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The socioeconomic burden of migraine The case of 6 European Countries

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List of Abbreviations

CVD	Cardiovascular diseases
DALY	Disability-adjusted life year
DM	Diabetes mellitus
FCA	Friction cost approach
GBD	Global burden of disease
GDP	Gross domestic product
GVA	Gross value added
HCA	Human capital approach
IHME	Institute for Health Metrics and Evaluation
IO	Input-output
NACE Rev. 2	Second revision of the Statistical Classification of Economic Activities in the European Community
OECD	Organization for Economic Cooperation and Development
SOB	Socioeconomic burden
USES	Unpaid substitution economic sector
YLD	Years lived with disability
YLL	Years of life lost

Summary

Objective
Strong evidence exists for the relationship between individual productivity and health. Consequently, disease burden directly affects the number and ability of productive workers, which in turn influences economic growth. This effect of disease burden on productivity is captured in the concept of socioeconomic burden (SOB). A disease with a high burden that predominantly affects women in their most productive ages is migraine. The aim of this report is to study the overall and gender specific SOB of migraine in Germany, Spain, France, the Netherlands, Czech Republic, and Portugal, contextualizing this burden relative to diabetes and cardiovascular diseases.

Method
Our analysis considered productivity losses from disease burden in both paid and unpaid work, treating years lost to disability or premature death as unproductive. For this, we used years lived with disability (YLDs) to assess presenteeism and absenteeism, and productive years of life lost (YLLs) to evaluate productivity losses due to mortality. To quantify productivity losses in paid work, we adopted an innovative method that integrates input-output analysis of value chain effects with health economics to explore how disease burden results in productivity losses in the wider economy. A disease does not only cause direct productivity losses, due to a reduction in the ability to do paid work but also triggers spillover effects across related economic sectors and induces further impacts along value chains. For unpaid work, the productivity of an industry sector of which the activities resemble the activities of unpaid work the most is taken to value lost time due to disease.

Results
The total SOB of migraine, which includes lost productivity of both paid and unpaid work, ranges from 1.20% of the Gross Domestic Product of the Netherlands to 2% of the GDP of Spain in 2021. Between 2011 and 2021, this translates into economic losses ranging from 35 billion euro in Czech Republic to 557 billion euro in Germany. When compared to CVD and DM, across the majority of countries examined, migraine consistently demonstrated the highest overall economic burden relative to other disease categories and it was relatively stable throughout the decade-long observation period. Analysis of gender-disaggregated data reveals that females experienced a disproportionately elevated migraine burden, resulting in approximately twice the overall productivity losses of males. Specifically, females demonstrated 4-9 times higher productivity losses from unpaid work and 1.7-2 times greater economic losses in paid work relative to males, with female-specific losses ranging from 0.84% to 1.47% of national GDP across countries examined.

Conclusion
The SOB of migraine is substantial across the six countries studied, affecting both paid and unpaid work productivity. Women disproportionately bear this burden, with gender inequalities in unpaid work contributing to significant productivity losses in this domain. Since unpaid work includes critical activities such as caregiving, addressing the burden of migraine could not only enhance productivity across both paid and unpaid sectors but also reduce strain on government budgets by lessening the reliance on public support systems.

1 Introduction

Migraine is a neurovascular disorder that is defined by recurring moderate to severe headaches (Goadsby, 2007). Globally, it has been estimated to have a prevalence of 14% in 2019, which translates in 1.1 billion people being affected (Amiri *et al.*, 2022). Due to the severity of headaches, this results in a heavy disease burden. In the Global Burden of Disease (GBD) study, it is estimated that migraine ranks second in terms of disease burden amongst all diseases concerning years lived with disability (IHME, 2024). A notable observation is that this burden is increasing over time. Between 1990 and 2021, the global prevalence increased by 39.52% (Chen *et al.*, 2024). It should also be observed that younger women are particularly affected. The global prevalence for women between the age of 40 and 44 showed the highest prevalence of disease in 2021, equivalent to 27,458 per 100,000 women (IHME, 2024).

Due to this disease burden, migraine also results in high costs to the healthcare system. A systematic review by Eltrafi *et al.* (2023) estimated the costs of migraine to the healthcare system in the organization for economic co-operation and development (OECD) countries. Such costs consist of costs related to physician or hospital visits, the cost of drugs, etc. This study shows that in OECD countries, the annual estimated direct cost per patient ranges from €1,495.20 to €8,344.30 in the 13 different articles that they identified. Considering the high prevalence of migraine, these high per patient costs results in a significant aggregated cost to the healthcare system.

Beyond the impact of migraine on the health burden of a population and disease related cost to the healthcare system, there is an additional cost of migraine when the relationship between health and economic productivity is considered (Suhrcke *et al.*, 2006; Jamison *et al.*, 2013; Bloom, Kuhn and Prettner, 2019). This relationship can be explained by the reduced productivity of a population that is more affected by disease (Shimizu *et al.*, 2021).
Evidence from comprehensive European research shows that migraine-related costs are predominantly driven by indirect expenses, with productivity losses from absenteeism and presenteeism accounting for approximately 90% of the total economic burden, while direct healthcare costs comprise only 10% of the overall financial impact (García-Azorín *et al.*, 2024).

To research these broader costs, a socioeconomic burden (SOB) of disease study can be conducted. The SOB of disease describes how disease impairs labor supply by reducing the ability of individuals to use their human capital. The SOB of a disease in a country can be assessed by studying the effects of a disease's mortality and morbidity on productivity. Mortality reduces the number of people who are able to work, thus directly affecting labor supply. Additionally, mortality results in the need to recruit new employees in the case of paid work. This also results in productivity losses due to the time it takes to onboard new employees. On the other hand, morbidity results in presenteeism and absenteeism. Due to living with the burden of a disease, presenteeism is the result of working while sick, leading individuals to become less productive at work. In the worst case, individuals might face temporary unplanned absences from work because of the disease, also known as absenteeism. In the context of migraine, European studies have demonstrated that these productivity impacts are substantial, with migraine patients showing significantly higher rates of both absenteeism and presenteeism compared to healthy controls, alongside increased activity impairment that affects daily functioning beyond the workplace (Doane *et al.*, 2020).

Particularly in the case of migraine, the SOB of disease can be high, since it predominantly affects younger women, and therefore when they are in their most productive life cycle. To illustrate this, an earlier study conducted at WifOR by Seddik et al. *(*2020) focused on Germany, estimated that the annual cost of productivity losses, as a result of migraine, can amount to €6,493 per patient, which due to the high prevalence of migraine results in a total aggregated cost of more than €100 billion per year. In this study, which focused on Germany, it was estimated that the annual cost of productivity losses, as a result of migraine, can amount to €6,493 per patient, which for Germany results in a total cost of more than €100 billion per year.

Despite these high broader societal costs, Eltrafi et al. (2023) found that most studies focus on direct costs to the healthcare system and that the broader productivity related costs of migraine to society remain understudied.

The aim of this report is therefore to describe the SOB of migraine in 6 different European countries: France, Spain, Netherlands, Portugal, Czech Republic and Germany. More specifically, the study will:

- Describe the SOB of migraine
- Compare the SOB of migraine with cardiovascular disease and diabetes mellitus
- Conduct a gender specific analysis on the SOB of migraine

2 Methods

2.1 Analysis

The analysis of the SOB of migraine relates disease burden to productivity losses. This is done in three major stages. In stage (A), the disease burden of migraine is estimated in terms of disability adjusted life years (DALYs). In stage (B), this disease burden is translated into losses in productivity in terms of lost of work time, with a loss of a DALY representing a non-productive year. In stage (C), this lost work time is valued in terms of gross value added (GVA). A description of these three stages is provided below, while the detailed formulas to derive the estimates are included in the Annex.

In stage (A), Disease burden is quantified in terms of DALYs. DALYs combine information about mortality and morbidity. Disease burden associated with mortality is expressed in terms of years of life lost (YLL), which reflects how many life years an individual could have lived if this individual had not died of a certain disease. To illustrate this, an individual who dies at the age of 30 due to a cardiovascular event could have lived up to an expected age of 80, which thus translates into 50 YLL. The disease burden associated with morbidity is reflected in years lived with disability (YLD), which reflects the burden of living with a disability. For instance, someone living with migraine has a disability weight of 0.4, which symbolizes that, 80 years of living with migraine is equal to living 48 years of living a healthy life (80 multiplied by 1 minus the disability weight), or in other words, 32 years are lost due to living with disability. Combined, it is possible to equate and aggregate disease burden in terms of YLD and YLL. The combination of YLD and YLL is the DALY.

To translate the disease burden into lost productivity in stage (B), we generally assume that any DALY lost reflects a non-productive year. There are, however, specific differences in how YLL and YLD are related to productivity losses. For YLL, we use two approaches: the human capital approach (HCA) and the friction cost approach (FCA). In the HCA, we assume that the death of an individual results in a loss of productivity that cannot be replaced. In the FCA, we assume that after one year, an organization adapts to the loss of an individual, through, for example, hiring, or organizational/technological adaptations. In other words, we assume that a death results in a productivity loss of one year. While both methodological approaches produce identical results for migraine, they yield different estimations for diabetes and CVD due to the influence of mortality. For DALY losses in terms of YLD, we assume similarly that a lost DALY reflects a non-productive year. To illustrate this, a healthy individual without migraine is equally productive as 2.5 individuals with migraine in a year (1 divided by the disability weight). In the case of YLD, we assume that these capture productivity losses due to presenteeism and absenteeism.

In stage (C), we value the losses in productive work time through GVA. Classically, this is done with wages. However, due to market inefficiencies, wages do not accurately reflect the productivity of workers. GVA however does accurately portrays the value contributed by a worker to the overall economy. GVA is estimated by taking the value of the productivity of an industry sector and subtract the value of the intermediate consumption of products that are used in this sector for productivity from the total value of productivity. The resulting measure therefore accurately reflects the economic value added by a specific industry sector. In SOB studies, the effect of disease burden on the productivity of an employed person (in terms of GVA per capita) is estimated . In this sense, the estimation of the monetary value of the burden of a disease will reflect the effect of reducing the working capacity of the productive people in the economy.

Additionally, to evaluate the effect of disease burden on productivity in terms of paid work, we use multipliers based on input-output models to not only assess direct costs, but also spillover effects in terms of indirect and induced costs. The direct effects reflect the direct economic impact of a reduction in paid work due to lost health. The indirect effects reflect the losses in intermediate consumption of goods and services, due to a loss of GVA related to disease loss. In other words, the indirect effects reflect productivity losses in other industry sectors due to a reduction in demand of good in the primary industry sector. Induced effects reflect the impact of disease on expenditures from income that is generated both directly and indirectly, with a reduction in income leading to lower household consumption. Indirect and induced effects reflect the spillover effects. The total productivity losses in terms of paid work are then calculated by combining the direct, indirect, and induced costs.

Besides paid work, also the socioeconomic burden of disease in terms of unpaid work is estimated. Unpaid work does not directly produce goods that are valued on the market, which means that the productive value of unpaid work has to be estimated indirectly. Here it is important to note that the nature of unpaid work is different from paid work in the type of tasks that it encompasses. Examples of such tasks include meal preparation, caretaking of household members, or taking care of the household itself. As such, we assume that there is a difference between the value of unpaid work as compared to paid work in our indirect estimation. Consequently, we value unpaid work by taking the value of an economic activity that most closely resembles the unpaid activity. Details about this adjustment can be found in the Annex.

To further contextualize the SOB of migraine, we additionally calculate the SOB of CVDs and diabetes following the methodology explained above. Lastly, we disaggregate the SOB of migraine by sex to further study the differences in how migraine affects the productive value of paid and unpaid work activity in men and women.

2.2 Data

Various datasets are used as inputs for the variables used in our analysis. To estimate disease burden, YLDs, YLLs, and number of deaths are derived from the GBD database for migraine, CVD, and diabetes mellitus (IHME, 2024) . Specifically, all of them were stratified by country, sex, age group, and year. Age groups are defined by 5-year intervals, from the age of 15 to 94, with the oldest age group being 95+.

For data on paid and unpaid working hours across all six countries, we utilized datasets from the United Nations Department of Economic and Social Affairs (UN Statistics Division, 2024), which compile results from various time use surveys conducted at different periods within each country. We selected data from the most recent survey available for each nation. Our methodology prioritized matching age groups between the GBD database and the country's latest survey. When possible, we extracted paid and unpaid working hours for the "15 years old and over" demographic; otherwise, we selected data from the closest comparable age group. Data was also stratified by gender. The UN database presented gaps for the Czech Republic (missing both paid and unpaid work data) and Portugal (missing paid work data). To address these limitations, we substituted data from comparable countries: Slovenia's working hours were applied to the Czech Republic, while Greece's paid working hours were applied to Portugal, with the assumption that these proxies accurately represented the missing data points. These countries were selected based on similarities in Gross Domestic Product (GDP) levels, comparable population size, and similar labor market characteristics.

Time spent on unpaid work covers the average hours per day spent on unpaid domestic work and care. This average per day is based on the full week, thus averaging out time spent on unpaid work during the week and on the weekend. Total time spent on work covers the time spent on both paid and unpaid work. Again, this data is presented as the average hours per day for the full week, including the weekend.

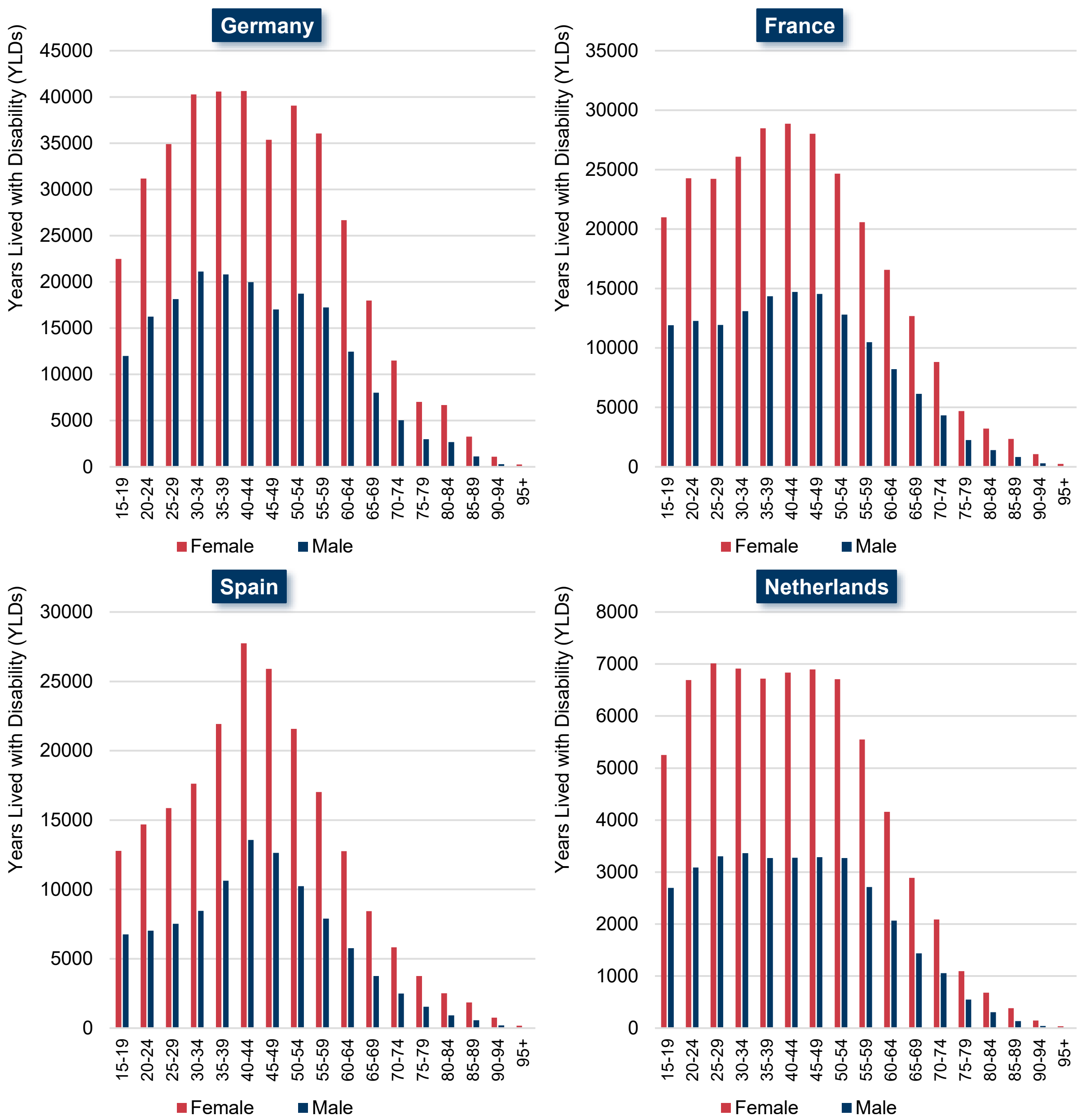
WifOR's methodology goes beyond the traditional paradigm in economic evaluation by addressing productivity losses through a unique blend of value chain effects (Input and Output [IO] analysis) and health economics. It examines how health investments enhance economic development by improving population health. Previous applications and versions of the methodology have been validated in numerous projects, peer review journals publications, conference presentations and books (e.g.; Ostwald *et al.,* 2023); a full list will be provided upon request).
Using Input-Output matrices, we estimate the direct economic effects and calculate spillover effects in adjacent economic sectors and induced effects along value chains (Bess and Ambargis, 2011; Scholz *et al.*, 2025). We start by approximating the potential direct economic benefits that would arise if the currently affected population became healthier and continued working, thereby directly contributing to GVA. Next, we calculate the indirect effects resulting from increased intermediate consumption of goods and services by suppliers in adjacent sectors, driven by the direct GVA generated. Finally, we address the induced effects caused by expenditures from incomes generated both directly and indirectly, leading to further consumption. Spillover effects encompass the sum of indirect and induced effects.

The demographic and economic data for all six countries were derived from the World Bank (World Bank, 2025b). Demographic inputs extracted include population aged 16-64 and 65 and above, disaggregated by gender, and the percentage distribution of male and female population. Economic indicators comprised labour force participation rate, gross value added (in both current and constant 2015 USD), unemployment rate, employment-to-population ratio, and GDP (in both current and constant 2015 USD).
To facilitate cross-country value comparisons, GVA data presented in constant 2015 USD were utilized. Subsequently, all prices were converted to euros using nominal exchange rate data obtained from the European Central Bank data portal (European Central Bank, 2025a).

3 Results

3.1 The socioeconomic burden of migraine

The disease burden of migraine is significant and typically affects younger women. Since migraine has no mortality rate, Figure 1 shows the YLDs per age group in the six countries for the year 2021.



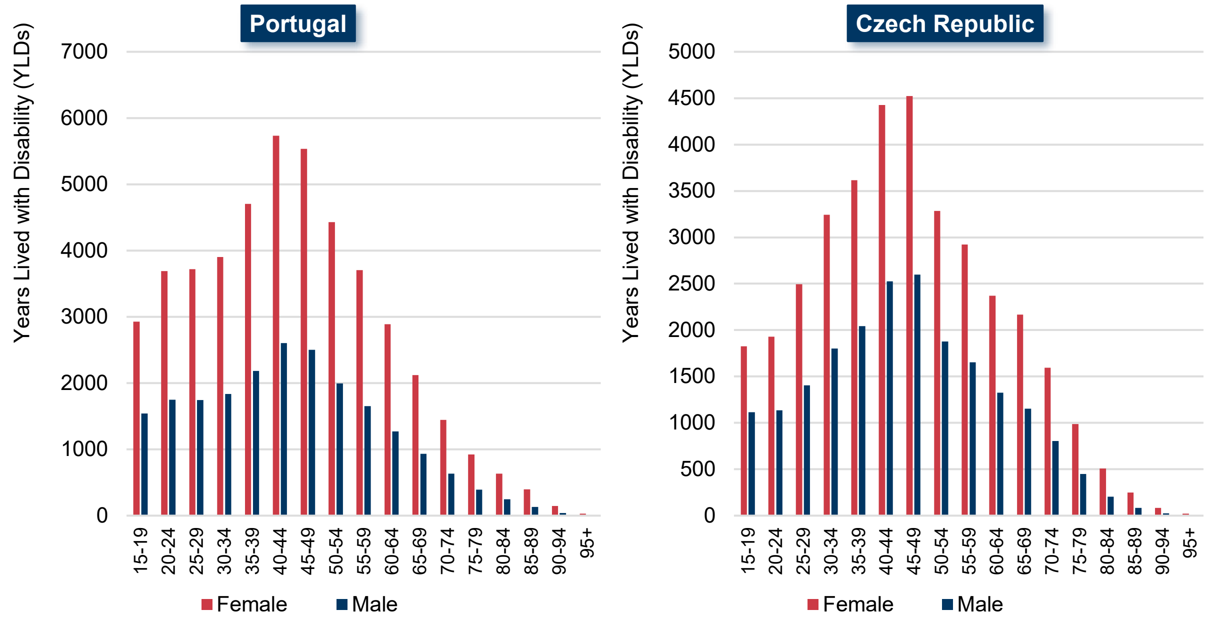


Figure 1. Years lived with disability (YLDs) for Migraine in six European countries

Source: IHME (2024)

Across all countries, the data reveal that the highest disease burden occurs in individuals between 20 and 60 years of age, after which the burden diminishes significantly in older age groups. Furthermore, a consistent pattern emerges wherein females demonstrate a persistently higher disease burden compared to males, with the burden in almost all countries being twice that observed in the male population.

The SOB of migraine is also significant. To contextualize this burden within each national economy, Figure 2 presents the SOB in 2021 as a percentage of each country's GDP, thereby facilitating more meaningful cross-national comparisons.

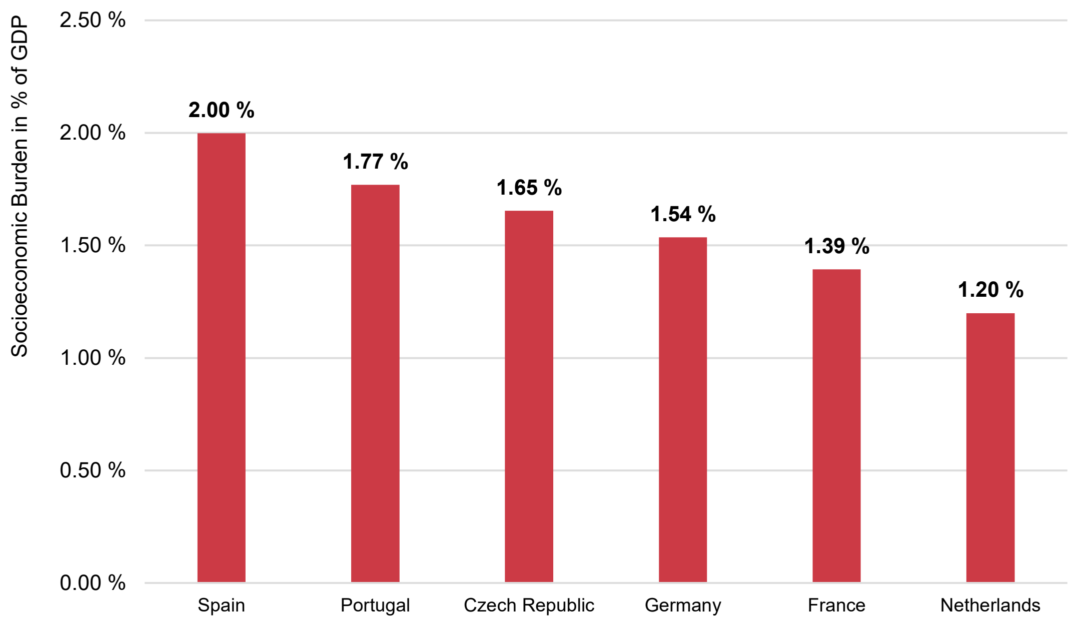


Figure 2. Overall socioeconomic burden of migraine as percentage of the country's GDP in 2021

Source: WifOR elaboration

Within this comparative framework, the total socioeconomic burden expressed as a percentage of GDP ranged from 2.00% to 1.20% across the countries of interest. Spain exhibited the highest proportional burden at 2.00% of

GDP, followed by Portugal (1.77%), the Czech Republic (1.65%), Germany (1.54%), France (1.39%), and the Netherlands (1.20%).

Figure 3 instead, illustrates the overall figures over a 10-year timeframe, culminating with the most recent data from 2021, for both current and adjusted for inflation prices.

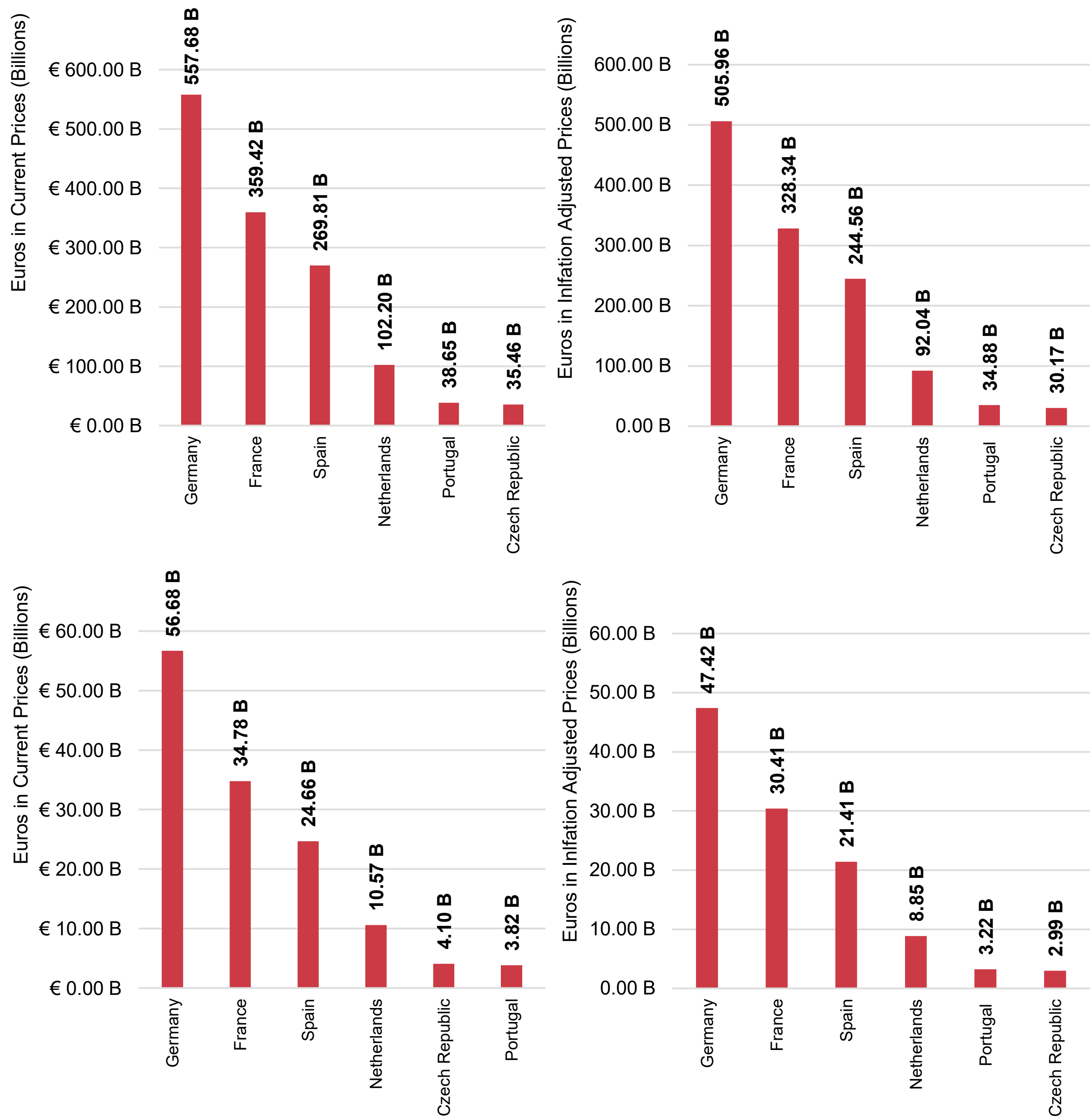


Figure 3. Total socioeconomic burden of migraine between 2011-2021 (upper graphs) and in 2021 (lower graphs) in current and adjusted prices

Source: WifOR elaboration

Analysis of data from 2011 to 2021, encompassing productivity losses from both paid and unpaid work, reveals that these losses ranged from €557 billion in Germany to €35 billion in the Czech Republic, when current prices were considered and from €505 billion in Germany to €30 billion in the Czech Republic if prices were adjusted for inflation. Germany, France, and Spain exhibited the highest productivity losses, followed by the Netherlands, Portugal, and Czech Republic.

In 2021, Germany maintained its position as the country with the highest productivity losses, amounting to €56 billion (€47 billion adjusted), while Portugal recorded the lowest figure at approximately €4 billion if current prices were considered and Czech Republic recorded the lowest figure at approximately €3 billion if prices were adjusted for inflation.

The majority of productivity losses stemmed from paid work activities. Figure 4 illustrates the detailed breakdown of these losses by effects, providing a comprehensive analysis of their distribution.

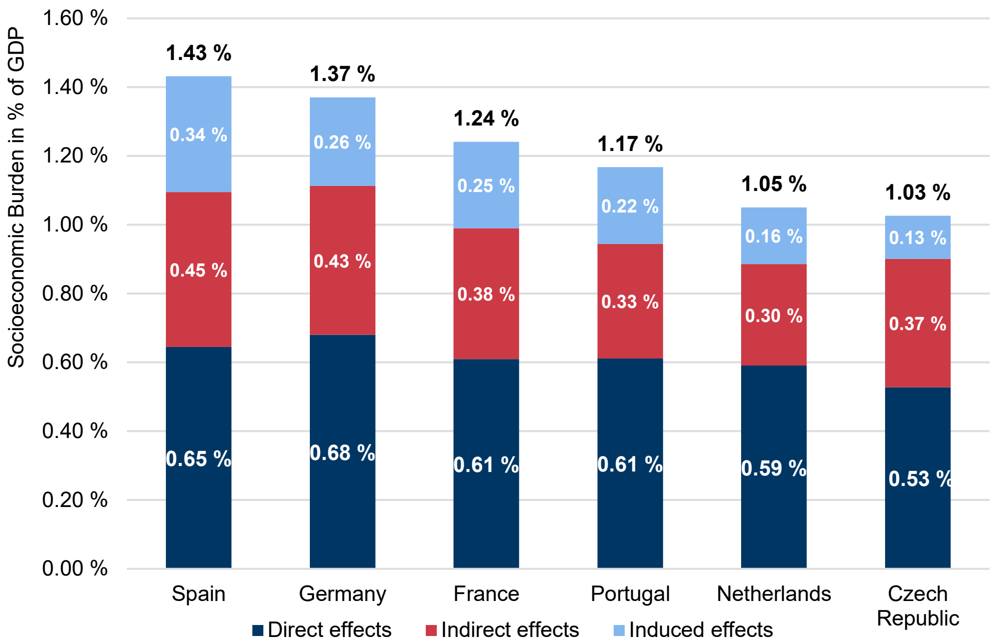


Figure 4. Overall socioeconomic burden of migraine as a percentage of the country's GDP related to paid work activities in 2021: Spillover effects in the six European countries

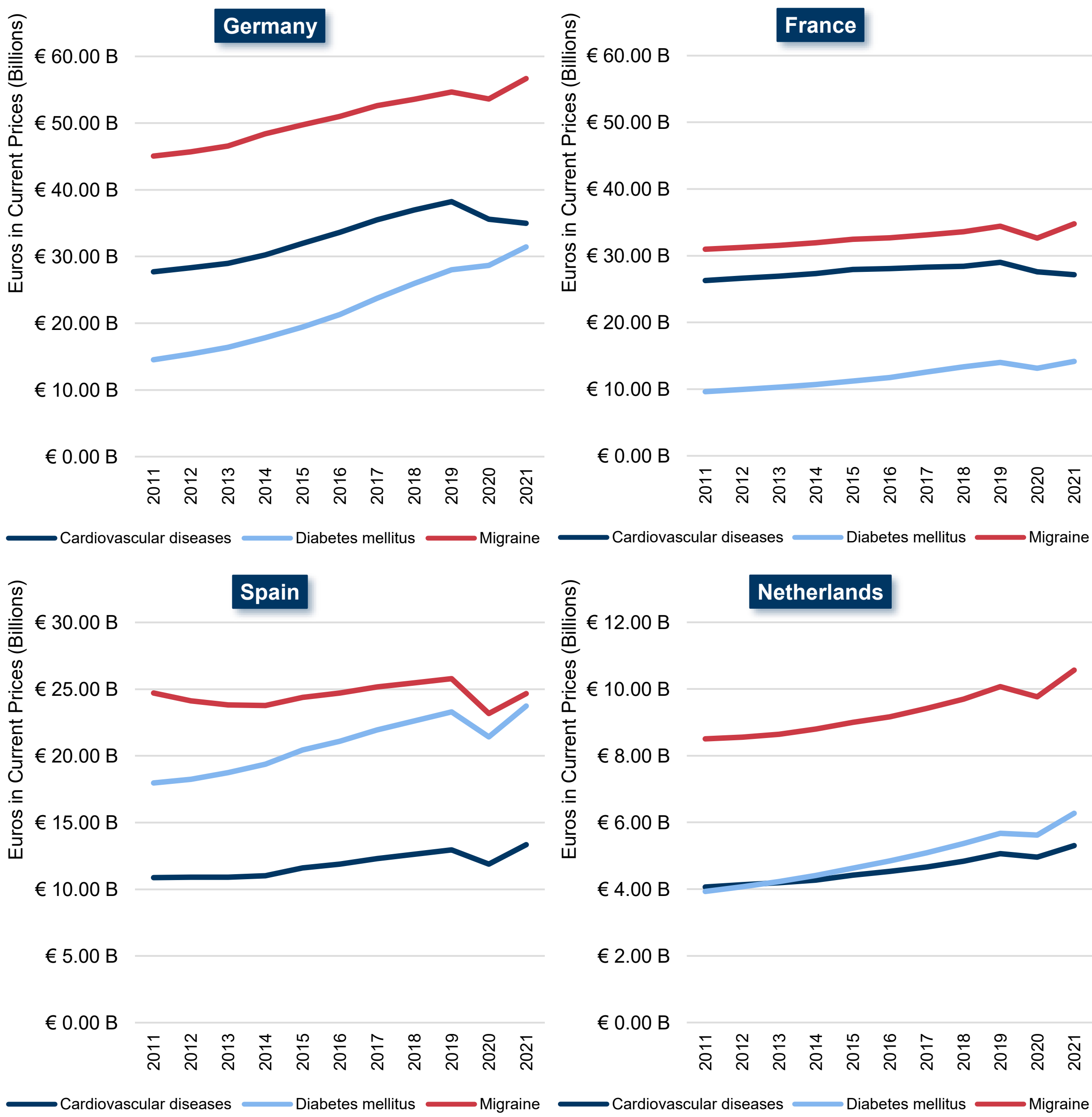
Source: WifOR elaboration

Analysis of paid work productivity losses reveals that direct effects constitute the primary source of economic burden across all countries examined. Germany exhibited the highest proportion of direct effect losses at 0.68% of GDP, followed by Spain (0.65%), Portugal and France (both 0.61%), the Netherlands (0.59%), and the Czech Republic (0.53%). The distribution pattern differs notably when examining indirect effect losses, where Spain demonstrated the largest proportion (0.45%), followed by Germany (0.43%), France (0.38%), Czech Republic (0.37%), Portugal (0.33%), and the Netherlands (0.30%). Regarding induced effect losses, Spain maintained its position as the most affected country (0.34%), followed by Germany (0.26%), France (0.25%), Portugal (0.22%), while the Netherlands recorded 0.16% and the Czech Republic 0.13%. It is important to note that there are no differences in the burden calculated using the FCA and HCA approaches for productivity losses, as migraine does not result in mortality.

To further contextualize those results, the additional working days required by an individual 15 years or older to recover the productivity losses from migraine were calculated.
The analysis revealed that in 2021, each individual over 15 years old in Germany would need to work an additional 1.81 days to compensate for the productivity losses incurred that year. Comparable figures were observed in the Netherlands and Spain, where individuals would need to work 1.74 and 1.77 additional days, respectively. France demonstrated the lowest compensatory requirement at 1.44 additional workdays, while Portugal and the Czech Republic exhibited the highest requirements at 2.08 and 1.98 additional workdays, respectively.

3.2 The socioeconomic burden of migraine compared with diabetes and cardiovascular diseases

A comparative analysis of productivity losses attributable to migraine versus those associated with diabetes and cardiovascular disease provides additional contextual perspective. Figure 5 illustrates temporal trends for these three conditions from 2011 to 2021, utilizing the Friction Cost Approach (FCA), which assumes labor market substitution in cases of premature mortality, or in other words, that the productivity of an employee can be replaced in one year.



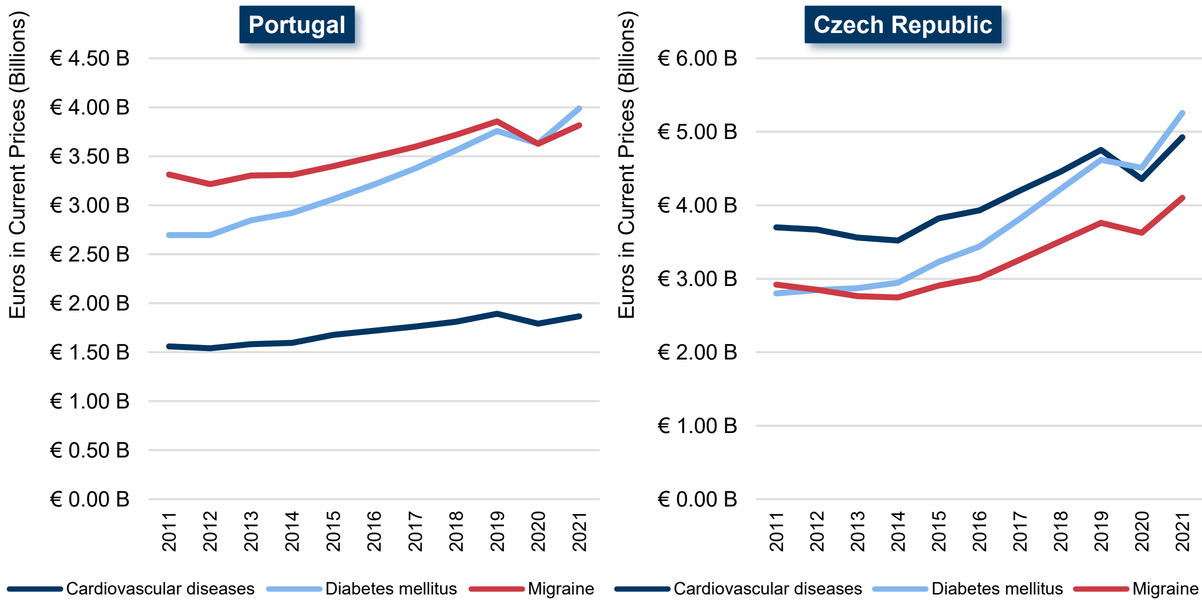


Figure 5. Time trends socioeconomic burden for migraine, cardiovascular disease and diabetes mellitus, FCA Approach – Assuming Substitution

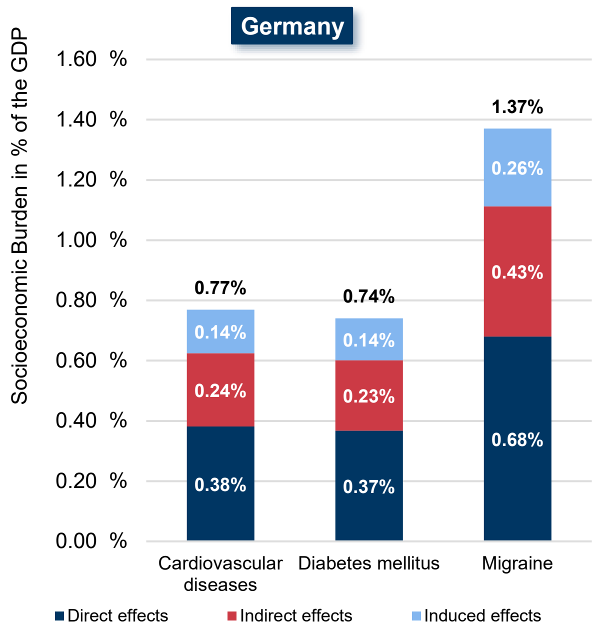
Source: WifOR elaboration

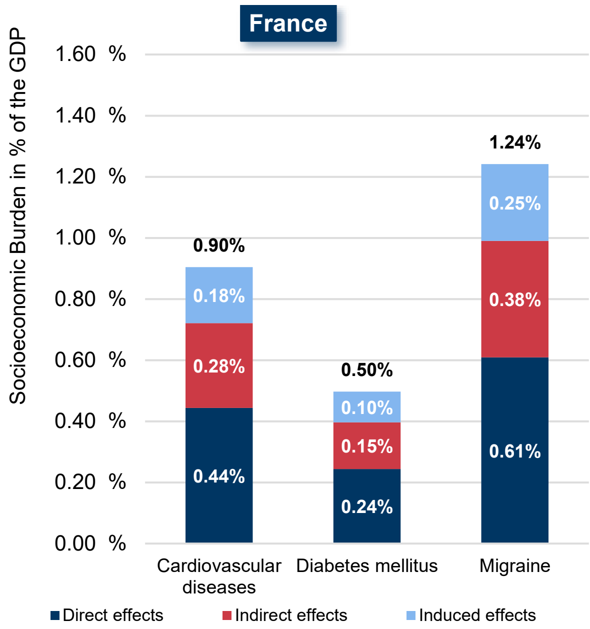
The data demonstrate that across the entire 10-year period, migraine imposed a higher economic burden than both cardiovascular diseases and diabetes mellitus in Germany, France, Spain, and the Netherlands. In Germany and the Netherlands, migraines exhibited a substantially higher burden than the other two conditions. France displayed a different pattern, with cardiovascular disease representing the condition most comparable to migraine in terms of economic impact. Spain presented yet another variation, with diabetes mellitus constituting the second most economically burdensome condition after migraine.

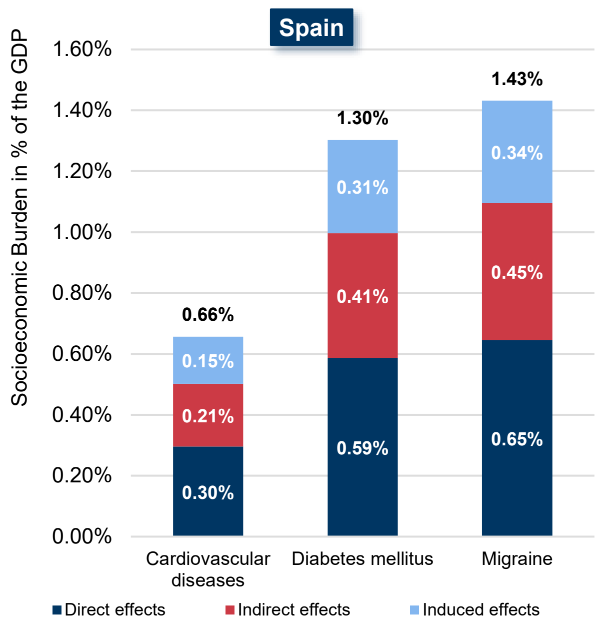
Portugal and the Czech Republic present distinctly different patterns. In Portugal, migraine and diabetes mellitus constitute the disease areas with substantially higher socioeconomic burden compared to cardiovascular disease. Initial data indicate that migraine exhibited a marginally higher socioeconomic impact relative to diabetes mellitus; however, post-2020, the economic burdens converged significantly (€39 billion for diabetes mellitus versus €38 billion for migraine). The Czech Republic demonstrates an alternative pattern, wherein the socioeconomic burdens of all three conditions display remarkable similarity, with migraine on average registering between €0.4 billion and €0.8 billion lower than the other conditions throughout the observed period.

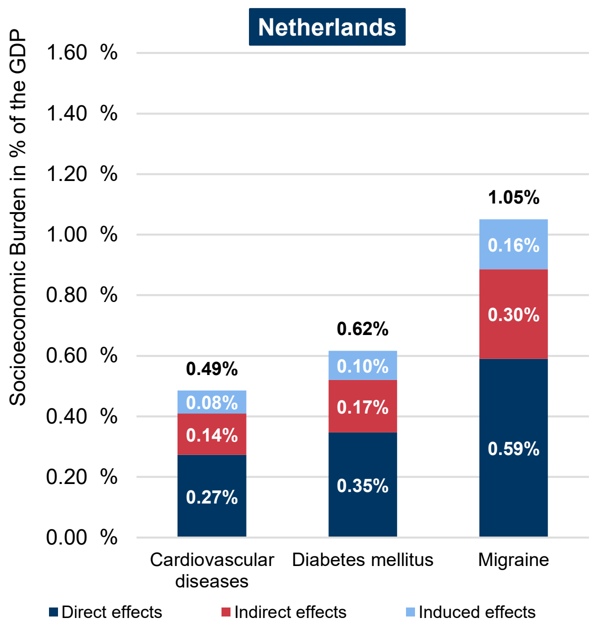
Consistent with the analytical approach applied to migraine burden in general, cross countries and inter-disease comparisons were made, expressing the socioeconomic burden relative to each country's GDP.

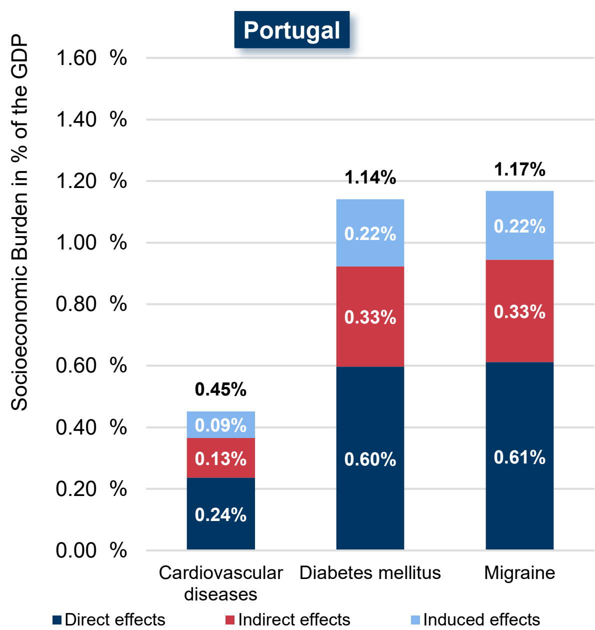
Figure 6A illustrates this proportional analysis specifically for paid work activities, which constitute the predominant source of SOB, while differentiating between direct and spillover effects across the examined conditions.


Germany
Socioeconomic Burden in % of the GDP
1.60 %
1.40 %
1.20 %
1.00 %
0.80 %
0.60 %
0.40 %
0.20 %
0.00 %
0.77%
0.14%
0.24%
0.38%
0.74%
0.14%
0.23%
0.37%
1.37%
0.26%
0.43%
0.68%
Cardiovascular diseases
Diabetes mellitus
Migraine
Direct effects
Indirect effects
Induced effects


France
Socioeconomic Burden in % of the GDP
1.60 %
1.40 %
1.20 %
1.00 %
0.80 %
0.60 %
0.40 %
0.20 %
0.00 %
0.90%
0.18%
0.28%
0.44%
0.50%
0.10%
0.15%
0.24%
1.24%
0.25%
0.38%
0.61%
Cardiovascular diseases
Diabetes mellitus
Migraine
Direct effects
Indirect effects
Induced effects


Spain
Socioeconomic Burden in % of the GDP
1.60%
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
0.66%
0.15%
0.21%
0.30%
1.30%
0.31%
0.41%
0.59%
1.43%
0.34%
0.45%
0.65%
Cardiovascular diseases
Diabetes mellitus
Migraine
Direct effects
Indirect effects
Induced effects


Netherlands
Socioeconomic Burden in % of the GDP
1.60 %
1.40 %
1.20 %
1.00 %
0.80 %
0.60 %
0.40 %
0.20 %
0.00 %
0.49%
0.08%
0.14%
0.27%
0.62%
0.10%
0.17%
0.35%
1.05%
0.16%
0.30%
0.59%
Cardiovascular diseases
Diabetes mellitus
Migraine
Direct effects
Indirect effects
Induced effects


Portugal
Socioeconomic Burden in % of the GDP
1.60 %
1.40 %
1.20 %
1.00 %
0.80 %
0.60 %
0.40 %
0.20 %
0.00 %
0.45%
0.09%
0.13%
0.24%
1.14%
0.22%
0.33%
0.60%
1.17%
0.22%
0.33%
0.61%
Cardiovascular diseases
Diabetes mellitus
Migraine
Direct effects
Indirect effects
Induced effects

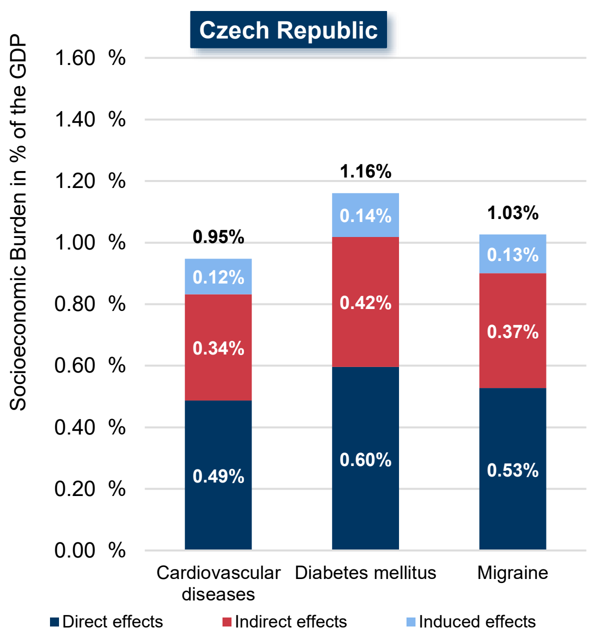
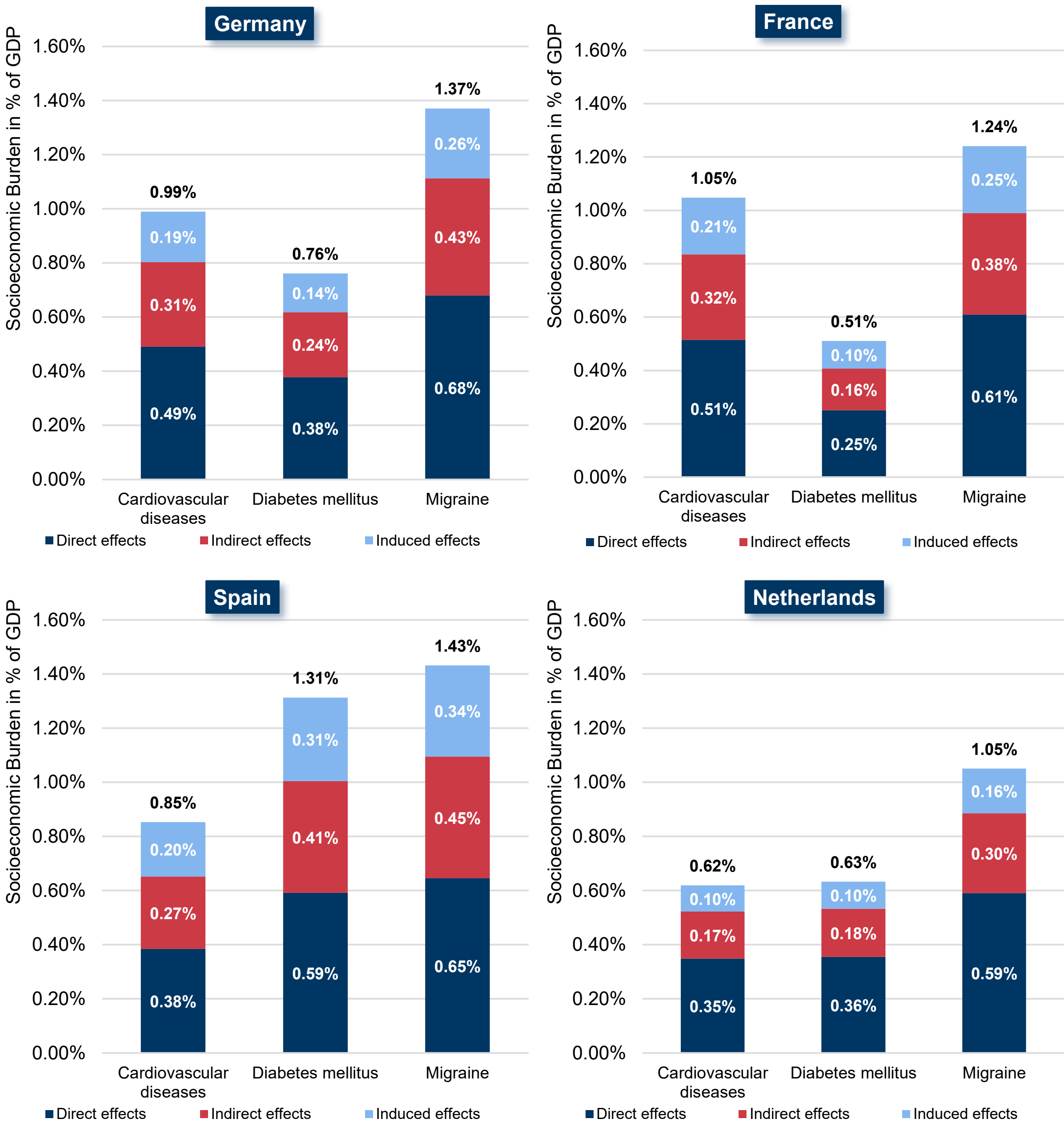

Czech Republic
Socioeconomic Burden in % of the GDP
1.60 %
1.40 %
1.20 %
1.00 %
0.80 %
0.60 %
0.40 %
0.20 %
0.00 %
0.95%
0.12%
0.34%
0.49%
1.16%
0.14%
0.42%
0.60%
1.03%
0.13%
0.37%
0.53%
Cardiovascular diseases
Diabetes mellitus
Migraine
Direct effects
Indirect effects
Induced effects

Figure 6A. Total socioeconomic burden related to paid work activities – 2021, FCA Approach (Assuming Substitution): Spillover effects related to the three disease areas

Source: WifOR elaboration

This proportional analysis further confirms that in Germany, France, Spain, and the Netherlands, migraine imposes a higher economic burden relative to GDP than both CVD and DM when labor market substitution is considered. Direct effects constitute the predominant source of productivity losses across all disease areas in paid work sectors, with migraine consistently registering the highest proportional losses. Czech Republic represents a partial exception, where diabetes mellitus approaches migraine in economic impact, demonstrating only a 0.07% differential. Regarding spillover effects (both indirect and induced), similar patterns emerge, with migraine accounting for the greatest proportional losses. Portugal exhibits a distinct pattern wherein diabetes mellitus and migraine generated identical proportional losses across all effect categories in 2021. The Czech Republic presents yet another variation, with nearly equivalent losses across all three disease areas, though diabetes mellitus demonstrates marginally higher overall impact.

Figure 6B presents results utilizing the Human Capital Approach (HCA), which assumes no labor market substitution and thus accounts for complete productivity loss if premature death occurs.



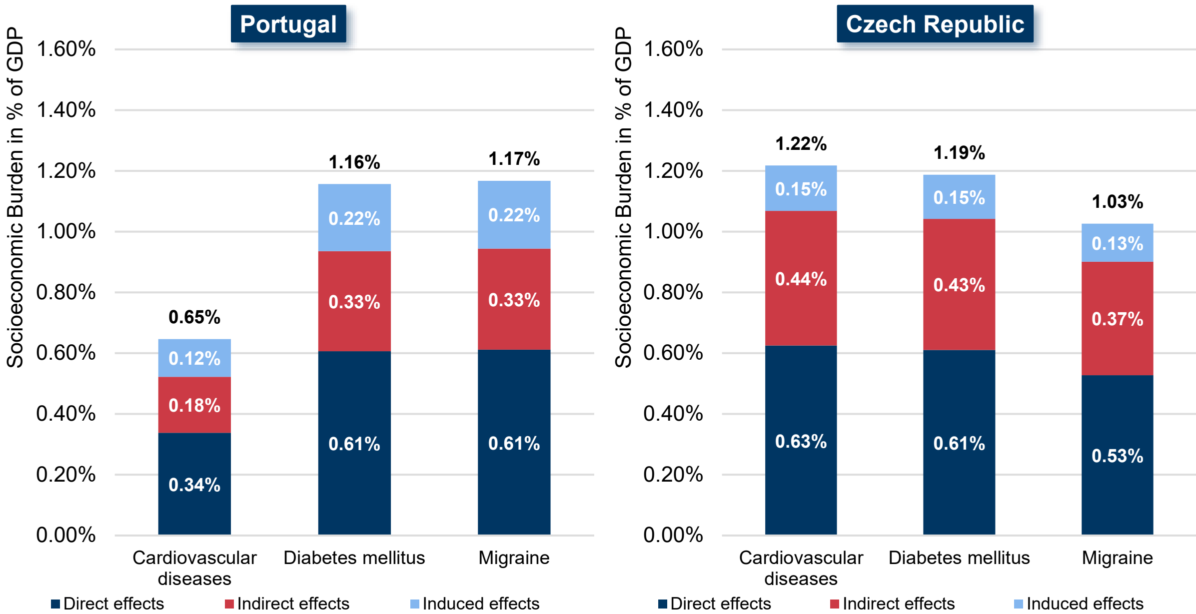
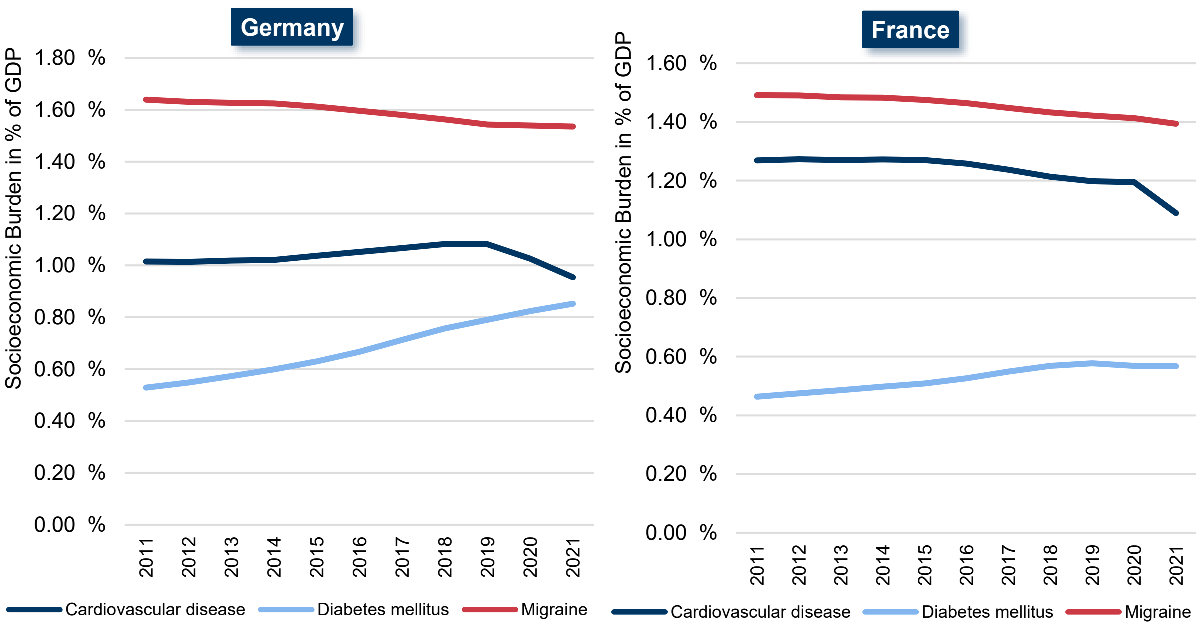


Figure 6B. Total socioeconomic burden related to paid work activities – 2021, HCA Approach (Assuming no substitution): Spillover effects related to the three disease areas

Source: WifOR elaboration

Under the HCA, migraine consistently maintains its position as the condition generating the highest SOB in Germany, Spain, France, and the Netherlands, although both CVD and DM demonstrate increased productivity losses across all effect categories. Direct effects remain the predominant source of productivity losses; however, a notable shift occurs wherein DM and particularly CVD exhibit substantially higher proportional burden compared to the FCA scenario. This divergence is primarily attributable to the HCA approach accounting for the complete, non-replaceable productivity losses associated with premature mortality. Portugal's relative SOB distribution remains largely consistent between methodological approaches, whereas the Czech Republic exhibits a significant reordering, with CVD assuming the position of highest economic impact.

Figure 7 illustrates the SOB of migraine, diabetes mellitus, and cardiovascular disease across selected countries for the period 2011-2021. These socioeconomic burden estimates relative to the GDP were calculated using the conservative Friction Cost Approach (FCA).



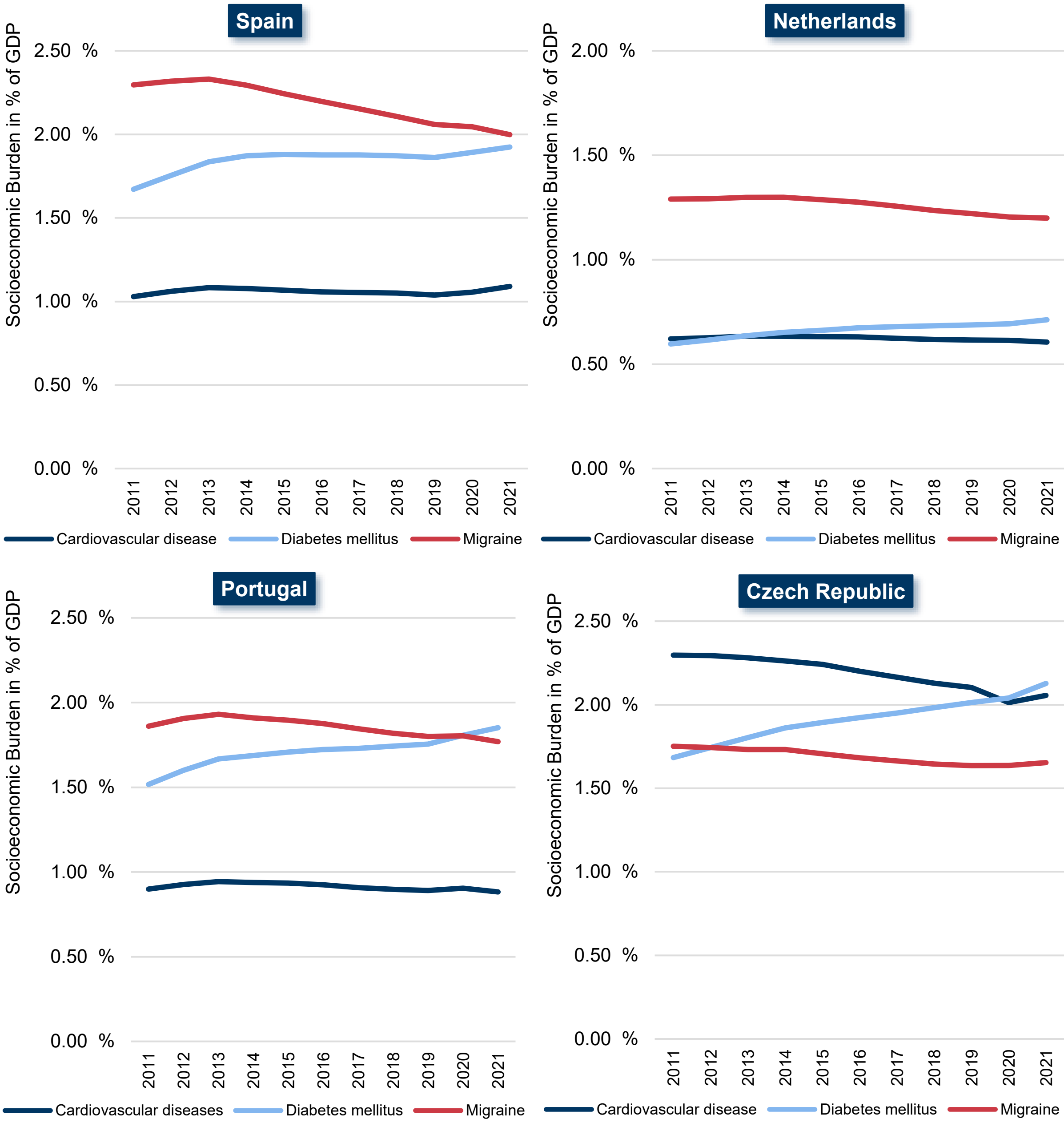


Figure 7. Time trends socioeconomic burden in percentage of the country's GDP for migraine, cardiovascular disease, and diabetes mellitus, FCA Approach – Assuming Substitution

Source: WifOR elaboration

The data demonstrate that the socioeconomic burden of migraine maintained remarkable stability throughout the decade-long observation period. Among the countries analyzed, Spain exhibited the most substantial proportional change, with its burden decreasing from 2.30% to 2.00% of GDP over the studied timeframe.

3.3 Gender specific differences in the socioeconomic burden of migraine

As illustrated in Figure 1, the burden of migraine disproportionately affects younger female populations. Figure 8A further corroborates that females account for the majority of the socioeconomic burden associated with migraine. The graph depicts productivity losses in absolute monetary terms (euros) from 2011 to 2021. Solid bars represent productivity losses in paid work sectors, whereas faded bars indicate productivity losses in unpaid work domains. Across all countries examined, females experienced approximately twice the productivity losses of males due to migraine, with this disparity reaching nearly threefold in Spain (2.78) and more than threefold in Portugal (3.15). Particularly noteworthy is the pronounced differential in productivity losses related to unpaid work. This disparity stems not only from the elevated disease burden among females but also from the inequitable distribution of unpaid labor (reference Table 1 in the annex for gender-based disparities in average weekly hours allocated to paid and unpaid work by country). Females experienced between 4 and 9 times greater productivity losses from unpaid work compared to males, with female-specific losses ranging from €11 billion to €69 billion. Regarding productivity losses in paid work sectors, females experienced between 1.7 and 2 times greater losses than males. Figure 8B illustrates the socioeconomic burden expressed as a percentage of GDP, providing further contextualization of these productivity losses across the six European countries in 2021. The gender disparity remains evident, with females experiencing substantially higher proportional losses ranging from 0.84% to 1.47% of national GDP, compared to male-specific losses ranging from 0.36% to 0.53% of national GDP.

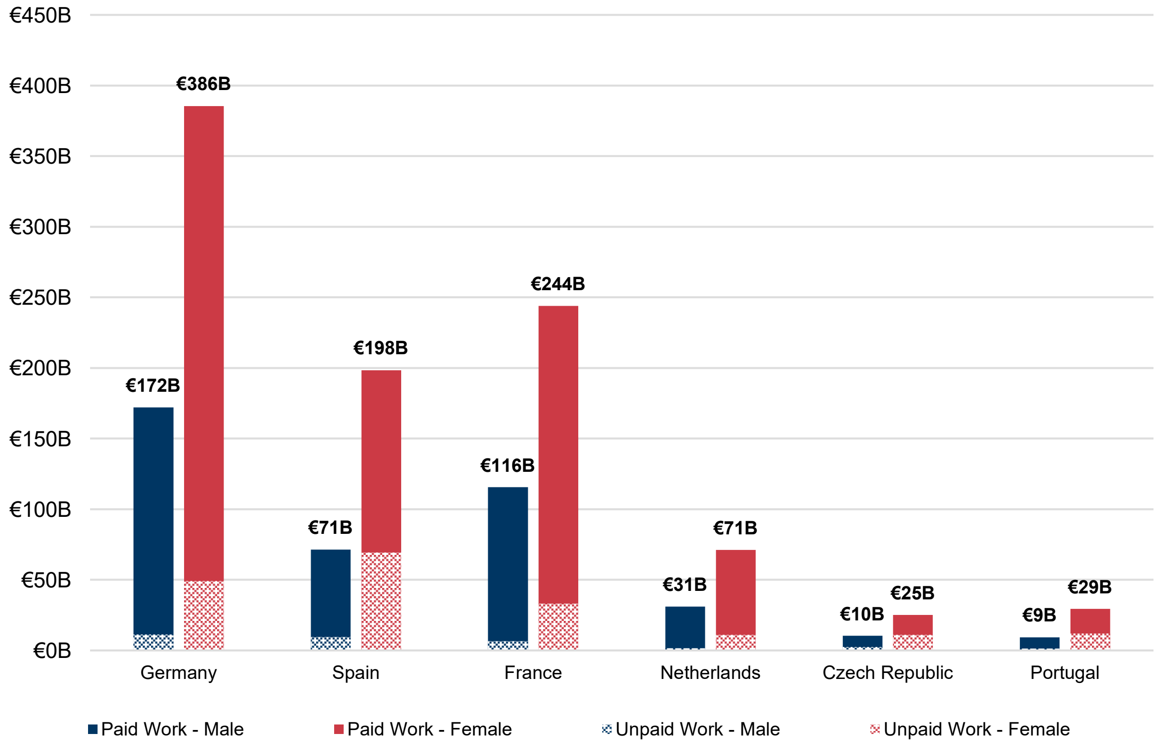


Figure 8A. Comparison of socioeconomic burden in terms of paid and unpaid work between men and women presenting the total figures (2011-2021)

Source: WifOR elaboration

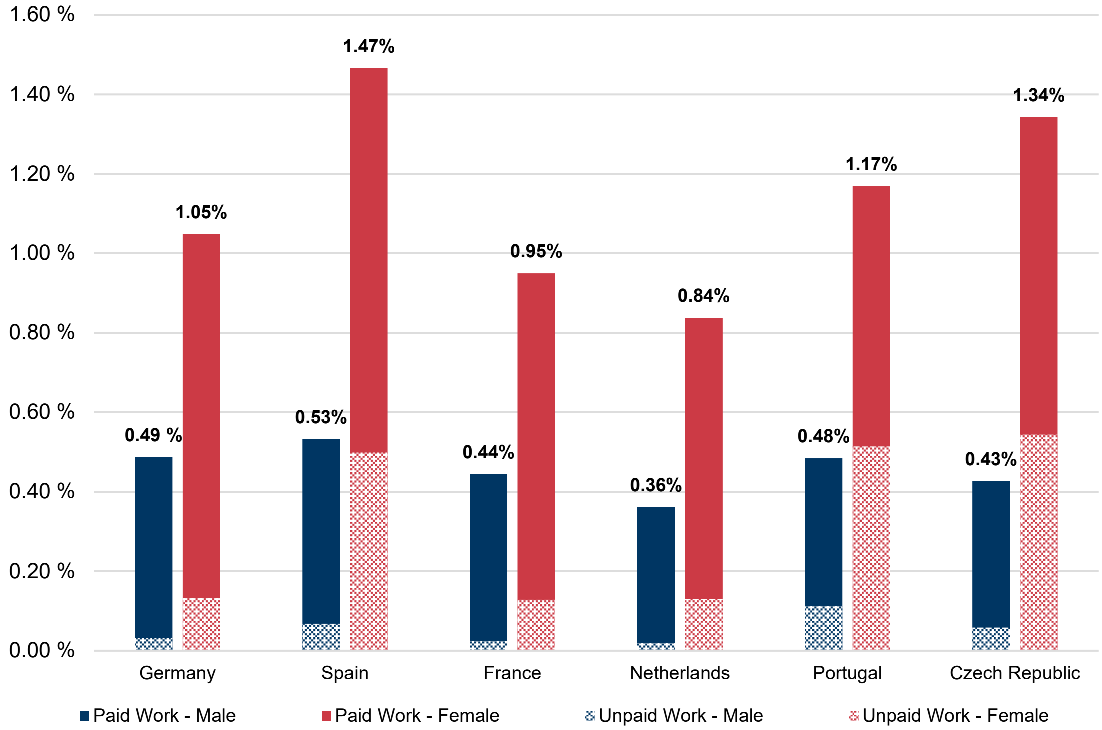
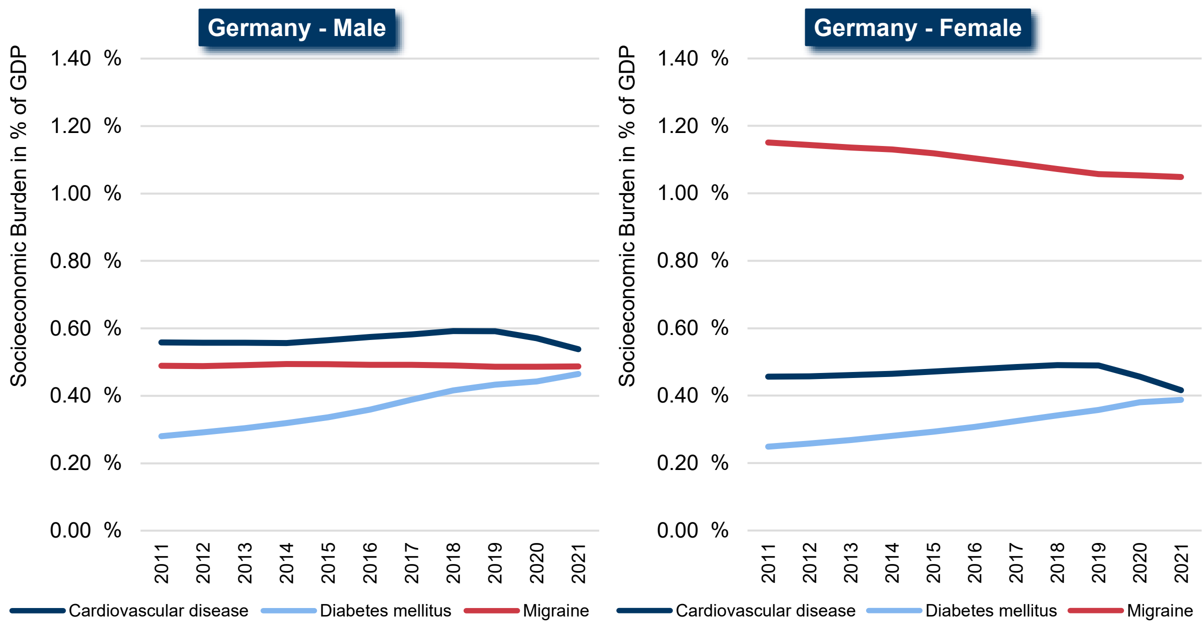
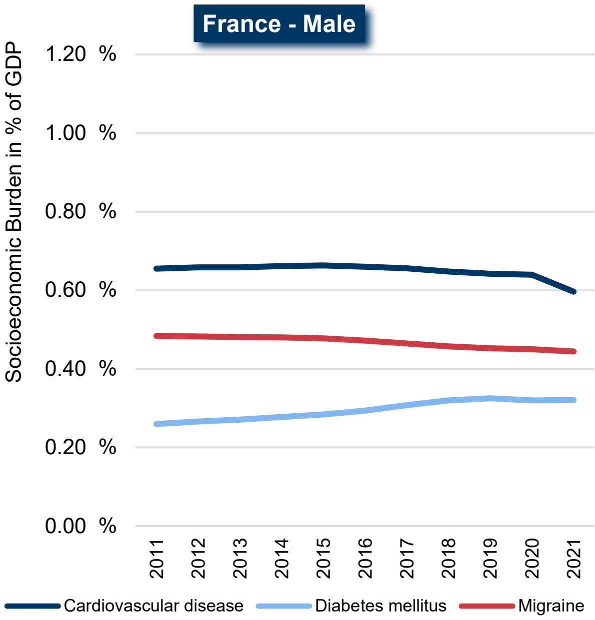


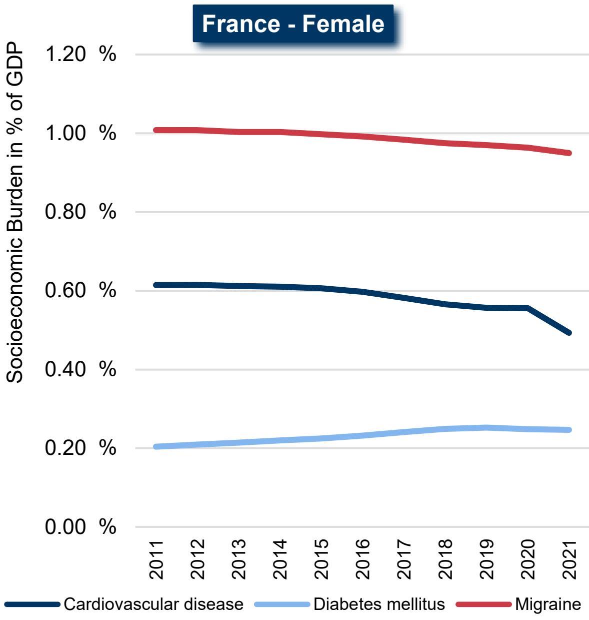
Figure 8B. Comparison of socioeconomic burden between men and women presenting the socioeconomic burden in % of the country's GDP in 2021.

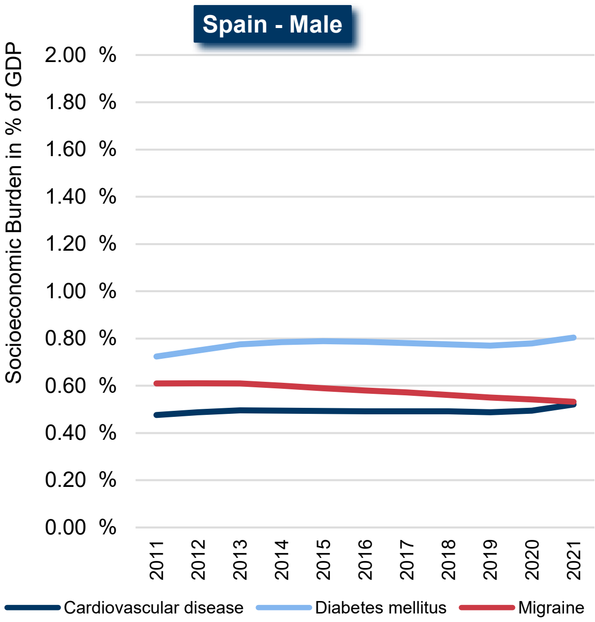
Source: WifOR elaboration

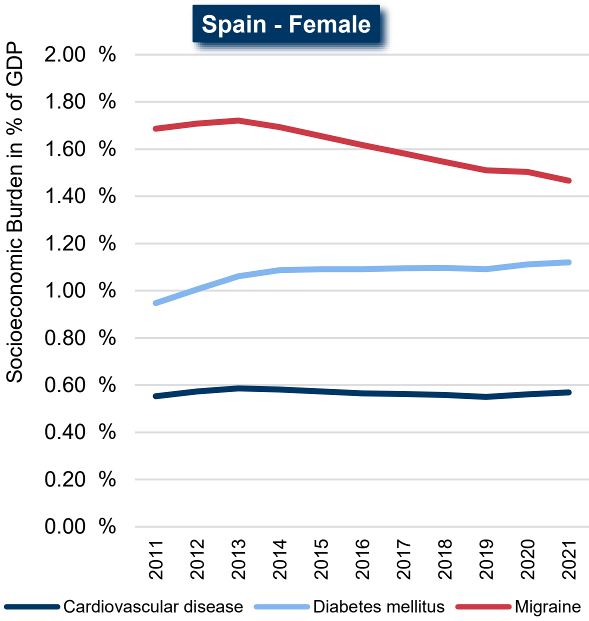
A final comparative analysis can be conducted by examining gender-specific variations in migraine impact relative to other diseases. Figure 9 illustrates this relationship by depicting the socioeconomic burden over time expressed as a percentage of GDP across different conditions, stratified by gender.




France - Male
Socioeconomic Burden in % of GDP
1.20 %
1.00 %
0.80 %
0.60 %
0.40 %
0.20 %
0.00 %
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
Cardiovascular disease
Diabetes mellitus
Migraine


France - Female
Socioeconomic Burden in % of GDP
1.20 %
1.00 %
0.80 %
0.60 %
0.40 %
0.20 %
0.00 %
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
Cardiovascular disease
Diabetes mellitus
Migraine


Spain - Male
Socioeconomic Burden in % of GDP
2.00 %
1.80 %
1.60 %
1.40 %
1.20 %
1.00 %
0.80 %
0.60 %
0.40 %
0.20 %
0.00 %
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
Cardiovascular disease
Diabetes mellitus
Migraine


Spain - Female
Socioeconomic Burden in % of GDP
2.00 %
1.80 %
1.60 %
1.40 %
1.20 %
1.00 %
0.80 %
0.60 %
0.40 %
0.20 %
0.00 %
2011
2012
2013
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2016
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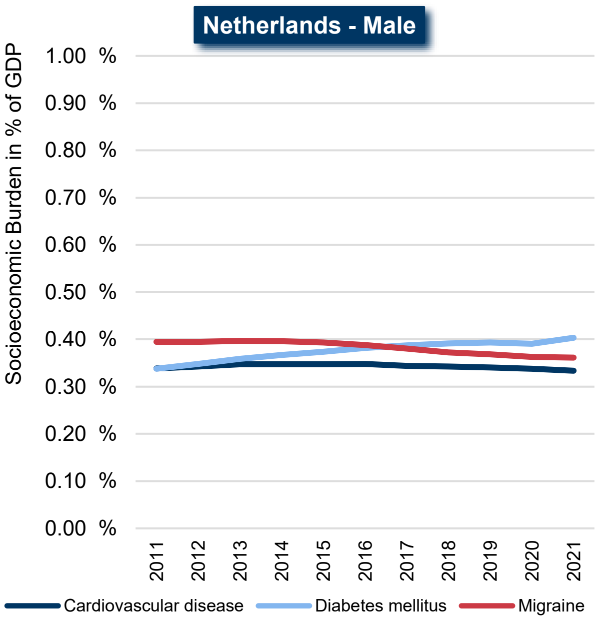
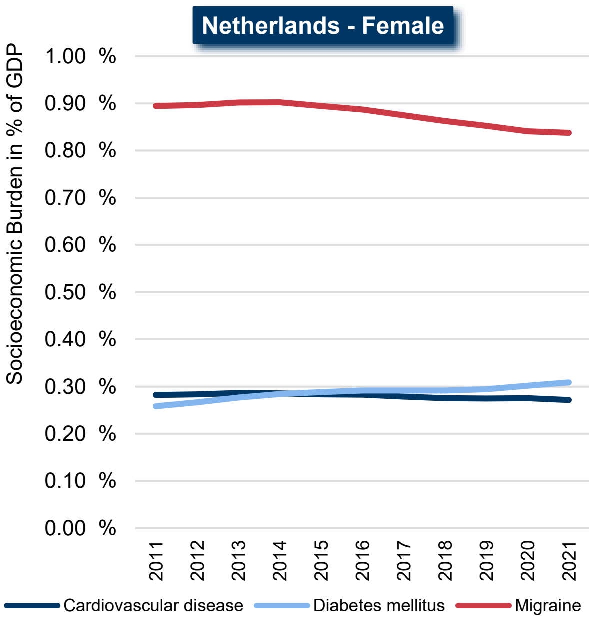
2019
2020
2021
Cardiovascular disease
Diabetes mellitus
Migraine


Netherlands - Male
Socioeconomic Burden in % of GDP
1.00 %
0.90 %
0.80 %
0.70 %
0.60 %
0.50 %
0.40 %
0.30 %
0.20 %
0.10 %
0.00 %
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
Cardiovascular disease
Diabetes mellitus
Migraine


Netherlands - Female
Socioeconomic Burden in % of GDP
1.00 %
0.90 %
0.80 %
0.70 %
0.60 %
0.50 %
0.40 %
0.30 %
0.20 %
0.10 %
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2011
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Cardiovascular disease
Diabetes mellitus
Migraine

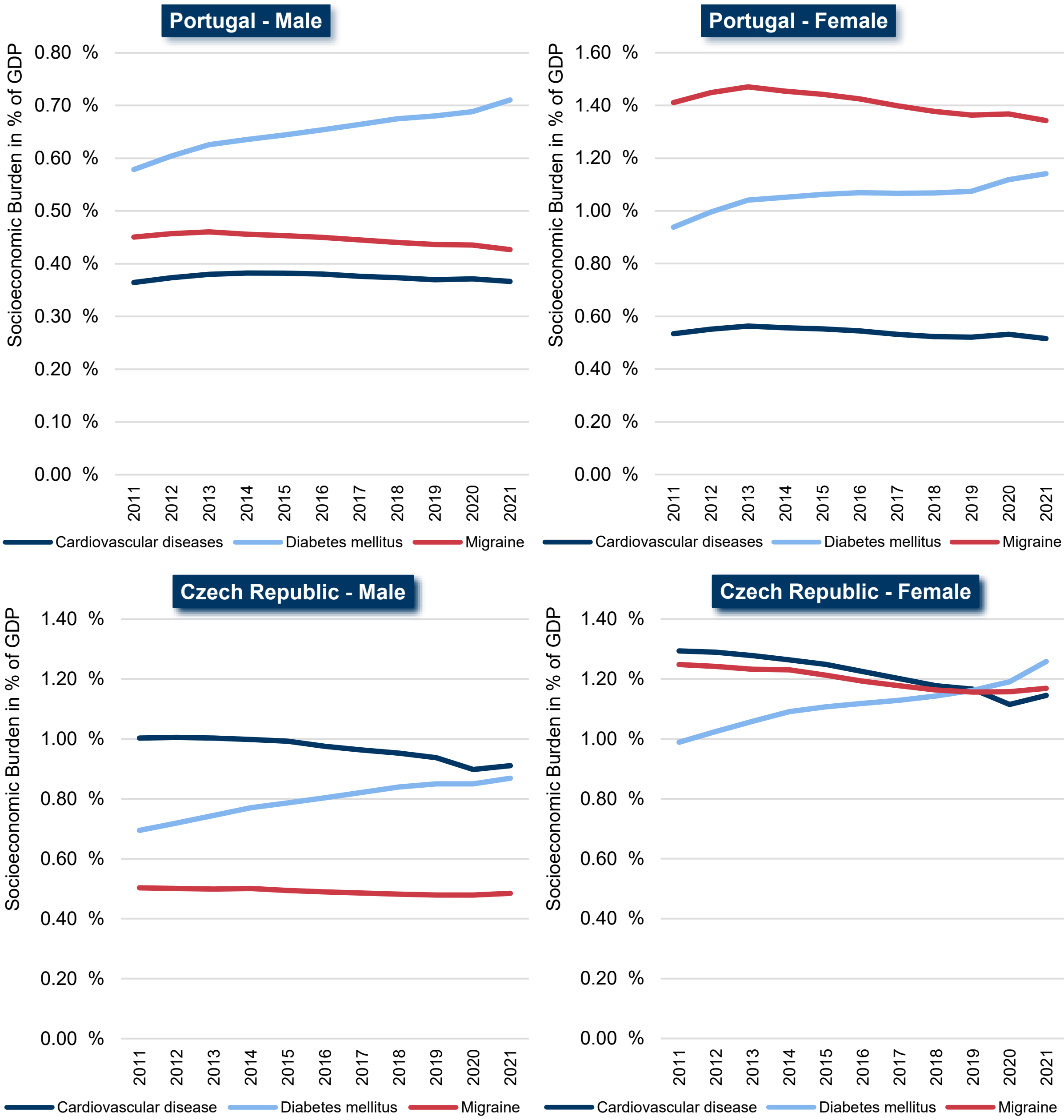

Figure 9. Time trends socioeconomic burden in percentage of the country's GDP for migraine, cardiovascular disease, and diabetes mellitus, country and gender specific using the FCA Approach – Assuming Substitution

Source: WifOR elaboration

Across nearly all examined countries, migraine demonstrates a significantly higher socioeconomic burden in females than in males, a gender disparity that exceeds the male-female differential observed in both cardiovascular disease and diabetes mellitus. The Czech Republic represents a notable exception, where all three disease categories demonstrate comparable burden among females, ultimately converging to nearly equivalent economic impact by 2021. Conversely, in male populations, either cardiovascular disease or diabetes mellitus consistently registers as the condition generating the highest socioeconomic burden, with migraine typically representing the second most impactful condition.

4 Discussion

The SOB imposed by migraine represents a substantial economic impact across the six European economies examined. Throughout the decade spanning 2011-2021, this cumulative burden ranged from €557 billion in Germany to €35 billion in the Czech Republic, for the current prices, and from €505 billion in Germany to €30 billion in the Czech Republic if prices were adjusted for inflation. Among the countries analyzed, Germany, France, and Spain experienced the highest absolute monetary losses. However, when expressed as a proportion of national GDP, a different pattern emerges. Spain registered the highest relative burden at 2.00% of GDP, followed by Portugal (1.77%) and the Czech Republic (1.65%) in 2021. This analysis demonstrates that despite experiencing lower absolute monetary losses, countries such as Portugal and the Czech Republic face significant economic challenges from migraine relative to their overall economic capacity.

A comparative analysis of the SOB of migraine relative to diabetes mellitus and cardiovascular diseases provides further contextual perspective on these findings. Across the majority of countries examined, migraine consistently demonstrated the highest overall economic burden compared to the other disease categories. Notable exceptions include the Czech Republic, where all three disease areas exhibited nearly equivalent economic impact, and Portugal, where both migraine and diabetes mellitus imposed similarly substantial burdens on the national economy.

Also retrospectively, the SOB of migraine maintained remarkable stability throughout the decade-long observation period across nearly all countries examined. When expressed as a percentage of GDP, most countries demonstrated consistent burden levels over time. Spain represents the sole exception, exhibiting a modest decline from 2.32% to 2.00%. While this reduction appears relatively minor in absolute terms, it potentially correlates with Spain's documented labor force contraction between 2013 and 2018 (World Bank, 2025a).

Analysis of gender-disaggregated data reveals that females experienced a disproportionately elevated disease burden, which consequently translated into significantly higher socioeconomic burden compared to males. This disparity resulted in females experiencing approximately twice the productivity losses of males due to migraine, with this ratio approaching threefold in countries such as Portugal and Spain. This substantial gender disparity stems from, apart the burden and prevalence of the disease itself, two principal determinants: the predominance of productivity losses occurring in the unpaid work domain, and the persistent gender-based asymmetry in unpaid labor allocation, wherein females disproportionately shoulder domestic and caregiving responsibilities. Consequently, females experienced between 4 and 9 times higher productivity losses from unpaid work relative to males. Even in paid work, females demonstrated higher economic losses, ranging from 1.7 to 2 times greater than their male counterparts. In aggregate terms, female-specific losses ranged from 0.84% to 1.47% of national GDP across the countries examined. Additionally, unpaid work, which is primarily conducted by women, also includes care taking (Gerth *et al.*, 2001). Considering that women are particularly affected by migraine, this could result in problems in care taking in the future as well, where other paid or unpaid work activities are neglected. Furthermore, this could result in additional pressure on the national budgets, if individuals do not get the care they need that is provided through informal unpaid work.

Several methodological limitations warrant acknowledgment. The economic and demographic parameters utilized in this analysis, including multipliers for direct, indirect, and induced effects, derive from aggregated databases, which inherently lack granularity regarding occupational and sectoral distributions of disease prevalence. For instance, the typical migraine patient—predominantly younger and female—likely occupies different industrial sectors than individuals with cardiovascular disease, who tend to be older and male. Future research should investigate how these demographic-occupational intersections modulate the economic ripple effects of specific diseases across diverse industrial sectors.

Furthermore, limitations existed regarding data availability for paid and unpaid work hours, which were sourced from the United Nations statistical database. Specifically, no relevant data were available for the Czech Republic, while Portugal's dataset contained only information on average hours allocated to unpaid domestic and care work. To address these gaps, proxy data were implemented: Slovenia's work patterns were applied to the Czech Republic, and Greece's total work hour distribution was utilized to estimate paid work hours in Portugal. These methodological decisions necessitated assumptions regarding comparable productivity levels, wage structures, and household employment characteristics between the selected and target countries. It is important to acknowledge that significant differences may exist between these nations, both in terms of labor market structures and the methodological approaches employed in their respective time-use surveys.

Additionally, this analysis does not account for the economic impact of informal caregiving necessitated by these conditions. Informal caregiving refers to unpaid care provided by family members, friends, or community members to individuals with chronic conditions, disabilities, or age-related health needs, often involving assistance with daily activities, medical management, and emotional support. This care typically falls disproportionately on women and can lead to reduced work hours, career interruptions, or complete workforce exit, creating substantial hidden economic costs. The relationship between disease burden, caregiving responsibilities, and subsequent labor market participation represents an important avenue for future investigation.

Regarding the Global Burden of Disease (GBD) methodology, it is essential to recognize its reliance on country-reported data. Despite employing sophisticated statistical techniques to address potential inconsistencies, residual reporting variations may persist, potentially affecting the robustness of cross-national comparisons of disease burden.

To conclude, migraines significantly affect both paid and unpaid work productivity in all 6 European countries. This SOB is most prevalent among individuals in their most productive years. Women, in particular, are disproportionately impacted, with gender disparities in unpaid work responsibilities further amplifying losses in unpaid work productivity. Addressing the burden of migraines could not only boost economic activity but also help reduce strain on government budgets.

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Annex

4.1 Methodology

This section will provide a more detailed overview of the methodology that is used in this report. Table 2 at the end of this annex provides an overview of the indicators that are used, how and where they can be identified, and how they are called throughout this manuscript (also include time use survey info here).

4.1.1 Overview of key assumption

For the analysis that is reported in this study, various methodological assumptions had to be made due to data availability and to facilitate the conduct of this study. The first key assumption is related to the use of YLD to estimate productivity losses. Here, it should be noted that DALY equals the loss of one year in full health. The loss of one year in full health is translated into a loss of one year of average working capability for both paid and unpaid work activities. With respect to YLDs, this means that any DALYs lost due to YLDs are assumed to result into a loss of one year of average working capability.

The second key assumption is that YLLs and YLDs are having the same effect on productivity. With respect to YLLs, it is possible that particularly in light of the FCA there are differences between countries in the speed to which workers can be replaced. Similarly, also with respect to YLDs, it is possible that there are national differences in how disease affects the productivity of workers, due to difference in presenteeism and absenteeism patterns.

The third key assumption is that the prevalence as reported by the IHME is a good reflection of the national disease prevalence estimates. Of course, on a national level, many methodologies exist to estimate the prevalence of disease. This could mean that there are deviations between national estimates and estimates by the IHME. We opted to use the IHME due to the benefits of using a uniform methodology to estimate prevalence in various countries, which directly results in the possibility to make cross country comparisons of the socioeconomic burden of disease.

4.1.2 Inputs regarding burden of disease

Data from the GBD study was used to evaluate the SOB of migraine, cardiovascular diseases, and diabetes. Specifically, the analysis utilized disease burden data, in terms of mortality and YLD, categorized by 5-year age groups (ranging from 15 to 95+ years), gender (male, female, and combined), and country. This data covered the period from 2012 to 2022.

4.1.3 Economic inputs

The comprehensive assessment of the economic effects of disease in terms of direct and spillover effects is based on Input-Output (IO) modelling (Conway, 2022). The essential underlying principle of IO models is that the economy consists of interconnected economic sectors. This means that an increase in production in one sector leads to an increased demand in (intermediate) inputs, the production of which results in additional productivity in other sectors.

To calculate these effects, we utilized an established algorithm from WifOR, which used WIOD (*World Input-Output Database*, 2016) and EORA (*Eora Global MRIO*, 2024) databases. Essentially, for each country, a specific Leontief inverse of the IO matrix is calculated (Leontief, 1986). This represents how change in a unit of output in one sector results in changes in output of all the other industrial sectors of a country. Through the introduction of quotes of each sector that represent the gross value added and the employment needed for a unit of output in each sector, we estimate the indirect effect of how adjacent sectors affect each other's creation of value and the contribution of employment. Additionally, through incorporating household consumption in the Leontief inverse, we account for how changes in productivity of a sector result in changes in demand by households, which leads to an estimation of the induced effects of changes in the productivity of a country.

The analysis is conducted per country, which means that any international effects are not accounted for. Industrial sectors are defined according to the NACE Rev.2 classification (Eurostat, 2008).

For each country, the following multipliers from IO analysis are derived and used to calculate direct, indirect, and induced effects.

- Direct multiplier per revenue increase (hereafter DirMult.Rev): this multiplier reflects the increase in GVA by each sector, for every additional 1 million USD in revenue (i.e. gross output, total value of sales, production value).
- Indirect multiplier per revenue increase (hereafter IndirMult.Rev): this multiplier reflects the effect of an increase in 1 million USD sector revenue on GVA.
- Induced multiplier per revenue increase (hereafter InducMult.Rev): this multiplier reflects the effect increased expenditures due to increases in directly or indirectly generated income due to an increase in 1 million USD sector revenue on GVA.
- GVA per economic sector (million USD) (hereafter GVA.PSector): this is an estimation of GVA generated per economic sector, that is based on the IO matrices of a country.
- Employees per economic sector (million of people) (hereafter EMP.PSector): an estimation of the number of employees per economic sector, based on IO matrices of a country.

4.1.4 GVA effects from paid work

Understanding how disease burden impacts individual productivity requires estimating the GVA generated per person. In the case of paid work, this is further narrowed down as the GVA generated by an employed person. The World Bank defines an employed person as "persons of working age who, during a short reference period, were engaged in any activity to produce goods or provide services for pay or profit, whether at work during the reference period (i.e., who worked in a job for at least one hour) or not at work due to temporary absence from a job, or to working-time arrangements" (World Bank, 2024a).

In order to study the impact of disease on the GVA of paid work, three different effects are assessed:

- Direct effects: these effects reflect the immediate impact of a decrease in paid work due to disease.
- Indirect effects: these effects reflect the decrease in GVA due to a decrease in intermediate consumption.
- Induced effects: these effects reflect the decrease in GVA due to a decrease in expenditures by households.

The three multipliers introduced in the previous section (DirMult.Rev, InderMult. Rev and InducMult.Rev) are needed to evaluate these three different effects from paid work (direct, indirect and induced effects), as well as the estimation for the GVA per economic sector (GVA.PSector).

Direct effects:

To estimate direct effects, a monetization of the average GVA per employee is calculated. For each country (c) and year (t), this is estimated by dividing the total GVA of a country (GVA.2015Pr) by the number of employed individuals in a population aged 15 years or older (Employees.15m), with the following equation:

$$DirectEffect.PerEmployee_{c,t} = GVA.2015Pr.PerEmployee_{c,t} = \frac{GVA.2015Pr_{c,t}}{Employees.15m_{c,t}}$$

Indirect effects:

To estimate indirect effects, we account for the interconnections between economic sectors. The indirect effect of disease therefore assesses the losses in productivity that are a consequence of a loss of demand for intermediate goods and services. Here, we again estimate indirect effects in terms of GVA per person. To do so, the input IndirMult.Rev (indirect multiplier per revenue increase) is transformed into IndirMult.GVA (indirect multiplier per GVA increase), by making use of the input DirMult.Rev (direct multiplier per revenue increase). For this, the following formula is used for each country (c) and economic sector (s):

$$IndirMult.GVA_{c,s} = \frac{IndirMult.Rev_{c,s} - DirMult.Rev_{c,s}}{DirMult.Rev_{c,s}}$$

To comprehensively capture the indirect multiplicative effects across all sectors, we applied the indirect total economy-wide average multiplier (TAv.MultIndir.GVA) for each country (c). This multiplier is calculated by dividing the total indirect GVA effects across the economy (i.e., the sum of indirect effects by economic sector, or GVA.Psector*IndirMult.GVA) by the total GVA. The latter is obtained from the sum of GVA generated by each economic sector (GVA.Psector), based on IO analysis.

$$TAv.MultIndir.GVA_c = sum_{s=1}^{S}(GVA.Psector_{c,s} * IndirMult.GVA_{c,s})/sum_{s=1}^{S}(GVA.PSector_{c,s})$$

Since only cross-sectional data, not time series data, is available for multipliers and GVA per sector, we assume that both the multipliers and the sectoral GVA distribution remain constant over time. As a result, we applied the average indirect GVA multiplier (TAv.MultIndir.GVA) to the direct effects derived from the time series data provided by the World Bank (DirectEffect). The indirect effects were then calculated by multiplying the average indirect GVA multiplier with the direct GVA effects in the economy.

$$IndirectEffect_{c,t} = DirectEffect.PerEmployee_{c,t} * TAv.MultIndir.GVA_c$$

Induced effects:

Direct and indirect effects occur across multiple sectors, generating induced effects throughout different parts of the value chain. Therefore, we need to estimate the induced effect multiplier per additional dollar of GVA (InducMult.GVA), rather than per additional dollar of sector revenue increase. This is obtained from dividing the induced effect multiplier per revenue increase (InducMult.Rev) by the direct multiplier per revenue increase (DirMult.Rev):

$$InducMult.GVA_{c,s} = \frac{InducMult.Rev_{c,s}}{DirMult.Rev_{c,s}}$$

To comprehensively capture the multiplicative effects across all sectors, we applied the induced total economy-wide average multiplier (TAv.MultInduc.GVA) for each country (c). Similarly as before, this multiplier is calculated by dividing the total induced GVA effects the economy (GVA.Psector*InducMult.GVA) by the total GVA.

$$TAvMultInduc.GVA_c = sum_{s=1}^{S}\left(GVA.Psector_{c,s} * InducMult.GVA_{c,s}\right)/sum_{s=1}^{S}(GVA.PSector)$$

As in the case of the indirect effects, we assume that these multipliers and the GVA distribution per sector remain constant over time. As a result, the induced effects are calculated by multiplying the average induced GVA multiplier (TVaMultInduc.GVA) with the direct GVA effects in the economy (DirectEffect):

$$InducedEffect_{c,t} = DirectEffect_{c,t} * TAvMultInduc.GVA_c$$

Total paid work effects:

The average effect of disease on reducing paid work (PaidW.PerEmployee) is then equal to the sum of the three calculated effects (DirectEffect, IndirectEffect and InducedEffect).

$$PaidW.PerEmployee_{c,t} = DirectEffect_{c,t} + IndirectEffect_{c,t} + InducedEffect_{c,t}$$

4.1.5 GVA effects from unpaid work

Given the nature of unpaid work, an indirect estimation of its productivity in monetary terms is necessary. To do so, several issues must be considered. First, it is important to account for the differences in productivity between countries. These differences are the result of different factors, such as the level of investment in the human or physical capital, or institutional and governmental policies (Hall and Jones, 1999). Second, due to the nature of unpaid work (e.g. preparation of meals, household upkeep, care taking of family), it is likely that there is a difference in the value of the productivity of unpaid work as compared to paid productivity in other sectors. To address this difference, we use data from a sector that is similar to unpaid work. To illustrate this, we assume that the value of household upkeep by an unpaid worker is similar to the productivity of hired household help.

To account for the differences between countries, the general approach is to start our estimation of the value of unpaid work of a certain country by calculating the relationship between time spent on paid and unpaid work for the different countries. Then, we initially assumed the same level of productivity in terms of GVA for both paid and unpaid work. After “anchoring” the value of unpaid work to the GVA of paid work of a country, we adjust the value of unpaid work with information about the value of productivity in terms of GVA of a sector that produces similar output as paid work. Following the second revision of the Statistical Classification of Economic Activities in the European Community (NACE Rev. 2), we assume that the sector with output most similar to unpaid work is “Sector T”, which reflect the output of “households as employers; undifferentiated goods- and services-producing activities of households for own use” (Eurostat, 2008). For simplicity, we call this sector Unpaid Substitution Economic Sector (USES) from here onwards.
Data for this sector was available for all countries apart from the Netherlands; therefore, data from Germany was utilized as a proxy. This methodological decision necessitated assumptions regarding comparable productivity levels, wage structures, and household employment characteristics between the proxy and target country. It is important to acknowledge that significant differences may exist between these nations, both in terms of labor market structures and the methodological approaches employed in their respective time-use surveys.

In more detail, we used a combination of time-use survey data, data from the IO analysis and data from the World Bank. With time-use survey data, we calculate the ratio of time spent on unpaid work per hour to time spent on paid work per individual.
As already explained in the method section, this data presents time use across different specific categories, such as time used on having meals, commuting, or work. These categories were reclassified to paid and unpaid work according to the International Classification of Activities for Time Use Statistics 2016 (UN Statistics Division, 2017).

Consequently, the time spent on work was used as an indicator for paid work, and time spent on housework, taking care of family, educating children, shopping or errands as indicators for time spent on unpaid work. This resulted in the following parameter inputs:

Country	Gender	Paid work hours	Unpaid work hours	Reference
Germany				
	Women	2.65	3.77	(UN Statistics Division, 2024)
	Men	3.68	2.53	
Spain				
	Women	2.35	4.55	(UN Statistics Division, 2024)
	Men	3.73	2.07	
France				
	Women	2.28	3.79	(UN Statistics Division, 2024)
	Men	3.63	2.28	
Netherlands				
	Women	2.08	3.63	(UN Statistics Division, 2024)
	Men	3.68	1.93	
Portugal				
	Women	1.9	4.27	(UN Statistics Division, 2024)
	Men	3.12	2.46	
Czech Republic				
	Women	3.15	4.93	(UN Statistics Division, 2024)
	Men	4.35	2.67	

Table 1. Paid and unpaid working hours by country and gender

These inputs were used to calculate gender specific work time ratios, with the following formulas:

$$WorkTimeRatio.Male_{c,t} = UnpaidHours.Male_{c}/PaidHours.Male_{c,t}$$

$$WorkTimeRatio.Female_{c,t} = UnpaidHours.Female_{c}/PaidHours.Female_{c,t}$$

Where UnpaidHours.Male is the number of unpaid hours worked by men, UnpaidHours.Female is the number of unpaid hours worked by women, PaidHours.Male is the number of hours spent on paid work by men, and PaidHours.Female is the number of paid hours spent on paid work by women, by country (c) and year (t).

Then, per employee, an estimation is made regarding the value of their unpaid work in terms of GVA. This is done with the following formula:

$$UnpaidWork.PerEmployee_{c,g,t} = (GVA.2015Pr_{c,t} * WorkTimeRatio_{c,g,t})/Employees.15m_{c,t}$$

With GVA.2015Pr being the GVA of a country in 2015 USD, WorkTimeRatio the ratio calculated in equation 9, and Employees.15m the number of paid workers 15 years and older, by country (c), gender (g), and year (t). This value essentially represents the value of unpaid work activities in terms of the average GVA produced by men and women in a country. However, as mentioned, this value needs further adjustment to more closely resemble the real value of unpaid work. This adjustment is explained in the next steps.

With data from the IO analysis, an estimation is made about the proportion of GVA that is contributed by USES relative to the output of all economic sectors. Assuming that this proportion remains stable over time, the annual GVA figures from the World Bank are multiplied by this proportion, to estimate the yearly contribution of USES to GVA over time. Following this, we calculate the proportion of individuals working in USES relative to all employees in all sectors and use this proportion to calculate the annual number of workers in USES over time. Then, we estimate the productivity per employee working in USES per year (GVA.2015Pr.PerEmployee.USES) by dividing the estimated contribution to GVA per year by the estimated number of employees working in USES. These steps are summarized in the following equation:

$$GVA.2015Pr.PerEmployee.USES_{c,t} = \left(\frac{GVA.PSector.USES_{c,USES}}{sum_{s=1}^{S}\left(GVA.PSector_{c,s}\right)}\right) * GVA.2015Pr_{c,t} / \left(\frac{EMP.PSector.USES_{c,USES}}{sum_{s=1}^{S}\left(EMP.PSector_{c,s}\right)}\right) * Employees.15m_{c,t}$$

Where GVA.PSector.USES corresponds to the GVA in the USES sector, EMP.PSector.USES to the number of people employed in the USES sector by country (c). It should be noted that there are deviations in both the GVA and number of employees between the World Bank and IO analysis, due to differences in the exact way that these numbers are estimated.

With the estimated GVA per person for employees in the USES sector, a ratio is calculated which represents the productive value of an employee working in this sector relative to the productive value of an employee in the general population (GVA.Unpaid.AdjRatio). This ratio is calculated by dividing the per person GVA added of an employee in the USES sector by the general per person GVA of an employed individual, with the following formula:

$$GVA.Unpaid.AdjRatio_{c,t} = GVA.2015PR.PerEmployee.USES_{c,t} / GVA.2015Pr.PerEmployee_{c,t}$$

This ratio is then finally used to adjust the value of unpaid work calculated earlier (UnpaidWork.PerEmployee), using the following formula:

$$UnpaidWork.Adj.PerEmployee_{c,g,t} = UnpaidWork.PerEmployee_{c,g,t} * GVA.Unpaid.AdjRatio_{c}$$

4.1.6 Health outcome metrics and the SOB of disease

For the SOB of disease analysis, we assume on a general level that individuals contribute to society in terms of paid and unpaid work throughout the year, and that years lost due to morbidity or mortality lead to losses in productivity. To calculate these lost years, we use the Disability Adjusted Life Year (DALY) concept by the GBD of disease study (IHME, 2024). DALYs are calculated on the basis of Years Lived with Disability (YLDs) and Years of Life Lost (YLL). These metrics have been developed to make it possible to compare morbidity and mortality across diseases.

In order to evaluate the impact of disease in terms of YLD and YLL on productivity, we need to establish the maximum age that individual can stay productive. In other words, the maximum productive age needs to be established. For paid work, the effective retirement age was considered to be the most appropriate measure. The effective retirement age represents the average age at which individuals cease employment, in contrast to the official retirement age established by government policy. The latest OECD report, "Pensions at a Glance 2023", provides effective retirement age data divided by sex for all six countries within the study scope (OECD, 2023). For unpaid work instead, we assume that people remain productive until the age of 85. Combined, the value of both paid and unpaid work is comprehensively assessed.

To evaluate the effect of morbidity on productivity, we use YLDs. YLDs represent the burden of disease on those living with a disease. This burden is reflected as the “health” that is lost living with disease. Through the way that this health loss is estimated, this burden reflects years lost. To illustrate, if a disease results in a burden of 0.5, then two years of living with this disease is equal to living 1 year in complete health, or in other words, over a period of 2 years, someone living with a disease with a burden of 0.5 “loses” 1 year of life. In relation to productivity, we assume that these losses reflect lost time in productivity due to absenteeism and presenteeism. To monetize this loss in productivity (MVal.YLD.UnpaidW.PerEmployee and MVal.YLD.PaidW.PerEmployee), the country- and year-specific YLD of a disease (YLD) is multiplied with the country- and year average paid and unpaid work productivity (UnpaidWork.Adj.PerEmployee and PaidW.PerEmployee).

For unpaid work, the following formula is used:

$$MVal.YLD.UnpaidW.PerEmployee_{c,g,t} = UnpaidWork.Adj.PerEmployee_{c,g,t} * YLD_{c,g,t}$$

Where (c) represents the country, (g) the gender, and (t) represents the year.

For paid work, we use the following formula, which also account for the proportion of individuals who is employed with the variable EmplToPop.15m.T.Per:

$$MVal.YLD.PaidW.PerEmployee_{c,g,t} = PaidW.PerEmployee_{c.t} * EmplToPop.15m.T.Per_{c,t} * YLD_{c,g,t}$$

Where again (c) represents country, (g) gender, and (t) represents year.

The total monetary value of the lost productivity due to the morbidity of a disease for a specific country and year (MVal.YLD.PerEmployee) is then calculated by the sum of productivity losses in paid and unpaid work with the following formula, by (t) year, (g) gender, and (c) country:

$$MVal.YLD.PerEmployee_{c,g,t} = MVal.YLD.UnpaidW.PerEmployee_{c,g,t} + MVal.YLD.PaidW.PerEmployee_{c,g,t}$$

To evaluate the effect of mortality on productivity, we calculate an adapted version of YLL. Where in the original GBD study YLL represents the life years lost in relation to life expectancy, we are interested in productive YLL lost, thus related at productive life expectancy. To calculate our adapted YLL, we use mortality estimated from the GBD study by age group, country, and year. To monetize the productivity losses related to YLL lost, we use two approaches: the FCA and the HCA.

For the FCA, we assume that the productivity of an individual can be replaced by another individual. To illustrate, if a company loses an employee through disease, then the company might hire a substitute, or might innovate, or conduct further adaptation to the production process to substitute the loss of an employee. This, of course, takes time. In this report, we therefore assume that the loss in productivity due to mortality is one year, or in other words, we assume that per deceased person, one year of productive work is lost.

Productive years of life lost are therefore the sum of all the deaths by country (c), gender (g), year (t), and age group (a) as follows:

$$YLLFCA_{c,g,t} = sum_{a=1}^{A}(Deaths_{c,g,t,a})$$

Where the oldest age group for unpaid work is 80 to 84, the oldest age group for paid work depends on the effective retirement age of different countries as previously mentioned. In our analysis, we used a report from the OECD (OECD, 2023), in which the following effective retirement ages are mentioned: 64 for men in Germany, 63 for women in Germany, 61 for men in France, 62 for women in France, 62 for both men and women in Spain, 65 for men in the Netherlands and 64 for women in the Netherlands, 64 for men in Czech Republic, 62 for women in Czech Republic, 66 for men in Portugal and 65 for women in Portugal. The monetized loss of these years is calculated with the following formula for unpaid work:

$$MVal.YLLFCA.UnpaidW.PerEmployee_{c,g,t} = UnpaidWork.Adj.PerEmployee_{c,g,t} * YLLFCA_{c,g,t}$$

Where UnpaidWork.Adj.PerEmployee refers to the earlier estimated monetary value of one year of an individual's unpaid productivity for a specific (c) country, (g) gender, and (t) year. For paid work, the following formula is used:

$$MVal.YLLFCA.PaidW.PerEmployee_{c,g,t} = PaidW.PerEmployee_{c,t} * EmplToPop.15m.T.Per_{c,t*}YLLFCA_{c,g,t}$$

Where PaidW.PerEmployee refers to the earlier estimated monetary value of the individual's productivity of paid work, and EmplToPop.15m.T.Per refers to the proportion of employed people by (c) country, (g) gender, and (t) year. The total loss in productivity due to mortality in terms of FCA is then calculated by summing the loss in productivity of paid and unpaid work with the following formula, by (c) country, (g) gender, and (t) year:

$$\begin{aligned} MVal.YLLFCA.PerEmployee_{c,g,t} \\ &= MVal.YLLFCA.UnpaidW.PerEmployee_{c,g,t} + MVal.YLLFCA.PaidW.PerEmployee_{c,g,t} \end{aligned}$$

For the HCA, it is assumed that an individual's death during her or his productive years results in a loss of productivity that cannot be replaced. Here, it is important to recall that productive years are defined according to effective retirement age for paid work and 84 years for unpaid work. Given that we have mortality data by age groups, we conduct the following steps to calculate the years of productive life that are lost:

- From the GBD study, the smallest range available for age groups are selected, which is mortality by 5-years (e.g. mortality in the age group of 15 to 19 years old, mortality in the age group of 20 to 24 years old etc.).
- On average, we assume that the average age of death within an age group is the midpoint of that age group. To illustrate, in the age group 20 to 24, we assume that the average of death is 22.5.
- To calculate the productive years of life lost for an age group, we then subtract the maximum productive age of paid and unpaid work from the average mentioned in the last step. For example, for the age group of 20 to 24, we subtract as follows: 84-22.5 = 61.5 productive years of unpaid work lost if an individual dies within this age group.
- To calculate the full number of years of life lost due to the number of deaths, we multiply the number of deaths per age group with the age specific value of productive years lost (e.g. number of deaths in age

group 20-24 multiplied by 61.5 for unpaid work). For paid and unpaid work, these are referred to as YLLpaid and YLLunpaid.

- To value future productivity losses to the respective year that an individual dies, a discount rate of 3.5% is applied.

These steps above can be summarized by the following formulas:

$$MVal.YLLHCA.UnpaidW.PerEmployee_{c,g,t} = sum_{a=1}^{A}\left[sum_{i=1}^{YLLunpaid}\left[Deaths_{a,c,g,t} * UnpaidWork.Adj.PerEmployee_{c,g,t} * \frac{1}{(1+DiscRate)^{i}}\right]\right]$$

Where a = age group, i= each year of productive life lost (i= 1…YLLunpaid or YLLpaid), c= country, g = gender, t = to the evaluated year, and DiscRate = 3.5%.

The monetary value of SOB of disease due to mortality calculated with the HCA is the sum of paid and unpaid productivity losses, which is calculated with the following formula:

$$MVal.YLLHCA.PerEmployee_{c,g,t} = MVal.YLLHCA.UnpaidW.PerEmployee_{c,g,t} + MVal.YLLHCA.PaidW.PerEmployee_{c,g,t}$$

It should be noted that there are extensive debates in health economic literature whether the FCA or HCA should be used, see for example (Brouwer and Koopmanschap, 2005) and Targoutzidis (2018). In this report, we refrain from making a judgement in this debate but do consider the FCA the conservative approach for estimating productivity losses. We therefore mainly report FCA based estimates throughout this study.

The complete SOB of disease, due to both mortality and morbidity, is then the sum of the productivity losses calculated with YLD and productivity losses calculated with life years lost (according to the HCA and the FCA). For this, the following formula is used, by (c) country, (g) gender, and (t) year:

$$MVal.Total.PerEmployee_{c,g,t} = MVal.YLD.Total.PerEmployee_{c,g,t} + MVal.YLL.Total.PerEmployee_{c,g,t}$$

Here, it should be noted that the gender specific estimates for men and women are then summed to calculate the overall effect of disease on productivity losses.

Name in formulas	Name in data source	Reference
Disease parameters		
YLD*	YLD	IHME (2024)
Deaths	Mortality	IHME (2024)
Economic parameters		

Name in formulas	Name in data source	Reference
GVA.2015Pr	GVA 2015 US$†	(World Bank, 2025b)
GVA.CurrPr	GVA current US$	(World Bank, 2025b)
GDP.2015Pr	GDP 2015 US$	(World Bank, 2025b)
GDP.CurrPr	GDP current US$	(World Bank, 2025b)
EXR.A.USD.EUR.SP00.A	Exchange rates Euro/US dollar 2011-2021	European Central Bank (2025b)
IndirMult.Rev	Not applicable, not public	WifOR's input/output model
InducMult.Rev	Not applicable, not public	WifOR's input/output model
GVA.PSector.USES	Not applicable, not public	WifOR's input/output model
GVA.PSector	Not applicable, not public	WifOR's input/output model
EMP.PSector.USES	Not applicable, not public	WifOR's input/output model
EMP.PSector	Not applicable, not public	WifOR's input/output model
Effective retirement age	Retirement Age Men/Women	OECD (2023)
Time use		
UnpaidHours.Male	Total time spent on unpaid domestic and care work	(UN Statistics Division, 2024)
UnpaidHours.Female	Total time spent on unpaid domestic and care work	(UN Statistics Division, 2024)
PaidHours.Male	See explanation in the annex	(UN Statistics Division, 2024)
PaidHours.Female	See explanation in the annex	(UN Statistics Division, 2024)
Demographic		
Pop.Fem.Per	Population, female (% of total population)	(World Bank, 2025b)
Pop.Male.Per	Population, male (% of total population)	(World Bank, 2025b)
Pop.1564.T	Population ages 15-64, total	(World Bank, 2025b)
Pop.60m.T	Population ages 65 and above, total	(World Bank, 2025b)
EmplToPop.15m.T.Per	Employment to population ratio, 15+, total (%) (modeled ILO estimate)	(World Bank, 2025b)

*Table 2. Variables and data sources. *YLD: years lived with disability, †GVA: gross value added*

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WifOR is an independent economic research institute, founded in 2009 as a spin-off from the Technical University of Darmstadt. As experts in macroeconomic analysis, our research focuses on the areas of labor markets, health, and sustainability. Through our studies, WifOR's mission is to enable data-based solutions to challenges on the labor market, set global standards in sustainability measurement, and illuminate worldwide the value of health investments. WifOR has over 75 employees located in Germany, Greece, Latin America, and the USA.

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