“The impact of health insurance models on reducing DALYS from cardiovascular diseases and neoplasms: A panel study across 51 OECD member and candidate countries”

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THE IMPACT OF HEALTH INSURANCE MODELS ON REDUCING DALYs FROM CARDIOVASCULAR DISEASES AND NEOPLASMS: A PANEL STUDY ACROSS 51 OECD MEMBER AND CANDIDATE COUNTRIES

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Abstract

As health systems worldwide increasingly focus on mitigating the burden of non-communicable diseases, the strategic role of insurance schemes in facilitating early detection and preventive care, thereby reducing the substantial costs associated with advanced-stage treatment, has become a critical area of policy and research attention. This study aims to evaluate the impact of various health financing models, specifically voluntary, compulsory, and social insurance, on the burden of cardiovascular diseases and neoplasms, measured by Disability-Adjusted Life Years (DALYs), across working-age and older populations. The analysis is based on unbalanced panel data from 51 countries covering the period 2000–2021, drawing from the Global Burden of Disease database for DALY rates and the OECD and WHO Global Health Expenditure Database for health financing indicators. Fixed and random effects panel regression models with clustered robust standard errors were employed to estimate the associations. Results show that voluntary private insurance significantly reduces DALY rates from cardiovascular diseases, by approximately 19-28%, among working-age (15-49) and older adults (50-69). Compulsory and social insurance models also exhibit protective effects, but of smaller magnitude. Government health financing schemes similarly correlate with improved outcomes. In contrast, enterprise-based financing is positively associated with higher DALY rates, especially in older age groups. Insurance schemes demonstrate weaker and more inconsistent associations for neoplasms, with compulsory insurance and government schemes showing the most stable links to reduced burden among older adults.

Keywords health insurance, DALY, CVDs, neoplasms, health financing

JEL Classification I13, I18, C33

INTRODUCTION

A well-founded rationale exists for health insurance schemes to shift their focus from treatment toward prevention by integrating routine screenings and medical examinations into standard coverage (WHO & World Bank, 2023). Early detection of conditions such as cardiovascular diseases and neoplasms can reduce reliance on high-cost, complex interventions and improve long-term health outcomes. Despite these advantages, preventive services remain underutilized in many insurance models, highlighting the need for further empirical assessment of their population-level impact.

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Cardiovascular diseases and neoplasms are among the leading causes of mortality globally, contributing heavily to Disability-Adjusted Life Years (DALYs). As ageing populations and lifestyle-related risks increase, it becomes essential to understand how health financing structures, especially insurance-based models, can mitigate this burden.

Countries are reforming healthcare financing in pursuit of universal health coverage. Insurance schemes, particularly those based on prepaid and pooled contributions, play a critical role in reducing out-of-pocket spending and expanding access to care (WHO & World Bank, 2023). The COVID-19 pandemic further underscored the importance of resilient and equitable financing models.

The COVID-19 pandemic highlighted weaknesses in global health financing and underscored the need for more resilient systems. While this study uses pre-2021 data, its focus on structural health determinants remains relevant for guiding post-pandemic reforms. National Health Accounts, promoted by the WHO and World Bank, continue to support data-driven policy design (WHO & World Bank, 2023).

This study contributes to current policy debates by examining the effect of various insurance types – voluntary, compulsory, and social – on DALYs from non-communicable diseases across 51 countries. It fills an empirical gap by evaluating the effectiveness of health insurance structures in improving outcomes for cardiovascular diseases and neoplasms, offering evidence to guide future financing reforms.

1. LITERATURE REVIEW

Research on the role of health insurance in shaping population health outcomes has developed along several major lines, including the analysis of willingness to pay for coverage, the structure and efficiency of insurance markets, policy transfer processes, and the broader social, economic, and institutional contexts of healthcare financing.

A foundational aspect of understanding health insurance efficacy is public engagement and acceptance. Otieno et al. (2025) explored perceptions and experiences about willingness to pay for community-based health insurance in East Africa. Their qualitative findings emphasize the importance of trust, perceived value, and sociocultural factors in influencing uptake. Similarly, Johnson and Kasztelnik (2024) examined how socioeconomic background affects financial socialization among African American women, indirectly shaping long-term health and insurance decisions. These studies highlight the behavioral dimensions that underlie financial participation in health systems.

From a systems and market perspective, Mańak-Szulik et al. (2023) applied fractal analysis to illustrate the complex dynamics of medical insurance markets, while Bednarczyk et al. (2023) and Dobiáš (2024) explored the role of life insurance and private risk coverage, showing how these interact with public health goals. These works contribute to the theoretical understanding of how insurance schemes behave under different regulatory and market conditions. Ganiyev et al. (2024) further emphasize the relevance of risk management principles, even in fields like construction, where safety and insurance models intertwine.

At the policy level, Awojobi and Adeniji (2023) and Simakhova et al. (2022), along with Tangcharoensathien et al. (2014) and Yam et al. (2019), analyzed how policy transfer, strategic purchasing, and voucher schemes affect social insurance reforms and efficiency. Their findings highlight the importance of adapting international models to local contexts and ensuring policies are designed for equitable implementation. Similarly, Artuykhov et al. (2024) and Dinu et al. (2024) emphasize the macro-level relationship between public social spending and national health indicators, suggesting that insurance reforms must align with broader fiscal strategies.

Broader socio-economic and institutional factors also play a critical role. Lyeonov et al. (2021), Syah and Suyitno (2025), and Xiong et al. (2022) demonstrated that system-level determinants, such as labor market vulnerability, primary care

capacity, and service delivery quality, condition the effectiveness of insurance. Supporting this view, Gheorghe and Panazan (2024) used neural network analysis to show how health system performance influenced pandemic-related volatility. Erdei-Gally and Vágány (2024) extended this understanding by analyzing how psychological well-being, particularly among students, was affected during health crises, highlighting the mental health dimensions relevant for insurance coverage. Lyeonov et al. (2025) also connected public health quality and labor productivity, reinforcing the economic value of efficient and inclusive insurance systems.

The role of targeted social protection is underscored in the work of Awojobi et al. (2023) and Langi et al. (2023), who assessed pandemic-era interventions in Africa and Indonesia. Their research shows that social safety nets must complement insurance to protect against systemic shocks. Ramonienė (2023) and Rouillé (2024) also address inclusivity, examining the role of NGOS and behavioral nudges in long-term care and insurance participation. Stehlíková et al. (2023) further argue that mortality from COVID-19 mirrored national healthcare quality, reinforcing the importance of systemic readiness in insurance planning. Al-Tamimi et al. (2023) and Prokopenko and Filipov (2024) highlighted the challenges faced by vulnerable groups, such as refugees, in accessing and navigating health systems, emphasizing the importance of health literacy and cultural adaptation in insurance implementation.

Preventive and behavioral health aspects are covered in studies by Li et al. (2022), Zhan et al. (2020), and Fang et al. (2018). These authors demonstrate that insurance schemes focusing solely on curative care may fail to optimize outcomes. Instead, integrating preventive services and addressing the unintended consequences of digital health tools are key for long-term efficiency. Complementary insights from Gavurova et al. (2024) and Baskiewicz et al. (2023) show how trust in medical staff and patient-centred management practices shape patient engagement and outcomes. Kerse et al. (2023) add to this by illustrating how health-oriented leadership fosters proactive service behavior among public sector staff, an essential organizational trait for delivering insurance-supported care.

Consumer behavior and media influence further shape insurance participation. Khwela et al. (2024), Choi and Feinberg (2024), and Agustina et al. (2024) explore how gender, lifestyle, and trust influence health-related purchasing behavior. These findings align with the behavioral economics view that insurance decisions are not solely financial but are deeply embedded in cultural and psychological contexts. Keller and Ercsey (2023) add that consumer reviews of digital health platforms often reflect deeper concerns with usability, credibility, and perceived health value. López-Felices et al. (2023) provide an environmental and sociocultural perspective, showing how community values influence engagement with health and ecosystem services, relevant for understanding insurance uptake in rural and ecologically sensitive areas.

Corporate and institutional dynamics also factor into the insurance landscape. Studies by Tessema (2025), Raho and Benchikh (2025), and Dao Mong and Mai Thi (2024) examine how corporate responsibility and internal welfare policies can act as informal insurance mechanisms. These contribute to the overall understanding of how non-state actors affect health security. Khan et al. (2023) complement this view by revealing how emotional strain and financial behavior interact, suggesting a psychological dimension to insurance uptake and use.

Finally, fiscal and economic constraints are critical to understanding the scope of insurance expansion. Hamadouche (2024), Ray (2024), and Arapovic and Kurtovic (2024) analyzed how public spending, inflation, and economic growth interact with health financing. Kuzior et al. (2022, 2023) provided quantitative evidence using DEA models, showing how countries with stronger organizational health systems managed COVID-19 more efficiently, underlining the link between insurance system structure and national resilience.

The literature presents a diverse and multi-dimensional view of health insurance systems. While evidence supports insurance as a cornerstone of health financing, its effectiveness depends on integration with behavioral, institutional, and socio-economic contexts. Future research should

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further explore how insurance schemes can be designed to promote not only access but also preventive care and long-term sustainability.

This study aims to examine the association between specific health insurance models, namely, public insurance, private insurance, and social insurance, and the disease burden over time, with a particular focus on preventing cardiovascular diseases and neoplasms among working-age and older populations. Other healthcare financing mechanisms, including enterprise financing, out-of-pocket payments, and NPISH schemes, are included as control variables to account for the diversity of healthcare financing systems (e.g., Beveridge, Bismarck models, National Health Insurance, etc.) across countries.

2. METHODOLOGY

This study applies a quantitative panel data analysis to examine the relationship between different health financing mechanisms and disease burden, measured by Disability-Adjusted Life Years (DALYs) per 100,000 people. The study focuses on two categories of non-communicable diseases (cardiovascular diseases and neoplasms) across two age groups (15-49 and 50-69 years).

2.1. Data sources and scope

The data cover 51 countries from 2000 to 2021, forming an unbalanced panel with between 6 and 22 years of observations per country. The selection of 2021 as the final year reflects the most recent available data from the sources used at the time of research. DALY data were obtained from the Institute for Health Metrics and Evaluation (IHME), while health financing indicators were drawn from the OECD and World Bank databases. These sources offer consistent, cross-nationally comparable data essential for robust panel regression analysis. However, the use of data up to 2021 is not a methodological choice but rather a constraint imposed by the latest available updates from these databases. The IHME, in particular, had not yet released complete DALY estimates beyond 2021 during the preparation of this study. The list of countries included in the panel dataset is provided in Appendix A.

2.2. Variables

The dependent variables are DALY rates for cardiovascular diseases and neoplasms, disaggregated by age group. A complete list of variables and sources is presented in Table 1.

Table 1. Variables and sources

Variable	Indicator	Source
y1	DALYs rate on 100k cardiovascular diseases (15-49 years)	IHME (n.d.)
y2	DALYs rate on 100k cardiovascular diseases (50-69 years)	IHME (n.d.)
y3	DALYs rate on 100k neoplasms (15-49 years)	IHME (n.d.
y4	DALYs rate on 100k neoplasms (50-69 years)	IHME (n.d.)
x1	Social health insurance schemes	OECD (n.d.)
x2	Compulsory private insurance schemes	OECD (n.d.)
x3	Voluntary health insurance schemes	OECD (n.d.)
x4	NPISH financing schemes	OECD (n.d.)
x5	Enterprise financing schemes	OECD (n.d.)
x6	Household out-of-pocket payments	OECD (n.d.), World Bank. (n.d.)
x7	Government schemes	OECD (n.d.), World Bank. (n.d.)

2.3. Analytical approach

Fixed effects (FE) and random effects (RE) panel regression models were estimated using the *plm* package in R. Model selection between FE and RE was determined by the Hausman test, which evaluates the correlation between regressors and individual country effects. Year dummies were included to account for global shocks such as medical innovations or international health policy changes.

To ensure robustness of the estimates, clustered robust standard errors at the country level were applied to address heteroskedasticity and serial correlation, as confirmed by the Breusch-Pagan and Wooldridge tests. Multicollinearity was assessed using Variance Inflation Factors (VIFs), all remaining within acceptable thresholds.

Separate models were specified for each disease category and age group to support more straightforward interpretation and enhance policy relevance.

3. RESULTS

The descriptive statistics output (Appendix B, Table B1) provides a comprehensive overview of the dataset's distribution and variability. Variables such as x2 and x3 exhibit high positive skewness (3.69 and 2.94, respectively) and elevated kurtosis (12.20 and 10.45), indicating distributions with long right tails and a higher propensity for outliers. Conversely, variables like x6 and x7 display near-normal distributions, with skewness values close to zero and negative kurtosis, suggesting lighter tails. The outcome variables (y1 to y4) also show positive skewness and moderate kurtosis, reflecting asymmetrical distributions with potential outliers. These insights are crucial for selecting appropriate statistical models and transformations, ensuring the robustness of subsequent analyses.

3.1. Preventing CVDs among individuals aged 15-49

Panel regression results (Table 2) assess the association between health financing mechanisms and DALYs for cardiovascular diseases in individuals aged 15-49, using both fixed effects (FE) and random effects (RE) models. Based on the Hausman test ($p = 0.089$), the FE model is preferred due to potential endogeneity.

The analysis shows (Table 2) that social health insurance (x1), compulsory private insurance (x2), and voluntary private insurance (x3) are all significantly associated with lower DALYs. Voluntary private insurance demonstrates the most significant effect (–262.64, $p < 0.001$), followed by compulsory (–156.62, $p < 0.001$) and social insurance (–83.63, $p < 0.001$). Government schemes (x7) also show a significant negative association (–88.83, $p < 0.001$), indicating their alignment with insurance-like risk pooling and access-enhancing functions.

In contrast, enterprise-based financing (x5) is positively associated with DALYs (+619.18, $p < 0.001$), potentially reflecting fragmented or inefficient employer-driven systems. Out-of-pocket payments (x6) exhibit a negative association (–120.86, $p < 0.001$), but this may reflect selection effects or reverse causality. NPISH financing (x4) shows no significant association.

The model explains approximately 20% of the variance in DALY outcomes ($R^2 = 0.20$), and the joint significance of the predictors is confirmed ($F = 33.46$, $p < 0.001$). Diagnostic tests indicate heteroskedasticity and autocorrelation (Breusch-Pagan and Wooldridge tests, $p < 0.001$), justifying the use of clustered robust standard errors (Table 3). Under robust estimation, key insurance variables (x1-x3) remain significant, while enterprise

Table 2. Outputs of the FE and RE models of the influence of healthcare financing schemes on the DALY rate for cardiovascular diseases in the 15-49 age group

Source: Authors' calculation in R Studio.

Variable	One-way (individual) fixed effect within model	One-way (individual) random effect model (Swamy-Arora's transformation)
Intercept	–	1986.119***(< 0.0001)
x1	–83.634***(< 0.0001)	–86.550***(< 0.0001)
x2	–156.616***(< 0.0001)	–152.158***(< 0.0001)
x3	–262.637***(< 0.0001)	–245.842***(< 0.0001)
x4	–338.744	–343.043
x5	619.178***(0.0002)	616.696***(0.0001)
x6	–120.855***(< 0.0001)	–107.410***(0.0002)
x7	–88.830***(< 0.0001)	–94.451***(< 0.0001)
R-Squared	0.19998	0.1975
Adj. R-Squared	0.15131	0.19181
F-statistic	33.4601 (< 0.0001)	–
Chisq	–	245.054(<0.0001)
Chisq = 12.385, df = 7, p-value = 0.08858 Alternative hypothesis: one model is inconsistent		

Note: '***' – 0.001; '**' – 0.01; '*' – 0.05; '.' – 0.1; 'No symbols' – insignificant.

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Table 3. Outputs of the robust standard errors calculations of the fixed effects model of the healthcare financing schemes' influence on the DALY rate for cardiovascular diseases in the 15-49 age group

Source: Authors' calculation in R Studio.

Variable	Estimate	std. Error	t value	Pr(> |t|)
xl	–83.634	31.055	–2.6931	0.0072**
x2	–156.616	30.337	–5.1626	< 0.0001***
x3	–262.637	111.206	–2.3617	0.0184*
x4	–338.744	521.573	–0.6495	0.5162
x5	619.178	347.689	1.7808	0.0753
x6	–120.855	122.061	–0.9901	0.3224
x7	–88.830	25.141	–3.5333	0.0004***

Note: '***' – 0.001; '**' – 0.01; '*' – 0.05; '.' – 0.1; 'No symbols' – insignificant.

financing (x5) becomes marginal (p = 0.075) and out-of-pocket payments (x6) lose significance. Voluntary insurance remains the most influential predictor, reaffirming its role in reducing the disease burden in younger adults.

Year-fixed effects were included to account for global trends and systemic shocks (Appendix B, Table B2). The insurance-related coefficients remain stable and significant, while the impact of other variables, such as enterprise financing and out-of-pocket payments, attenuates. This suggests their initial associations may partially reflect time-varying influences. The persistence of insurance effects underscores their structural relevance in promoting cardiovascular health in this age group.

3.2. Preventing CVDs among individuals aged 50-69

Results for the 50-69 age group (Table 4) demonstrate similarly strong and consistent associations between insurance-based financing and reduced DALYs. Voluntary private insurance (x3) again shows the most significant adverse effect (–2174.68, p < 0.001), followed by compulsory private (x2: –1314.23, p < 0.001) and social insurance (x1: –891.91, p < 0.001). Government schemes (x7) and out-of-pocket payments (x6) also show significant adverse effects, though to a lesser extent.

Enterprise financing (x5) is associated with significantly higher DALYs (+8206.56, p < 0.001), again

Table 4. Outputs of the RE and RE models of the healthcare financing schemes' influence on the DALY rate for cardiovascular diseases in the 50-69 age group

Source: Authors' calculation in R Studio.

Variable	One-way (individual) fixed effect within model	One-way (individual) random effect model (Swamy-Arora's transformation)
Intercept	–	17,000.504***(< 0.0001)
x1	–891.91***(< 0.0001)	–884.821***(< 0.0001)
x2	–1,314.23***(< 0.0001)	–1,276.383***(< 0.0001)
x3	–2,174.675***(< 0.0001)	–2,065.205***(< 0.0001)
x4	–1507.85	–1,405.356
x5	8,206.56***(0.0002)	8,135.522***(0.0001)
x6	–1,518.04***(< 0.0001)	–1,420.232***(0.0002)
x7	–727.00***(< 0.0001)	–785.838***(< 0.0001)
R-Squared	0.26583	0.26155
Adj. R-Squared	0.22116	0.25631
F-statistic	48.46641 (< 0.0001)	–
Chisq	–	350.823(< 0.0001)
Chisq = 8.4922, df = 7, p-value = 0.2912 Alternative hypothesis: one model is inconsistent		

Note: '***' – 0.001; '**' – 0.01; '*' – 0.05; '.' – 0.1; 'No symbols' – insignificant.

Table 5. Output of the robust inference results from the RE model of the healthcare financing schemes' influence on the DALY rate for cardiovascular diseases in the 50-69 age group

Source: Authors' calculation in R Studio.

Variable	Estimate	Std. Error	t value	Pr(> |t|)
Intercept	1986.119	286.045	6. 9434	< 0.0001***
xl	–86.550	27.851	–3.1076	0.0019**
x2	–152.158	26.142	–5.8204	0.0001***
x3	–245.842	95. 204	–2.5823	0.01**
x4	–343.043	508.607	–0.6745	0.500166
x5	616.696	343.653	1.7945	0.0730 .
x6	–107.410	115.412	–0.9307	0.3523
x7	–94.451	22.129	–4.2683	< 0.0001***

Note: '***' – 0.001; '**' – 0.01; '*' – 0.05; '.' – 0.1; 'No symbols' – insignificant.

indicating inefficiencies or inequities in employer-based systems. NPISH financing (x4) remains statistically insignificant.

The model's explanatory power is higher in this age group (R^2 = 0.27). Hausman test results (p = 0.291) suggest no significant difference between FE and RE estimates; thus, the RE model is statistically appropriate. Robust standard errors (Table 5) confirm the significance of insurance variables, while the effects of NPISH and out-of-pocket payments are not statistically strong.

Notably, voluntary, compulsory, and social insurance associations remain significant and negative even after correcting for heteroskedasticity and within-panel correlation. Enterprise financing is positively associated with DALYs, but only marginally significant (p = 0.073), indicating some estimation uncertainty.

Year-fixed effects were also incorporated to control for uniform temporal shocks. These effects explain only a negligible portion of the overall variance (<4%), suggesting that cross-sectional differences, rather than shared time-specific factors, primarily account for the variation in cardiovascular DALYs in this age group. However, their inclusion improves model specification by controlling for potential omitted temporal influences.

The findings confirm that insurance-based financing, mainly voluntary and compulsory private insurance, is robustly associated with improved cardiovascular health outcomes in younger and older adult populations. These associations persist under multiple specifications and diagnostic controls, underscoring the structural role of insurance in disease burden reduction.

3.3. Preventing the neoplasms burden among individuals aged 15-49

The relationship between health financing mechanisms and cancer burden in individuals aged 15-49 was examined using fixed effects (FE) and random effects (RE) panel models, with DALYs per 100,000 as the outcome variable. The Hausman test (χ^2 = 20.08, p = 0.0054) supports using the FE model, indicating that unobserved country-specific effects correlate with the regressors. Diagnostic tests identified violations of classical assumptions, including heteroskedasticity (Breusch-Pagan, p < 0.001) and serial correlation (Wooldridge, p < 0.001).

Applying robust standard errors clustered at the group level (Table 6) affected the statistical significance of several coefficients. Notably, social health insurance (x1) and voluntary private insurance (x3) became statistically insignificant (p = 0.065 and p = 0.160, respectively), suggesting earlier effects were influenced by model misspecification. However, compulsory private insurance (x2) and government financing schemes (x7) retained strong negative associations with neoplasm-related DALYs (p < 0.001), highlighting their robust impact.

Appendix B (Table B3) further explores temporal effects by including year dummies. Most financing variables, including insurance and enterprise

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Table 6. Outputs of the robust standard errors calculations of the fixed effects model of the healthcare financing schemes' influence on the DALY rate for neoplasms in the 15–49 age group

Source: Authors' calculation in R Studio.

Variable	Estimate	std. Error	t value	Pr(> |t|)
xl	–57.287	31.055	–1.8447	0.0654 .
x2	–136.422	30.337	–4.4970	< 0.0001***
x3	–156.432	111.206	–1.4067	0.1599
x4	–171.866	521.573	–0.3295	0.7418
x5	453.071	347.689	1.3031	0.1929
x6	–98.575	122.061	–0.8076	0.4195
x7	–98.161	25.141	–3.9044	0.0001***

Note: '***' – 0.001; '**' – 0.01; '*' – 0.05; '.' – 0.1; 'No symbols' – insignificant.

schemes, do not display statistically significant associations. However, out-of-pocket payments (x6) show a substantial adverse effect ($p = 0.017$), possibly reflecting selective access or reverse causality. More importantly, a clear and statistically significant downward trend in DALY rates is observed from 2008 onward ($p < 0.001$ for most years), likely driven by medical advancements, early screening programs, and public health initiatives. This underscores the importance of isolating temporal trends from structural financing effects in policy evaluation.

3.4. Preventing the neoplasms burden among individuals aged 50-69

Analysis of DALYs related to neoplasms among individuals aged 50-69 also favors the FE model (Hausman $\chi^2 = 67.39$, $p < 0.001$), with diagnostic tests again confirming heteroskedasticity and serial correlation. Table 7 presents the robust fixed effects estimates. Social health insurance (x1), compulsory private insurance (x2), and government schemes (x7) demonstrate strong and statistically significant negative associations with DALYs ($p < 0.001$), reinforcing their role in reducing cancer burden in older populations.

Enterprise financing (x5) is positively and significantly associated with increased DALYs ($p = 0.012$), suggesting inefficiencies or limited coverage within employer-based schemes. Voluntary private insurance (x3) and out-of-pocket payments (x6) display negative coefficients, but neither reaches conventional statistical significance under robust inference, though x6 is marginally significant at the 10% level. NPISH financing (x4) remains statistically insignificant.

Appendix B (Table B4) incorporates year-fixed effects for standard temporal shocks. After their inclusion, most financing variables – including social and compulsory insurance – lose statistical significance, while household out-of-pocket payments (x6) remain significantly negative ($p = 0.004$), possibly reflecting selective access patterns. A consistent downward trend in DALY rates emerges from 2001, with extreme declines after 2008 ($p < 0.001$), attributable to improved diagnostics, treatment protocols, and public health interventions.

Table 7. Outputs of the robust standard errors calculations of the fixed effects model showing the healthcare financing schemes' influence on the DALY rate for neoplasms in the 50-69 age group

Source: Authors' calculation in R Studio.

Variable	Estimate	std. Error	t value	Pr(> |t|)
xl	–561.467	115.734	–4.8514	< 0.0001***
x2	–723.748	148.949	–4.8590	< 0.0001***
x3	–666.350	426.845	–1.5611	0.1188
x4	–942.074	2331.369	–0.4041	0.6862
x5	2304.549	909.791	2.5331	0.0115*
x6	–574.190	295.525	–1.9429	0.0523
x7	–651.513	96.936	–6.7211	< 0.0001***

Note: '***' – 0.001; '**' – 0.01; '*' – 0.05; '.' – 0.1; 'No symbols' – insignificant.

These findings reinforce the value of robust econometric design in distinguishing structural policy effects from broader health system trends. While financing mechanisms play a role in shaping cancer outcomes, the observed improvements are also strongly influenced by long-term, system-wide developments in global health.

4. DISCUSSION

This study contributes to the growing body of evidence affirming the effectiveness of insurance-based health financing mechanisms in reducing the burden of non-communicable diseases, particularly cardiovascular diseases and neoplasms. The empirical results show that voluntary and compulsory private and social health insurance are significantly associated with lower DALY rates, especially among older populations. These findings support and extend prior literature while providing nuanced insights into age- and disease-specific dynamics.

The strong protective effect of insurance schemes aligns with previous research highlighting the importance of structured and pooled financing for health outcomes. For example, Tangcharoensathien et al. (2014) and Artuykhov et al. (2024) emphasized the necessity of strategic public funding and its positive macro-level impact on health indicators. Similarly, Awojobi and Adeniji (2023) demonstrated that Ghana's successful health policy transfers and insurance reforms improved access and system efficiency, paralleling this study's finding that government and social insurance models reduce disease burden.

In particular, the finding that voluntary private insurance had the most significant adverse effect on DALYs from cardiovascular diseases in both age groups is notable. While previous studies (e.g., Mańak-Szulik et al., 2023; Bednarczyk et al., 2023) described the complexity and innovation within private insurance markets, this study adds empirical weight to the argument that such schemes can play a crucial role when well-integrated into broader health systems. However, as the literature warns (e.g., Dobiáš, 2024), private schemes may also risk inequity without regulation and inclusivity.

The statistically insignificant or even positive associations found for enterprise-based schemes and NPISH financing further corroborate concerns raised by Gavurova et al. (2024) and Khan et al. (2023) about inefficiencies and limited coverage in employer-linked or informal care systems. Moreover, the positive association between enterprise financing and DALY rates in older cohorts suggests that reliance on employer-based coverage may be insufficient or poorly aligned with the needs of ageing populations.

Interestingly, the mixed results for out-of-pocket payments contrast with earlier findings by Li et al. (2022), who highlighted self-protective behavior linked to financial responsibility. In this study, the significance of out-of-pocket payments appears inconsistent and often disappears after robust correction, indicating the importance of controlling for reverse causality and economic self-selection.

The decline in neoplasm-related DALYs over time, particularly from 2008 onward, appears more related to broader healthcare system improvements, such as early detection and improved therapies, than to specific financing structures. This observation is consistent with the findings of Xiong et al. (2022) and Stehlíková et al. (2023), who stress that system readiness and technological advancement have substantially affected cancer outcomes. Thus, while insurance plays a role, temporal factors and global innovation trends likely account for much of the observed variance in cancer burden.

Moreover, the literature has stressed the need to shift toward preventive models of care. While this study does not directly measure preventive coverage, the better performance of insurance schemes may indirectly support arguments by Rouillé (2024) and Ramonienė (2023), who advocate for integrating preventive services and behavioral interventions into insurance policies. The observed effectiveness of compulsory and voluntary schemes suggests that their design may better accommodate early interventions than fragmented or reactive financing models.

The study supports the broader consensus that effective insurance design is critical to achieving better health outcomes. It complements findings from Kuzior et al. (2022, 2023), who emphasized how the structure and responsiveness of health fi-

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nancing systems influenced national resilience during health shocks such as COVID-19. While this study does not directly assess pandemic outcomes, the mechanisms identified here are likely relevant to ongoing debates about resilient, equitable, and cost-effective healthcare systems.

This study is subject to several limitations related to data coverage, timeframe, methodology, and external geopolitical and health-related disruptions. First, the datasets utilized in the analysis, sourced from the OECD (n.d.), the Institute for Health Metrics and Evaluation (IHME) (n.d.), and the World Bank (n.d.), represent a sample of countries, primarily OECD members or countries with sufficient data availability, and therefore may not fully capture the global diversity of health financing systems or disease patterns. Furthermore, one of the primary data sources, the IHME database, only includes data up to 2021, which poses a significant limitation, especially given the profound global health and socioeconomic changes that have occurred since then.

One notable constraint of using pre-2021 data is the inability to account for the full impact of the COVID-19 pandemic, which has caused widespread disruptions in healthcare access, diagnosis, treatment, and outcomes. COVID-19 significantly exacerbated disease burdens, including increased mortality, reduced preventive care, and deteriorating mental health, all of which could affect DALY rates across disease categories. In addition, Russia's invasion of Ukraine in 2022 has caused a severe geopolitical and humanitarian crisis, mainly affecting Ukrainian citizens. The war has caused direct health impacts (e.g., injuries, fatalities from fighting, bombings, missile and drone attacks) as well as indirect health consequences, such as increased rates of post-traumatic stress disorder, psychological distress, and disruptions to healthcare infrastructure. These developments could considerably affect DALY trends in the region and are not captured in this study due to data limitations.

Methodologically, although fixed and random effects models were employed to control for unobserved heterogeneity and robust standard errors were used to address heteroskedasticity and serial correlation, residual confounding from unmeasured country-level factors may persist. The observational nature of the data also raises the potential for endogeneity between health spending and disease outcomes. Moreover, while DALYs are a widely accepted summary measure, they may obscure within-group disparities and do not fully capture care quality or patient experiences.

Despite these limitations, the study provides valuable cross-national evidence on the associations between health financing structures and disease burden, though its conclusions should be interpreted with appropriate caution.

CONCLUSION

This study aimed to assess how different health insurance models, specifically social, compulsory private, and voluntary private insurance, affect the burden of non-communicable diseases, focusing on cardiovascular conditions and neoplasms among working-age and older adults. It sought to inform health policy design by identifying financing schemes most strongly associated with improved public health outcomes, particularly through the lens of Disability-Adjusted Life Years.

A robust econometric methodology was employed using unbalanced panel data from 51 countries from 2000 to 2021 to achieve this. The study utilized fixed and random effects regression models with clustered robust standard errors to account for heteroskedasticity and serial correlation. DALY rates across age groups (15-49 and 50-69) and disease types (cardiovascular disease and neoplasms) served as dependent variables. In comparison, seven types of health financing schemes were included as explanatory and control variables.

The results reveal that health insurance-based financing models – particularly voluntary and compulsory private insurance – are consistently associated with significantly lower DALY rates for cardiovascular diseases in both age cohorts. Social insurance and government health schemes also demonstrate protective effects. However, enterprise financing shows a statistically significant positive association

with higher DALY rates, suggesting inefficiencies or inadequate coverage in employer-based systems. In contrast, financing mechanisms such as NPISH and out-of-pocket payments yielded inconsistent or statistically insignificant results, especially after applying robust corrections. While results were more variable for neoplasms, government schemes and compulsory insurance remained relevant, particularly in older age groups, with voluntary private insurance losing significance in some models. Temporal trends further underscored substantial health improvements over the study period, suggesting global advancements in healthcare delivery, early detection, and treatment access.

Based on these findings, several policy recommendations can be drawn. First, expanding access to structured insurance, particularly voluntary and compulsory private coverage, may yield substantial health benefits, especially in reducing the burden of cardiovascular disease. Second, governments should continue to invest in and expand universal or social health insurance schemes, which show consistently favorable effects across conditions and age groups. Third, enterprise-based healthcare systems should be critically reviewed and restructured to address their apparent inefficiencies. Finally, policies that reduce reliance on out-of-pocket payments may improve equity but should be paired with efforts to evaluate the actual quality and continuity of care provided.

These insights emphasize the importance of health financing design as a strategic tool for improving population health and reducing disease burden. While the study's scope is limited by data availability and external shocks not captured post-2021, its evidence-based implications are timely and relevant for countries seeking to reform or enhance their health systems for long-term resilience and effectiveness.

AUTHOR CONTRIBUTIONS

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APPENDIX A

The list of countries included in the panel dataset

Argentina, Australia, Austria, Belgium, Brazil, Bulgaria, Canada, Chile, China, Colombia, Costa Rica, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, India, Indonesia, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Malta, Mexico, Netherlands, New Zealand, Norway, Peru, Poland, Portugal, Romania, Slovak Republic, Slovenia, South Africa, Spain, Sweden, Switzerland, Türkiye, Ukraine, United Kingdom, and United States.

APPENDIX B

Table B1. Descriptive statistics output

Variable	year	xl	x2	x3	x4	x5	x6	x7	y1	y2	y3	y4
Mean	12.34	2.43	0.34	0.46	0.05	0.06	1.74	2.83	1,201.33	9,314.12	1,436.35	10,388.63
SD	6.03	2.37	1.16	0.63	0.06	0.09	0.66	2.67	825.28	6,402.31	352.94	2,676.72
Median	13	2.12	0	0.23	0.03	0.02	1.63	1.4	895.99	6,617.56	1,369.98	9,941.2
Trimmed	12.45	2.17	0.02	0.33	0.04	0.04	1.71	2.51	1,047.83	8,172.25	1,403.9	10,236.19
Mad	7.41	3.1	0	0.31	0.04	0.03	0.64	1.60	440.22	3,588.75	301.74	2,640.76
Min	1	0	0	0	0	0	0.45	0.01	279.17	2,384.11	727.41	5,505.9
Max	22	9.14	5.84	3.68	0.45	0.78	3.60	10.1	4,810.24	37,525.23	3,095.03	18,993.77
Range	21.00	9.14	5.84	3.68	0.45	0.78	3.15	10.09	4,531.06	35,141.12	2,367.62	13487.87
Skew	–0.12	0.60	3.69	2.94	1.39	2.49	0.42	0.85	1.70	1.56	1.02	0.58
Kurtosis	–1.09	–0.69	12.2	10.45	2.57	8.58	–0.47	–0.65	2.53	2.13	1.38	0.03
Se	0.19	0.08	0.04	0.02	0	0	0.02	0.08	26.16	202.97	11.19	84.86

Table B2. Outputs of the temporal t-coefficient analysis using year dummies of the influence of healthcare financing schemes on the DALY rate for cardiovascular diseases in the 15-49 age group

Source: Authors' calculation in R Studio.

Estimate	Estimate	Std. Error	t value	Pr(> |t|)
xl	53.8288	29.8913	1.8008	0.07206 .
x2	49.9339	32.9299	1.5164	0.12977
x3	33.8247	64.0153	0.5284	0.59736
x4	–378.2493	387.7053	–0.9756	0.32952
x5	131.8701	246.2034	0.5356	0.59235
x6	–127.2751	79.1336	–1.6084	0.10810
x7	43.7904	22.0182	1.9888	0.04702*
factor(year)2001	–5.4871	13.6671	–0.4015	0.68816
factor(year)2002	29.6627	17.3469	–1. 7100	0.08761 .
factor(year)2003	–4.2873	32.8531	–0.1305	0.89620
factor(year)2004	3.7782	38.4907	0.0982	0.92183
factor(year)2005	–41.6576	36.0660	–1.1550	0.24838
factor(year)2006	–63.4383	40.5287	–1.5653	0.11786
factor(year)2007	–79.9274	43.8763	–1.8217	0.06883 .
factor(year)2008	–161.1980	40.3638	–3.9936	< 0.0001***
factor(year)2009	–214.4373	41.4370	–5.1750	< 0.0001***
factor(year)2010	–257.1491	45.0261	–5.7111	< 0.0001***
factor(year)2011	–298.0223	48.9064	–6.0937	< 0.0001***
factor(year)2012	–325.3887	48.4037	–6.7224	< 0.0001***
factor(year)2013	–349.9604	48.8819	–7.1593	< 0.0001***
factor(year)2014	–364.0183	48.1766	–7.5559	< 0.0001***
factor(year)2015	–385.3144	50.4324	–7.6402	< 0.0001***
factor(year)2016	–394.2417	49.4034	–7.9800	< 0.0001***

Table B2 (cont.). Outputs of the temporal t-coefficient analysis using year dummies of the influence of healthcare financing schemes on the DALY rate for cardiovascular diseases in the 15-49 age group

Estimate	Estimate	Std. Error	t value	Pr(> |t|)
factor(year)2017	–410.0824	50.1005	–8.1852	< 0.0001***
factor(year)2018	–417.8291	51.4275	–8.1246	< 0.0001***
factor(year)2019	–451.2379	55.4921	–8.1316	< 0.0001***
factor(year)2020	–507.6682	66.0539	–7.6857	< 0.0001***
factor(year)2021	–510.4006	65.7195	–7. 7663	< 0.0001***

Note: '***' – 0.001; '**' – 0.01; '*' – 0.05; '.' – 0.1; 'No symbols' – insignificant.

Table B3. Outputs of the temporal t-coefficient analysis using year dummies, the influence of healthcare financing schemes on the DALY rate for neoplasms in the 15-49 age group

Source: Authors' calculation in R Studio.

Estimate	Estimate	Std. Error	t value	Pr(> |t|)
xl	46.4995	30.3570	1.5318	0.1259
x2	20.0789	31.8365	0.6307	0.5284
x3	63.6609	60.2719	1.0562	0.2911
x4	–233.5081	404.9852	–0.5766	0.5644
x5	78.2708	240.3374	0.3257	0.7448
x6	–110.5407	46.1289	–2.3963	0.0168*
x7	5.3456	21.2274	0.2518	0.8012
factor(year)2001	–16.0027	9.6158	–1.6642	0.0964
factor(year)2002	–32.0456	14.5350	–2.2047	0.0277*
factor(year)2003	–17.1587	29.6218	–0.5793	0.5626
factor(year)2004	–20.4116	32.9987	–0.6186	0.5364
factor(year)2005	–67.1803	34.6606	–1.9382	0.0529 .
factor(year)2006	–90.7883	38.0674	–2.3849	0.0173*
factor(year)2007	–103.7737	41.2939	–2.5130	0.0121*
factor(year)2008	–150.3197	38.7428	–3.8799	0.0001***
factor(year)2009	–172.4216	50.9546	–3.3838	0.0008***
factor(year)2010	–204.2305	50.7673	–4.0229	< 0.0001***
factor(year)2011	–237.9376	51.0797	–4.6582	< 0.0001***
factor(year)2012	–251.3475	52.3744	–4.7991	< 0.0001***
factor(year)2013	–274.3217	54.1468	–5.0663	< 0.0001***
factor(year)2014	–285.4095	54.5565	–5.2314	< 0.0001***
factor(year)2015	–298.1746	56.2295	–5.3028	< 0.0001***
factor(year)2016	–306.8504	58.5058	–5.2448	< 0.0001***
factor(year)2017	–329.0049	59.0429	–5.5723	< 0.0001***
factor(year)2018	–339.0813	61.3096	–5.5306	< 0.0001***
factor(year)2019	–357.8735	64.4291	–5. 5545	< 0.0001***
factor(year)2020	–419.7809	81.9829	–5.1203	< 0.0001***
factor(year)2021	–424.6794	82.2409	–5.1638	< 0.0001***

Note: '***' – 0.001; '**' – 0.01; '*' – 0.05; '.' – 0.1; 'No symbols' – insignificant.

Table B4. Outputs of the temporal t-coefficient analysis using year dummies, the influence of healthcare financing schemes on the DALY rate for neoplasms in the 50-69 age group

Source: Authors' calculation in R Studio.

Estimate	Estimate	Std. Error	t value	Pr(> |t|)
xl	–66.671	129.797	–0.5137	0.6076
x2	34.340	140.268	0.2448	0.8067
x3	395.147	298.934	1.3219	0.1866
x4	–1,480.132	1855.930	–0.7975	0.4254
x5	453.381	1084.000	0.4182	0.6759
x6	–683.524	239.665	–2.8520	0.0044

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Table B4 (cont.). Outputs of the temporal t-coefficient analysis using year dummies, the influence of healthcare financing schemes on the DALY rate for neoplasms in the 50–69 age group

Estimate	Estimate	Std. Error	t value	Pr(> |t|)
x7	–146.929	95.587	–1.5371	0.1246
factor(year)2001	–144.822	60.709	–2.3855	0.0173
factor(year)2002	–273.809	69.217	–3.9558	< 0.0001***
factor(year)2003	–397.236	105.990	–3.7479	0.0002
factor(year)2004	–452.522	113.630	–3.9824	< 0.0001***
factor(year)2005	–671.432	148.417	–4.5239	< 0.0001***
factor(year)2006	–746.110	176.831	–4.2193	< 0.0001***
factor(year)2007	–857.208	194.232	–4.4133	< 0.0001***
factor(year)2008	–954.871	180.001	–5.3048	< 0.0001***
factor(year)2009	–934.830	219.104	–4.2666	< 0.0001***
factor(year)2010	–1,082.109	220.730	–4.9024	< 0.0001***
factor(year)2011	–1,214.320	217.999	–5.5703	< 0.0001***
factor(year)2012	–1,251.857	221.032	–5.6637	< 0.0001***
factor(year)2013	–1,394.072	234.382	–5.9479	< 0.0001***
factor(year)2014	–1,460.513	240.475	–6.0735	< 0.0001***
factor(year)2015	–1,530.309	245.711	–6.2281	< 0.0001***
factor(year)2016	–1,604.873	252.549	–6.3547	< 0.0001***
factor(year)2017	–1,808.902	261.164	–6.9263	< 0.0001***
factor(year)2018	–1,919.034	266.593	–7.1984	< 0.0001***
factor(year)2019	–2,073.132	278.785	–7.4363	< 0.0001***
factor(year)2020	–2,266.681	360.279	–6.2915	< 0.0001***
factor(year)2021	–2,333.131	362.786	–6.4312	< 0.0001***

Note: '***' – 0.001; '**' – 0.01; '*' – 0.05; '.' – 0.1; 'No symbols' – insignificant.