Who Bears the Highest Costs of Breast Cancer? A Cost-of-Illness Study in Poland from a Societal Perspective

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Article

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Highlights

What are the main findings?

- Indirect costs accounted for approximately 73% of the total economic burden of breast cancer in Poland, exceeding direct healthcare expenditures.
- Productivity losses due to absenteeism, presenteeism, unpaid work, and informal caregiving constituted the largest components of the overall burden.

What are the implications of the main findings?

- Economic evaluations of breast cancer should adopt a societal perspective, as analyses limited to direct costs substantially underestimate the true burden.
- Policies supporting early detection, effective treatment, and survivorship care may reduce long-term productivity losses and improve resource allocation.

Abstract

Background/Objectives: Breast cancer represents a major public health and economic challenge, generating substantial costs for healthcare systems, patients, and the broader economy. In Poland, comprehensive assessments capturing the full societal burden remain limited. This study aimed to estimate the cost of illness of breast cancer in Poland in 2024 from a societal perspective, including direct and indirect costs, and to assess their distribution across cost bearers. **Methods**: A cost-of-illness analysis was conducted using a societal perspective. Data were derived from administrative sources, including the National Health Fund (NFZ), Social Insurance Institution (ZUS), Central Statistical Office (GUS), and National Cancer Registry (NCR), supplemented with a patient survey (n = 289). Direct medical, direct non-medical, and indirect costs were estimated. Productivity losses were valued using a human capital approach with a GDP-based productivity metric adjusted by a correction factor. **Results**: Total costs of breast cancer in Poland in 2024 were dominated by indirect costs, which accounted for approximately 73% of the total burden. Direct costs represented 27% and included €837.7 million in public healthcare expenditures and €322.4 million in patient-borne costs. Among indirect costs, absenteeism, presenteeism, unpaid work, and informal caregiving contributed substantially, with productivity losses exceeding several hundred million euros in each category. The largest single indirect component was absenteeism, followed by presenteeism and unpaid work. **Conclusions**: Breast cancer imposes a substantial societal burden in Poland, driven predominantly by indirect costs. These findings highlight the importance of adopting a societal perspective in economic evaluations and support the inclusion of productivity losses in health policy decision-making.

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1. Introduction

Cancer remains one of the leading causes of morbidity and mortality worldwide, with far-reaching consequences for patients, families, healthcare systems, and national econo-mies. In Poland, the cancer burden has been steadily increasing, creating mounting chal-lenges for public health and the healthcare system as well as for society at large [1–3]. Breast cancer (BC) is the most commonly diagnosed malignancy among women. According to the World Health Organization, an estimated 2.3 million women were diagnosed with breast cancer in 2022, and approximately 670,000 died from the disease [4]. Breast cancer incidence increases with age, and outcomes vary across countries, reflecting differences in detection and access to effective treatment [4]. In Poland, breast cancer accounts for 25.3% of all malignant neoplasms among women, compared with 28.7% in the European Union [5]. Beyond its clinical impact, breast cancer generates a substantial economic burden through both direct and indirect costs borne by multiple stakeholders, including the healthcare payer, the social insurance system, patients and their households, and employers [6–8].

Direct costs include healthcare and non-healthcare expenditures financed by third-party payers as well as patients' out-of-pocket spending. Indirect costs are primarily driven by productivity losses due to morbidity, disability, and premature mortality, with measurable consequences for employers and the broader economy. To align with a societal perspective, we attribute costs to specific cost bearers, distinguishing expenditures financed by the healthcare payer and social insurance from out-of-pocket payments by patients/households and productivity losses affecting employers and the wider economy. Because the diagnostic workup and treatment pathway is often prolonged and multi-stage, breast cancer can also impose considerable financial strain on patients and families. Routine travel to specialized centers for follow-up visits and ongoing therapy requires time and financial resources, and additional out-of-pocket expenses may include supportive medications used during chemotherapy, specialized foods and oral nutritional supplements, and payments for medical services that are not always covered or reimbursed [7,9]. More-over, the disease may limit or preclude continued employment, reducing household in-come; in some cases, families must also finance long-term care, further compounding the economic burden and contributing to financial hardship and psychological stress [10].

Despite the growing significance of breast cancer, the economic burden of the disease has not yet been comprehensively assessed in Poland from a societal perspective that simultaneously captures public payer expenditures, patient-incurred costs, and productivity loss-es in both paid and unpaid work. Therefore, the aim of this study is to estimate the cost of illness of breast cancer in Poland from a societal perspective and to examine how the bur-den is distributed across the healthcare system, the social insurance system, and patients/households.

A clearer understanding of the societal burden—and of how costs are distributed across stakeholders—can inform strategies to mitigate financial impacts and support more effi-cient allocation of resources across treatment, survivorship care (including rehabilitation), and prevention.

2. Materials and Methods

2.1. Study Design and Analytical Perspective

We conducted a cost-of-illness analysis for breast cancer in Poland covering the calendar year 2024. The primary analysis adopted a societal perspective, quantifying direct medical costs, direct non-medical costs, and indirect costs linked to productivity losses among patients and informal caregivers. In addition, we present a complementary patient/household and caregiver perspective, focusing on income losses attributable to sickness absence and reduced working time.

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2.2. Data Sources and Study Populations

Cost estimates were derived by combining administrative data with patient-reported information. Public healthcare expenditures were obtained from the National Health Fund (Narodowy Fundusz Zdrowia, NFZ) for services attributed to breast cancer (ICD-10 C50) and oncology treatment episodes coded as Z51 with concurrent C50.

Productivity-related parameters (GDP and employment counts) were obtained from Central Statistical Office (GUS) publications [11,12]. Sickness absence volumes were derived from Social Insurance Institution (ZUS) reporting for ICD-10 C50 [13]. Mortality inputs were obtained from the National Cancer Registry (NCR) [14], and disability burden estimates (Years Lived with Disability, YLD) were taken from the Institute for Health Metrics and Evaluation (IHME) [15].

Where necessary, NFZ-derived patient counts were used to extrapolate survey-based estimates to the national population of patients treated for breast cancer in 2024.

2.3. Patient Survey

To capture cost components not observable in administrative sources—particularly out-of-pocket medical expenditures, visit-related non-medical costs, reduced working time, presenteeism, and caregiving impacts—we conducted a survey among 289 women with breast cancer.

Respondents reported economic consequences related to treatment, employment, and caregiving. Survey outputs were used to estimate mean resource use and the proportion of respondents affected by each cost component.

Because the study assessed economic consequences using aggregated administrative data and an anonymous patient survey without clinical intervention, it was treated as non-interventional; participation was voluntary and ethics committee approval was not required. Characteristics of survey respondents are presented in Appendix A.

2.4. Cost Categories and Attribution to Cost Bearers

Costs were grouped into:

- Direct medical costs financed by the public healthcare payer (NFZ).
- Direct medical costs paid privately by patients (out-of-pocket).
- Direct non-medical costs borne by patients/households (e.g., transportation and visit-related expenses).
- Indirect costs reflecting productivity losses among patients and informal caregivers and the value of reduced unpaid work.

In line with the study objective, results were also interpreted by cost bearer (healthcare payer, social insurance system, patients/households, and informal caregivers).

2.5. Direct Costs

2.5.1. Public Healthcare Expenditures (NFZ)

NFZ-financed costs were compiled for major service areas relevant to breast cancer care (specialist outpatient care; inpatient care; drug program; chemotherapy; radiotherapy; rehabilitation; palliative and hospice care). Primary care (POZ) costs were excluded because POZ services are settled through capitation, preventing diagnosis-specific allocation. To minimize double counting, inpatient costs were interpreted net of components reported separately (drug program, chemotherapy, radiotherapy, rehabilitation, palliative/hospice).

2.5.2. Patient Out-of-Pocket and Direct Non-Medical Costs

Patient-paid medical expenditures (e.g., private visits/diagnostics, supportive medications, medical products) and non-medical spending were estimated from the survey. Survey means were

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annualized and extrapolated to the treated population using the proportion of respondents reporting each cost component.

2.6. Indirect Costs

Indirect costs were valued using a human capital approach and included productivity losses due to short-term work impairment (sickness absence and reduced working time), presenteeism, long-term productivity losses (premature mortality and disability), and losses related to informal caregiving and unpaid work.

To avoid overstating productivity losses when using average output per worker, a β correction factor (CF = 0.65) was applied, consistent with recommendations for macroeconomic productivity valuation [16]. Productivity losses were estimated using a GDP-based productivity metric derived from national data on gross domestic product and employment [11,12], and expressed per day and per hour of lost work time.

Future productivity losses were discounted at 5% annually, in line with Polish HTA methodological guidance [17].All costs were calculated in PLN and converted to EUR using the National Bank of Poland (NBP) reference exchange rate as of 31 December 2024 (1 EUR = 4.2730 PLN) [18]; results are presented in EUR throughout.

Detailed calculation methods, parameter definitions, and model specifications are provided in Appendix B.

3. Results

3.1. NFZ-Financed Direct Medical Costs of Breast Cancer in Poland in 2024

Breast cancer care in Poland is financed by the National Health Fund (Narodowy Fundusz Zdrowia, NFZ) across several settings, including specialist outpatient care, inpatient care (including surgery), chemotherapy, radiotherapy, drug programs, rehabilitation, and palliative/hospice care. Primary care (POZ) services are reimbursed through capitation (lump-sum payments) and cannot be reliably attributed to a specific diagnosis; therefore, POZ costs were not included in this analysis.

NFZ reimbursement amounts for 2024 were obtained via direct communication with NFZ for patients with a primary diagnosis of ICD-10 C50 (breast cancer) or a primary diagnosis of Z51 with coexisting C50. Total NFZ-financed spending on breast cancer treatment in 2024 amounted to EUR 837,690,279, with the largest components being the drug program (EUR 297,842,505; 35.6%), inpatient care excluding separately reported modalities (EUR 274,093,412; 32.7%), and radiotherapy (EUR 167,528,304; 20.0%) (Table 1).

Table 1. NFZ-financed costs of breast cancer treatment in Poland in 2024 (EUR).

Scope of care	Total cost (EUR)	Share of total
Specialist outpatient care (AOS)	€ 32,347,558	3.9%
Drug program	€ 297, 842,505	35.6%
Chemotherapy	€ 23,588,463	2.8%
Radiotherapy	€ 167,528,304	20.0%
Inpatient care (excluding drug program, chemotherapy, radiotherapy)	€ 274,093, 412	32.7%
Rehabilitation	€ 6,150,103	0.7%
Palliative and hospice care	€ 36,139,935	4.3%
Total	€ 837,690,279	100.0%

3.2. Direct Costs of Breast Cancer Borne by Patients in 2024

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Survey results indicate that women with breast cancer incur additional out-of-pocket medical expenditures related to disease management, including specialist consultations, diagnostic tests, and the purchase of medicines and medical products. The mean monthly out-of-pocket medical cost was € 75 per patient, corresponding to an annual amount of € 897 per patient. Extrapolated to the NFZ-reported breast cancer population treated in 2024 (n = 231,422) and accounting for the proportion of patients reporting these expenditures (93%), total private medical spending was estimated at € 193,957,556 (Table 2).

Table 2. Private out-of-pocket medical expenditures of breast cancer patients in Poland in 2024 (EUR)*.

Monthly cost per patient	Annual cost per patient	Patient population	Share of patients incurring medical OOP costs	Total private expenditures
€ 75	€ 897	231,422	93%	€ 193,957,556

Note: Values are rounded to the nearest euro; totals may not equal the sum of components due to rounding.

In addition to medical out-of-pocket payments, the analysis included direct non-medical costs incurred during treatment-related visits to healthcare facilities. These costs comprised transportation and other visit-related expenditures (e.g., temporary care for children or other family members, accommodation, and meals). Based on the survey, the average travel cost per visit was € 23, and mean additional visit-related expenses were € 9, resulting in a mean total per-visit expenditure of € 33 (Table 3).

Table 3. Average patient spending per treatment-related visit in 2024 (EUR)*.

Average travel cost	Average additional visit-related costs	Average total per-visit spending
€ 23	€ 9	€ 33

Note: Values are rounded to the nearest euro; totals may not equal the sum of components due to rounding.

To estimate the population-level burden of visit-related non-medical costs, the mean per-visit spending was multiplied by the average annual number of visits reported in the survey (17.0 visits per year) and extrapolated to the breast cancer population treated in 2024. Total visit-related direct non-medical costs were estimated at € 128,460,698 (Table 4).

Table 4. Total direct non-medical costs associated with treatment-related visits in 2024 (EUR)*.

Average spending per visit	Visits per year	Patient population	Total visit-related costs
€ 33	17.0	231,422	€ 128,460,698

Note: Values are rounded to the nearest euro; totals may not equal the sum of components due to rounding.

Overall, total direct costs borne by patients—including visit-related non-medical costs and other out-of-pocket medical expenditures—were estimated at € 322,418,225 in 2024 (Table 5).

Table 5. Total direct costs borne by patients in 2024 (EUR).

Visit-related costs	Other out-of-pocket medical expenditures	Total
€ 128,460,698	€ 193,957,556	€ 322,418,255

3.3. Indirect Costs of Breast Cancer

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Indirect costs, together with direct costs, represent a substantial share of the overall eco-nomic burden of breast cancer. They include a broad range of productivity losses and oth-er societal costs, affecting patients and their families while also influencing the wider economy through reduced labor market participation, lower household income, and downstream social consequences. The macroeconomic parameters used to estimate the value of productivity loss are summarized in Table 6.

Table 6. Economic Parameters Used in the Valuation of Productivity Losses, 2024 (EUR).

Parameter	Description	Value
GDP_{2024}	Gross domestic product in 2024	€852,143,692,956
E_{2024}	Number of employed persons	15,169,658
CF	Correction factor	0.65
WD_{2024}	Number of working days	228
K_{day}	Estimated value of 1day of lost productivity	€160.15
Working day length	Hours per working day	8h
K_{hour}	Estimated value of one hour of lost productivity	€20.02

3.3.1. Costs of Short-Term Absenteeism

Productivity losses related to short-term work impairment among breast cancer patients were estimated based on sickness absence and reductions in working time. Data on sickness absence were obtained from administrative records of the Social Insurance Institution (ZUS) [13], while information on reduced working time was derived from a patient survey.

Sickness absence constituted a substantial component of indirect costs. In 2024, the total number of breast cancer–related sick-leave days exceeded 1.4 million, translating into considerable productivity losses when valued using the GDP-based approach. The estimated cost of absenteeism alone reached over €230 million (Table 7). Detailed calculation methods and formulas are provided in Appendix B2.

Table 7. Value of GDP loss per day of sickness absence in 2024 (EUR).

Number of sickness-absence days	Value of lost productivity per day	Total cost of sickness absence
1,452,329	€160.15	€ 232,573,739

Survey data indicate that a substantial proportion of breast cancer patients remain economically active, with nearly three-quarters reporting employment. Among those employed, a majority declared reducing their working time due to the disease.

Reduced working time represents a major source of productivity loss. The average decrease in weekly working hours translated into a considerable annual reduction in total labour input, which—when valued using the GDP-based approach—resulted in productivity losses exceeding €560 million in 2024 (Table 8).

Table 8. Productivity Losses Due to Reduced Working Time Among Breast Cancer Patients in 2024 (EUR).

Parameter	Description	Value
Patient population	Number of breast cancer patients	69.591
Employed patients	Share of patients who are employed	74%
Patients reducing working time	Share reporting reduced working hours	66%
Average reduction in working hours	Mean reduction per patient (hours/week)	3.7

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Total reduced working hours	Annual number of hours lost due to reduced working time	28,170,340
Productivity loss	Total cost of reduced working time	€563,909,214

3.3.2. Costs of Long-Term Absenteeism

Long-term productivity losses associated with breast cancer were driven by two main components: premature mortality and disability-related reductions in work capacity. Detailed methodological assumptions underlying these estimates are provided in the Methods section and Appendix B3.

Premature mortality constituted the largest component of long-term productivity losses. In 2024, deaths attributable to breast cancer among individuals of working age resulted in substantial economic losses due to the permanent withdrawal of individuals from the labor market. When valued using a human capital approach—incorporating age-specific employment rates, GDP per employed person adjusted by a correction factor, and discounted over the remaining working life—the total cost of premature mortality exceeded €250 million.

Disability-related productivity losses represented an additional significant burden. Breast cancer–related morbidity, including long-term treatment effects, disease recurrence, and metastatic progression, contributed to reduced work capacity over time. Using years lived with disability (YLD) as a measure of non-fatal disease burden, and valuing these using the same macroeconomic parameters, the total cost of disability-related productivity losses was estimated at over €160 million.

Overall, the combined cost of long-term absenteeism attributable to breast cancer in Poland reached approximately €417 million in 2024, highlighting the substantial and persistent impact of the disease on labor market outcomes and economic productivity (Table 9).

Table 9. Total Costs of Long-Term Productivity Losses Due to Breast Cancer in Poland in 2024 (EUR).

Component	Cost (EUR)	Share %
Premature mortality	€254,156,656	61%
Disability (YLD-based)	€162,457,102	39%
Total	€416,613,758	100%

3.3.3. Costs of Presenteeism

Presenteeism was defined as reduced effectiveness during hours still worked. To capture heterogeneity in work impairment, survey respondents were stratified into four mutually exclusive subgroups based on reductions in working time and use of sick leave.

For each subgroup, productivity losses were estimated by applying self-reported impairment rates to the effective working time in 2024, taking into account reductions in working hours and time spent on sick leave. Lost productivity was valued using the GDP-based hourly productivity metric adjusted by a correction factor (CF).

In 2024, the total number of hours lost due to reduced on-the-job productivity approached 34 million, resulting in substantial economic losses exceeding €679 million (Table 10).

Following a conservative approach, the analysis was restricted to actively treated patients, as the survey primarily reflected this population and productivity impairment is expected to be highest during the treatment period. Detailed calculation methods and formulas are provided in Appendix B4.

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Table 10. Total Costs of Presenteeism Due to Breast Cancer in Poland in 2024 (EUR).

Parameter	Value
Total lost productivity hours	33,953,649
Productivity value per hour	€20.02
Total cost of presenteeism	€679,691,794

3.3.4. Costs of Informal Caregiving

Informal caregiving represents an additional source of productivity loss associated with breast cancer, affecting family members who provide care to patients. These costs arise primarily from work absence and reduced working time among caregivers.

Caregiver productivity losses were substantial, particularly those related to reduced working time. In 2024, the total cost of informal caregiving exceeded €565 million, with reduced working time accounting for the majority of this burden (Table 11).

Table 11. Costs of Informal Caregiving Due to Breast Cancer in Poland in 2024 (EUR).

Parameter	Value
Sick leave (caregivers)	€49,884,059
Reduced working time (caregivers)	€515,578,696
Total informal caregiving	€565,462,755

3.3.5. Costs of Unpaid Work

Unpaid work represents non-market activities such as household tasks and caregiving responsibilities performed by patients, which contribute to overall economic productivity but are not compensated in formal labor markets.

Breast cancer significantly affects patients' ability to perform unpaid work. Survey results indicate that a substantial proportion of patients experience limitations in daily activities, leading to a considerable loss of non-market productivity. When valued using a replacement cost approach, the total cost of unpaid work losses exceeded €660 million in 2024 (Table 12).

Table 12. Total Costs of Presenteeism Due to Breast Cancer in Poland in 2024 (EUR).

Parameter	Description	Value
Patient population	Number of breast cancer patients	231,422
Patients with reduced unpaid work	Share reporting limitations	70%
Average reduction in unpaid work	Hours per day	2
Days per year	Assumed number of days	365
Replacement cost	Hourly wage of domestic help	€8.31
Total cost of unpaid work	—	€667,413,177

3.4. Total Economic Burden and Cost Structure

The total economic burden of breast cancer in Poland in 2024 was driven predominantly by indirect costs, which accounted for approximately 73% of total costs, compared with 27% for direct expenditures. Among indirect costs, absenteeism represented the largest share (39%), followed by presenteeism (22%), unpaid work (21%), and informal caregiving (18%).

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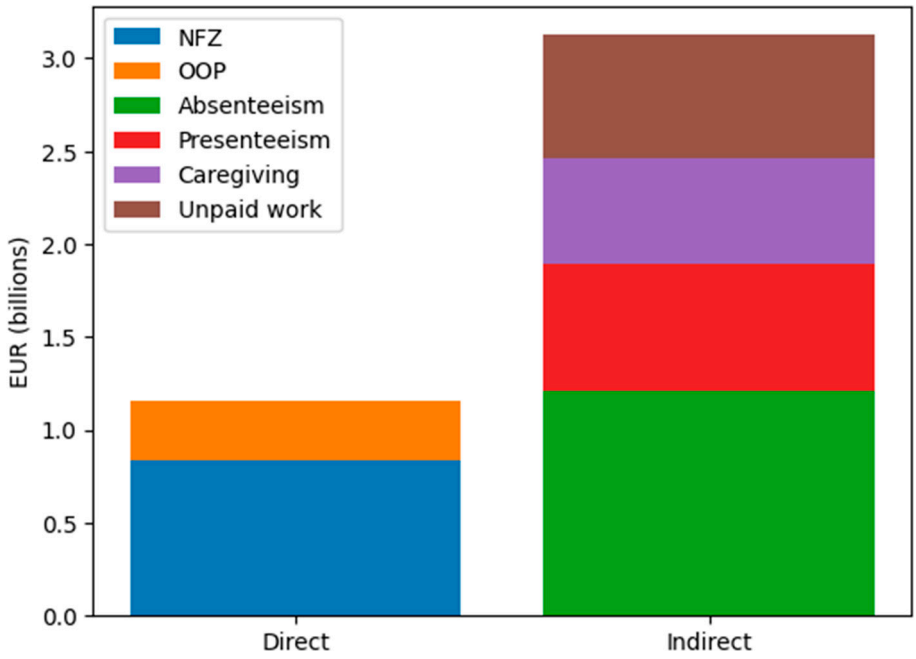

Figure 1. Structure of the economic burden of breast cancer in Poland in 2024 (EUR).

4. Discussion

Breast cancer constitutes a substantial and growing economic burden, both in terms of direct healthcare expenditures and indirect costs related to productivity loss. The findings of the present study are consistent with previous evidence from Poland, which demonstrated a steady increase in total costs over time and highlighted the significant contribution of indirect costs to the overall burden [19]. Similar conclusions have been reported in broader analyses of the Polish healthcare system, indicating a continuous rise in expenditures and a considerable societal burden associated with breast cancer [7]. A key finding of this study is the substantial contribution of indirect costs, which remain frequently underestimated. Evidence from Poland indicates that even when limited to absenteeism, productivity losses account for a considerable share of total costs, while broader approaches suggest that absenteeism represents only a fraction of the total indirect burden [7,19]. This is consistent with earlier analyses demonstrating that long-term components, such as disability and premature mortality, constitute major drivers of productivity losses [8].

International evidence further supports these observations. A systematic review of triple-negative breast cancer demonstrated that both direct and indirect costs increase substantially with disease progression and treatment intensity, with wide variability across healthcare systems [20]. Similarly, a cost-of-illness study from Turkey showed that indirect costs constitute the dominant component of the economic burden, exceeding direct medical expenditures and accounting for the majority of total costs [21].

Consistent findings are reported in a recent systematic review by Franklin et al. [22] which highlighted that indirect costs—particularly those related to productivity loss and informal caregiving—are substantially underrepresented in the literature. Importantly, when these components are included, they may exceed direct healthcare costs, underscoring the importance of adopting a societal perspective in economic evaluations. At the same time, the review emphasized considerable heterogeneity across studies and concluded that current evidence captures only part of the total economic burden of breast cancer, limiting its usefulness for policy-making [22].

The structure of indirect costs is also important for interpretation. Evidence from Poland indicates that productivity losses are driven not only by short-term absenteeism but also by long-term effects such as disability and premature mortality [8]. In addition, broader approaches incorporating presenteeism and caregiver-related productivity losses provide a more comprehensive

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estimate of the societal burden. These components are increasingly recognized in the literature as essential elements of cost-of-illness analyses [22]. The structure of direct costs observed in this study is consistent with both national and international evidence. In Poland, pharmacological treatment—particularly within drug programs—accounts for the largest share of direct expenditures, followed by surgery and radiotherapy [19]. This pattern is also reflected in international studies, which consistently identify systemic therapies as the primary cost driver in breast cancer treatment [6].

The economic burden of breast cancer varies substantially depending on disease stage. Evidence from international studies indicates that costs increase markedly with disease progression, with advanced and metastatic disease associated with significantly higher expenditures [6,20].This is further supported by country-level analyses, which demonstrate several-fold differences in costs between early-stage and metastatic disease [21]. These findings highlight the economic importance of early detection and timely treatment.

A recurring limitation across studies is the lack of methodological standardization. Differences in cost components, valuation approaches, and data sources limit comparability between studies and contribute to variability in reported estimates [8,22]. Moreover, many studies omit key elements such as presenteeism or informal caregiving, leading to systematic underestimation of indirect costs. This highlights the need for more comprehensive and standardized approaches to cost-of-illness analyses.

The findings of this study have important implications for health policy. First, they support the inclusion of indirect costs in economic evaluations and health technology assessments. Second, they emphasize the importance of interventions aimed at reducing disease progression, disability, and premature mortality, which are the main drivers of productivity losses. Furthermore, given the dominant role of pharmacological treatment in direct costs, pricing and reimbursement policies for innovative therapies remain critical determinants of the overall economic burden.

This study has several limitations that should be acknowledged. Estimates of indirect costs rely on methodological assumptions, particularly when applying the human capital approach. Additionally, some parameters—such as presenteeism—are based on survey data, which may introduce uncertainty. Finally, differences in methodology across studies limit direct comparability of results [22].

5. Conclusions

Breast cancer imposes a substantial and multidimensional economic burden in Poland, extending far beyond the healthcare system. This study demonstrates that indirect costs—particularly those related to absenteeism, presenteeism, unpaid work, and informal caregiving—constitute the dominant component of the total burden, accounting for nearly three-quarters of overall costs. These findings highlight that analyses limited to direct medical expenditures significantly underestimate the true societal impact of the disease.

The distribution of costs across stakeholders reveals that, in addition to the public healthcare payer, a considerable share of the burden is borne by patients, households, and the broader economy through lost productivity. This underscores the importance of adopting a comprehensive societal perspective in economic evaluations of breast cancer.

From a policy perspective, the results suggest that investments in early detection, effective treatment, and survivorship care may yield substantial economic benefits by reducing long-term productivity losses. Furthermore, incorporating indirect costs into health technology assessment and decision-making processes may support more efficient allocation of resources. Overall, a more holistic understanding of the economic burden of breast cancer is essential for designing policies that not only improve clinical outcomes but also mitigate its broader social and economic consequences.

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Institutional Review Board Statement: Ethical review and approval were waived for this study, as it was based on aggregated administrative data and an anonymous, non-interventional survey. According to applicable national regulations, such studies do not require ethics committee approval.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the survey. Participation was voluntary and anonymous.

Data Availability Statement: All data analyzed in this study are publicly available and fully referenced in the article.

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Abbreviations

The following abbreviations are used in this manuscript:

GDP	Gross Domestic Product
CF	Correction Factor
YLD	Years Lived with Disability
NFZ	Narodowy Fundusz Zdrowia/National Health Fund
ZUS	Zakład Ubezpieczeń Społecznych/Social Insurance Institution
GUS	Główny Urząd Statystyczny/Central Statistical Office
NCR	Krajowy Rejestr Nowotworów/National Cancer Registry

Appendix A

This appendix presents detailed characteristics of breast cancer patients participating in the survey (n = 289) and summarizes productivity loss and informal care outcomes by disease stage. Table A1 describes the distribution of respondents across disease stages. Tables A2 and A3 present mean values calculated using two approaches: across all patients (with zero values assigned where applicable) and among patients affected by each parameter only.

Table A1. Characteristics of Female Breast Cancer Patients Included in the Survey.

Stage	Number of Patients	Percentage of Patients
Unknown	28	10%
Stage 0 (early breast cancer, non-invasive)	16	6%
Stages I and II (early breast cancer)	112	39%
Stage III (locally advanced breast cancer)	53	18%
Stage IV (advanced metastatic breast cancer)	80	28%
Total (all patients)	289	100%

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Table A2. Mean Values of Productivity Loss and Informal Care Among Breast Cancer Patients (Including Zero Values).

Parameter	Stage 0	Stages I–II	Stage III	Stage IV
Unpaid work of patients – mean reduction in duties [hours/week]	4.56	9.79	10.91	13.23
Reduced productivity at work – mean [% reduction]	40%	49%	38%	33%
Reduction in working hours – mean [hours/week]	6.59	14.17	15.92	19.14
Sick leave (patients) – mean [days/year]	15.84	19.93	16.85	11.09
Reduction in caregivers' working hours – mean [hours/week]	0.00	1.96	1.83	4.04
Sick leave (caregivers) – mean [days/year]	0.00	1.08	0.75	1.78

Patients for whom a given parameter was not applicable were also included. For example, in the case of reduction in household duties, patients who reported no change were assigned a value of 0 for calculation purposes.

Table A3. Mean Values of Productivity Loss and Informal Care Among Affected Breast Cancer Patients.

Parameter	Stage 0	Stages I–II	Stage III	Stage IV
Percentage of patients with reduced household duties [%]	56%	66%	77%	78%
Unpaid work – mean reduction in duties [hours/week]	8.11	14.82	14.10	17.06
Percentage of employed/self-employed patients [%]	88%	81%	62%	64%
Percentage of unemployed patients who stopped working due to illness [%]	50%	67%	55%	79%

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Reduced productivity at work [% reduction]	46%	61%	62%	52%
Percentage of employed patients who reduced working time [%]	36%	64%	73%	73%
Mean reduction in working hours (patients) [hours/week]	13.10	17.71	16.81	16.53
Sick leave (patients) – mean [days/year]	18.11	24.53	27.06	17.39
Percentage of caregivers who reduced working time or stopped working [%]	0%	17%	17%	18%
Mean reduction in caregivers' working hours [hours/week]	0.00	24.75	10.78	23.11
Percentage of caregivers taking sick leave/care leave [%]	0%	8%	8%	19%
Sick leave (caregivers) – mean [days/year]	0.00	13.50	9.88	9.47

Only patients to whom a given parameter applied were included. For example, in the case of reduction in household duties, only patients who reported a change in their household responsibilities were considered.

Appendix B

Appendix B1. Detailed Methods for the Estimation of Indirect Costs

This appendix provides a detailed specification of the methods used to estimate indirect costs, including calculation formulas, parameter definitions, and model assumptions underlying the valuation of productivity losses.

The average value of one day of lost productivity ($\boldsymbol{K_{day}}$) was calculated as:

$$K_{day} = \frac{GDP_{2024}}{E_{2024}} \cdot \beta \cdot \frac{1}{WD_{2024}}$$

where GDP_{2024} denotes gross domestic product in 2024, E_{2024} the number of employed persons in 2024, $WD_{2024}$the number of working days in 2024, and CF the correction factor applied to avoid overestimation of productivity losses.

Productivity losses were additionally expressed on an hourly basis. Assuming an 8-hour workday, the value of one hour of lost productivity was derived as:

$$K_{hour} = \frac{K_{day}}{8}$$

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For 2024, the number of working days (net of annual leave) was set to $WD_{2024} = 228$, and one working day was assumed to equal 8 h. For long-horizon components (premature mortality), future losses were discounted at 5% per year, consistent with Polish HTA practice [17].

Appendix B2. Short-Term Absenteeism in Patients

Short-term absenteeism included:

- Sickness absence: valued using the total number of sick-leave days reported to ZUS under ICD-10 C50 multiplied by the GDP-based productivity value per day (adjusted by CF).
- Reduced working time: among employed respondents, the proportion reporting reduced hours and the mean reduction (hours/week) were converted into annual hours lost and valued using the GDP-based productivity value per hour (adjusted by CF).

Appendix B3. Long-Term Productivity Losses

Two long-term components were included:

- Productivity losses due to premature mortality were estimated using a human capital approach, based on the discounted stream of future production lost among individuals who died at working age. The estimation incorporated age-specific mortality data from the National Cancer Registry (NCR), employment rates by age group, and GDP per employed person adjusted by a correction factor (CF), projected up to the statutory retirement age. The cost of lost productivity was calculated as follows:

$$C_{(mort\_a)} = D_a \cdot \sum_{t=0}^{T_a} \left(\frac{GDP}{E} \cdot \beta \cdot ER_{a+t} \cdot \frac{1}{(1+r)^t}\right)$$

where:

  - $C_{mort,a}$– productivity loss due to premature mortality in age group a
  - D_a– number of deaths in age group a
  - GDP– gross domestic product in 2024
  - E– number of employed persons in 2024
  - β– correction factor (0.65)
  - ER_{a+t}– employment rate at age (a + t)
  - r– discount rate (5%)
  - T_a– remaining working years for individuals in age group a
- Productivity losses due to disability were estimated using years lived with disability (YLD) as a measure of time spent in less than full health. The estimation combined age-specific YLD values with employment rates and GDP per employed person adjusted by a correction factor (CF).The cost of lost productivity was calculated as follows:

$$C_{(dis\_a)} = YLD_a \cdot \left(\frac{GDP}{E} \cdot \beta \cdot ER_a\right)$$

where:

  - $C_{dis,a}$– productivity loss due to disability in age group a
  - YLD_a– years lived with disability in age group a
  - GDP– gross domestic product in 2024
  - E– number of employed persons in 2024
  - β– correction factor (0.65)
  - ER_a– employment rate in age group *a*

Appendix B4. Presenteeism

- Productivity losses due to presenteeism were estimated as reduced effectiveness during hours still worked. The estimation combined subgroup-specific productivity impairment rates with effective working time, accounting for differences in working hours and sick leave. Lost

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productivity was valued using GDP per employed person, adjusted by a correction factor (CF). The cost of lost productivity was calculated as follows:

$$C_{pres} = \sum_{g} (N \cdot ER \cdot S_g \cdot H_g \cdot W \cdot PI_g \cdot \frac{GDP}{E \cdot H_{year}} \cdot \beta)$$

- C_{pres}– total cost of presenteeism
- N– number of breast cancer patients under active treatment
- ER– employment rate
- S_g– share of patients in subgroup g
- H_g– average weekly working hours in subgroup g
- W– number of working weeks per year
- PI_g– productivity impairment rate in subgroup g
- GDP– gross domestic product in 2024
- E– number of employed persons
- H_{year}– annual working hours
- β– correction factor (0.65)

Table B01 presents subgroup-specific input parameters used in the presenteeism analysis, including the distribution of patients, working time, sick leave, and self-reported productivity impairment. Table B02 reports the corresponding estimated lost productivity hours for each subgroup, aggregated to obtain the total number of hours used in cost calculations.

Table B01. Presenteeism inputs by patient subgroup.

Subgroup	Share%	Weekly hours	Sick leave days	Productivity loss
Reduced hours + sick leave	48%	15	33	66%
Reduced hours only	17%	19	0	58%
Sick leave only	25%	40	25	48%
Neither	9%	40	0	39%

Table B02. Estimated lost productivity hours by subgroup.

Subgroup	Population	Lost hours
Reduced hours + sick leave	24,802	15,690,273
Reduced hours only	8,910	4,881,715
Sick leave only	12,762	9,955,761
Neither	4,816	3,425,900
Total	—	33,953,649

Appendix B5. Informal Caregiving

Productivity losses related to informal caregiving were estimated based on survey data on caregiver absenteeism and reduced working time. Lost productivity was valued using the GDP per employed person, adjusted by a correction factor (CF).

Productivity losses due to caregiver sick leave were calculated as:

$$C_{(care\_abs)} = N \cdot S \cdot D \cdot V_{day}$$

where:

- $C_{care,abs}$– cost of caregiver absenteeism
- N– number of patients
- S– share of caregivers taking sick leave
- D– average number of sick-leave days
- V_{day}– value of lost productivity per day

Productivity losses due to reduced working time among caregivers were calculated as:

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$$C_{(care\_red)} = N \cdot S \cdot H \cdot WD \cdot V_{hour}$$

where:

- $C_{care,red}$– cost of reduced working time
- H– average daily reduction in working hours
- WD– number of working days per year
- V_{hour}– value of lost productivity per hour

Appendix B6. Unpaid Work

Productivity losses related to unpaid work were estimated using a replacement cost approach, valuing lost household production based on the market price of equivalent services. The estimation was based on survey data on the proportion of patients experiencing reduced ability to perform unpaid activities and the average reduction in time spent on such activities.

$$C_{unpaid} = N \cdot S \cdot H \cdot D \cdot \beta$$

where:

- C_{unpaid}– total cost of unpaid work
- N– number of patients
- S– share of patients with reduced unpaid activity
- H– daily hours of unpaid work lost
- D– number of days per year
- W– hourly wage of domestic help (replacement cost)
- β– correction factor (0.65)

References

1. GBD 2023 Cancer Collaborators. The global, regional, and national burden of cancer, 1990-2023, with forecasts to 2050: a systematic analysis for the Global Burden of Disease Study 2023. Lancet. 2025 Oct 11;406(10512):1565-1586. doi: 10.1016/S0140-6736(25)01635-6
2. Łyszczarz, B. Productivity losses from short-term work absence due to neoplasms in Poland. Sci Rep 14, 3289 (2024). https://doi.org/10.1038/s41598-024-53878-4
3. Gąska I, Czerw A, Pajewska M, Partyka O, Charkiewicz D, Deptała A, Badowska-Kozakiewicz A, Sygit K, Dziubek I, Wojtyła-Buciora P, et al. Direct and Indirect Costs of Cancer in Adult Population of Poland in the Period 2021–2023. Cancers. 2025; 17(23):3725. https://doi.org/10.3390/cancers17233725
4. https://www.who.int/news-room/fact-sheets/detail/breast-cancer
5. Seweryn M, Banaś T, Augustyńska J, Leszczyńska A, Potocki PM. Non-drug related costs of treatment with pertuzumab and trastuzumab in HER2-positive breast cancer patients in Poland. Oncology in Clinical Practice. 2024;20(3):181–189. doi:10.5603/ocp.97426
6. Gąska I, Czerw A, Pajewska M, Partyka O, Deptała A, Badowska-Kozakiewicz A, Budzik M, Sygit K, Wojtyła-Buciora P, Drobnik J, et al. The Cost of Breast Cancer: Economic and Social Perspective. Cancers. 2025; 17(18):3012. https://doi.org/10.3390/cancers17183012
7. Sierocki W, Kornowska L, Dudek A, Szpakowicz M, Dompe C, Roszak M. The burden of breast cancer in Poland: current status and future directions. Front Oncol. 2025 Jun 26;15:1599741. doi: 10.3389/fonc.2025.1599741. PMID: 40641924; PMCID: PMC12241066.
8. Łyszczarz B, Nojszewska E. Productivity losses and public finance burden attributable to breast cancer in Poland, 2010-2014. BMC Cancer. 2017 Oct 10;17(1):676. doi: 10.1186/s12885-017-3669-7. PMID: 29017454; PMCID: PMC5634844.
9. Rosenzweig M, West M, Matthews J, Stokan M, Yoojin Kook YK, Gallups S, Diergaarde B. Financial Toxicity Among Women With Metastatic Breast Cancer. Oncol Nurs Forum. 2019 Jan 13;46(1):83-91. doi: 10.1188/19.ONF.83-91.
10. Culbertson MG, Bennett K, Kelly CM, Sharp L, Cahir C. The psychosocial determinants of quality of life in breast cancer survivors: a scoping review. BMC Cancer. 2020 Oct 2;20(1):948. doi: 10.1186/s12885-020-07389-w.

 doi:10.20944/preprints202604.1254.v1

11. Statistics Poland (GUS). Announcement on the first estimate of gross domestic product in 2024 [Internet]. Warsaw (PL): Statistics Poland; [cited 2025 Aug 22]. Available from: https://stat.gov.pl/sygnalne/komunikaty-i-obwieszczenia/lista-komunikatow-i-obwieszczen/obwieszczenie-w-sprawie-pierwszego-szacunku-wartosci-produktu-krajowego-brutto-w-2024-r-,280,12.html
12. Statistics Poland (GUS). Persons employed in the national economy in Poland in December 2024—Tables [Internet]. Warsaw (PL): Statistics Poland; [cited 2025 Aug 22]. Available from: https://stat.gov.pl/obszary-tematyczne/rynek-pracy/pracujacy-zatrudnieni-wynagrodzenia-koszty-pracy/pracujacy-w-gospodarce-narodowej-w-polsce-w-grudniu-2024-r-tablice,28,24.html
13. Social Insurance Institution (ZUS). Statistics [Internet]. Warsaw (PL): Zakład Ubezpieczeń Społecznych; [cited 2025 Aug 14]. Available from: https://www.zus.pl/baza-wiedzy/statystyka
14. National Cancer Registry (Poland). Reports [Internet]. Warsaw (PL): National Cancer Registry; [cited 2025 May 14]. Available from: https://onkologia.org.pl/pl/raporty
15. Institute for Health Metrics and Evaluation (IHME). GBD Foresight Visualization [Internet]. Seattle (WA): IHME, University of Washington; [cited 2025 Aug 22]. Available from: https://vizhub.healthdata.org/gbd-foresight/
16. European Commission. 2024 ageing report: underlying assumptions & projection methodologies [Internet]. Luxembourg: Publications Office of the European Union; 2023 [cited 2025 Sep 30]. doi:10.2765/960576.
17. Agency for Health Technology Assessment and Tariff System (AOTMiT). Guidelines for conducting health technology assessment 3.0 [Internet]. Warsaw: AOTMiT; 2016 [cited 2025 Sep 13]. Available from: https://www.aotm.gov.pl/wp-content/uploads/2020/07/20160913_Wytyczne_AOTMiT.pdf
18. National Bank of Poland (NBP). Exchange rate table No. 252/A/NBP/2024 of 31 December 2024 [Internet]. Warsaw (PL): Narodowy Bank Polski; [cited 2025 Sep 10]. Available from: https://nbp.pl/archiwum-kursow/tabela-nr-252-a-nbp-2024-z-dnia-2024-12-31
19. Seweryn M, Banas T, Augustynska J, Lorenc O, Kopel J, Pluta E, Skora T. The Direct and Indirect Costs of Breast Cancer in Poland: Estimates for 2017-2019. Int J Environ Res Public Health. 2022 Dec 7;19(24):16384. doi: 10.3390/ijerph192416384.
20. Rezaei S, Babaei M. A systematic literature review on direct and indirect costs of triple-negative breast cancer. Cost Eff Resour Alloc. 2023 Nov 30;21(1):92. doi: 10.1186/s12962-023-00503-2.
21. Malhan S, Akinci MB, Akyürek N, Bilici A, Demirci U, Geredeli Ç, et al. A cost-of-illness study on the economic burden of breast cancer in Türkiye: a Delphi panel-based analysis of direct and indirect costs. Turk J Oncol. 2024;39(4):383–392. doi:10.5505/tjo.2024.4347
22. Franklin M, Pollard D, Sah J, Rayner A, Sun Y, Dube F, Sutton A, Qin L. Direct and Indirect Costs of Breast Cancer and Associated Implications: A Systematic Review. Adv Ther. 2024 Jul;41(7):2700-2722. doi: 10.1007/s12325-024-02893-y.