions, and for nothing else. It would be at the expense of diseases in which women are the majority: that is contradicted by the study's own data, female-dominant diseases being funded like neutral diseases. The conclusion therefore rests on a nomenclature bias, and its second half, that of a disadvantage of diseases in which women are the majority, is not supported by the study's own data.

The sixth is the absence of any control. No variable for advocacy, scientific maturity, size of the research community or tractability is introduced. The correlation between the residual and the dominant sex is reported

without anything allowing it to be attributed to sex rather than to a quantity correlated with it, and the National Institutes of Health in fact replies to Nature that it takes into account considerations foreign to disease burden. These considerations are not specified; they join the construction bias noted in the second reservation.

What the study establishes is therefore a correlation between the residual of a funding-burden regression and the dominant sex, using U.S. data, under a single burden metric and three thresholds set by the author. No independent replication could be identified, however, and the conclusion drawn from it exceeds what the method can establish, on two points that must be named.

The first concerns the word disproportionate. The residual measures a deviation from the sample's average relationship, not from a norm. Calling it disproportionate slides a descriptive quantity towards a normative one, whereas the reference precisely does not have that status. To establish a disproportion, a key external to the data themselves would be needed. It is therefore an equivocation: the same word, "disproportionate", is used successively in a descriptive sense, where it denotes a deviation from a sample mean, and in a normative sense, where it denotes a shortfall from what would be due; the premise is true in the first sense, the conclusion is drawn in the second.

The second concerns the expression "at the expense of". It asserts a transfer: what male-dominant diseases receive would be taken from female-dominant ones. Nothing in the method identifies a transfer. Two deviations of opposite sign from the same fitted curve do not constitute a redistribution from one to the other, and no design here makes it possible to establish one. It is a causal step that the data do not support. It is a non sequitur: the conclusion asserts a transfer that the premises do not establish.

These results therefore do not make it possible to identify a disadvantage specific to female-dominant diseases: the reference is fitted on the sample, the burden metric tends to produce the result, the units of measurement do not coincide, the count rests on nested categories and on a nomenclature that individualises female conditions, the over-funding observed is that of transmissible diseases and addictions, and no control variable is introduced. The method is published and verifiable; it is the inference drawn from it that is not supported.