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The mitigating effect of social protection on undernourishment during economic downturns: A longitudinal study of 46 low- and middle-income countries over the last two decades

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ABSTRACT

Background: Low- and middle-income countries (LMICs) are particularly vulnerable to the adverse effects of economic downturns on the Prevalence of Undernourishment (PoU). Our study aimed to evaluate the impact of Social Protection and Labor Programs (SPL) on PoU in 46 LMICs from 2001 to 2019, and to estimate SPL mitigating effects during economic downturns.

Methods: This cohort study used a multi-country ecological design with two-ways fixed effects multivariable linear regression models, adjusted for relevant demographic, socioeconomic, and contextual variables. Interaction terms between economic downturns and SPL were used to evaluate SPL mitigating effects.

Findings: Our study cohort displayed an average 15.30% PoU and 34.34% SPL coverage in the initial year, contrasting with 8.58% PoU and 43.81% SPL coverage in the final year. A 10% SPL coverage was associated with a 0.51% PoU reduction (95%CI: 0.04–0.99) across all countries and 0.78% reduction within the poorest subgroup. SPL have been able to prevent an estimated 1.01 billion (95% UI: 0.16–1.86) cases of undernourishment over the study period in the 46 LMICs. Economic downturns were associated with a 4.55% PoU increase (95% CI: 1.28–7.81) in all countries, and a 6.06% PoU increase in the poorest subgroup. High SPL coverage during the downturns had significant mitigating effects, reducing an overall 1.17% PoU for every 10% SPL coverage in all countries, and 1.81% PoU in the poorest nations.

Interpretation: Amid the ongoing multiple global crises, expanding the coverage of social protection could effectively mitigate the potential increases in undernourishment during economic downturns, contributing to the achievement of nutrition-related Sustainable Development Goals in LMICs.

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1. Introduction

The understanding and evaluation of the relationships between economic downturns and populational prevalence of undernourishment (PoU) is of utmost importance in the current era of multiple global crises. As a result of the COVID-19 pandemic, world economies decreased 3.1% in their Gross Domestic Product (GDP) in 2020. Recent projections point to a significant and enduring deceleration in economic growth worldwide. In 2023, global growth is anticipated to fall to 2.1%, with a widespread decline, affecting nearly every region across the globe (World Bank, 2023a). The result is per-capita income growth lower than observed in the decade preceding the COVID-19 pandemic. The adverse impact on global prosperity is expected to persist.

Moderate food insecurity refers to the inability to regularly eat healthy and balanced diets while severe food insecurity to the high probability of having a reduced food intake (United Nations, 2023). Undernourishment is defined as "an uncomfortable or painful physical sensation caused by insufficient consumption of dietary energy", becomes chronic when the person does not consume enough calories on a regular basis to lead a normal, active, and healthy life(FAO et al., 2019). Severe food insecurity and undernourishment are very similar concepts situated in the extreme spectrum of food insecurity. They differ in that the first refers to the personal experience related to nutrition and the second directly refers to energy intake. Due to the current widespread economic downturns and economic volatility, the World Bank expressed food insecurity as a critical issue (World Bank, 2020). FAO estimates that about one in three people in the world (2.4 billion people) faced moderate or severe food insecurity in 2022, representing 391 million more people since 2019. Moreover, it has been estimated that 735.1 million people worldwide faced hunger in 2022, an increase of 146.2 million from 2015 when the United Nations' 2030-Sustainable Development Goal's (SDGs) agenda was set (FAO et al., 2023). These figures compel the need for a better understanding of the influence of countries economic evolutions over undernourishment levels as well of the social protection capacity to mitigate this.

Country GDP downturns are one of the principal drivers that negatively affect the dynamics of food systems and people's access to food. This is because GDP downturns affect employment levels and wages (i.e., lowering household real income), which reduces people's ability to afford healthy food, increasing food insecurity and undernourishment (FAO et al., 2019). In turn, the adverse effects of economic downturns also include fiscal deterioration and increases in public debt, which often negatively impact the funding of Social Protection and Labor Programs (SPL), especially in low- and middle-income countries (LMICs) (see Fig. 1). SPL provides income support to vulnerable populations, including food, which can mitigate undernourishment (FAO et al., 2019).

The PoU, per capita GDP growth, and social protection systems are monitoring indicators for the achievement of the SDG targets 2.1, 8.1, and 1.3 respectively (United Nations, 2023). Previous studies have analysed the association between macroeconomic determinants and nutrition-associated health outcomes, including undernourishment (Aziz et al., 2021; Fathelrahman et al., 2022; Headey and Ruel, 2022; Saccone, 2021; Smith and Haddad, 2014). A recent article by Saccone estimated the effects of economic growth on the PoU in a sample of 84 countries over the period of 2000–2017 and found that limited economic growth can negatively affect the PoU (Saccone, 2021).

Social protection policies and programs are considered some of the most effective interventions to improve the nutritional status of the population (Olney et al., 2021). Social protection can be sub-categorized into three main components: social safety nets (where beneficiaries do not need to make contributions to the funds), social insurance (where individuals make contributions to the fund), and labour market programs (where beneficiaries may or may not need to make contributions to the funds, with the aim of increasing employment and income, such as training, wage subsidies, unemployment insurance, among others). Each one addresses specific vulnerabilities, buffers against unexpected income drops, and protects against income loss from unemployment. Social protection promotes resilience, equity, and opportunities, which are especially needed during an economic crisis (Ivaschenko et al., 2018).

A review and analysis of different international experiences and evidence on social protection and food insecurity have highlighted the importance of increasing access and availability of food through social protection schemes including cash transfers, labour and input production programs, food transfers, and other more integral programs to improve nutrition outcomes (Slater et al., 2014). Observational analyses of the association between social protection and food insecurity have been conducted in both high-income countries and LMIC's (Borjas, 2004; Maffioli et al., 2023; Men et al., 2021; Reeves et al., 2021; Schmidt et al., 2016). Recently, Reeves et al. found a positive association between lower or no social financial assistance and increased risk of food insecurity using individual data from 142 countries (Reeves et al., 2021); Maffioli et al. have also found that cash transfers are negatively associated with food insecurity, and positively with consumption of

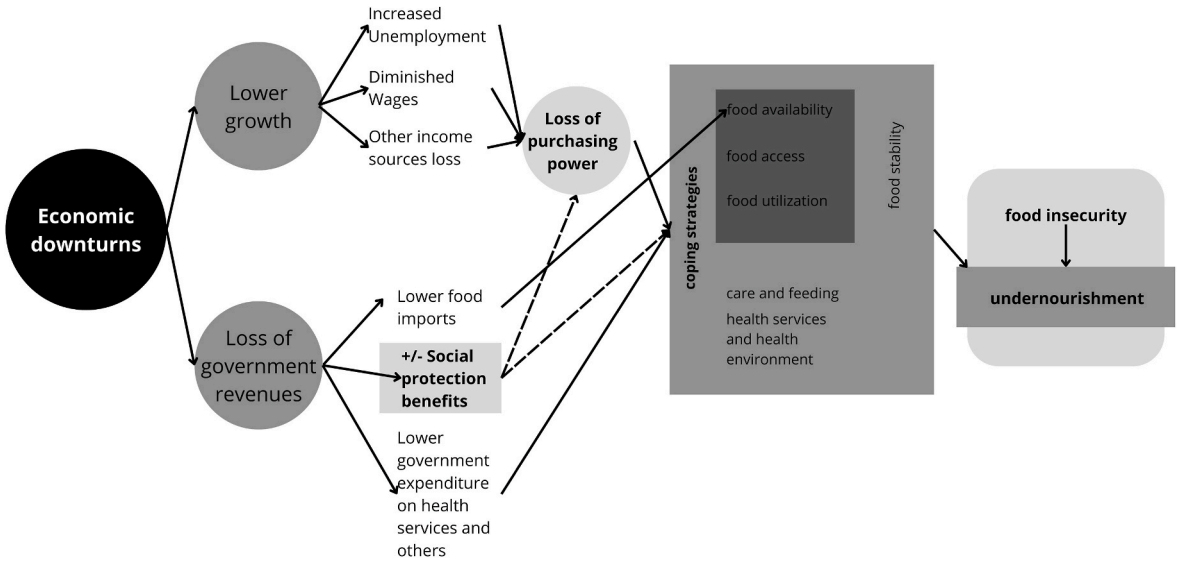

Fig. 1. Conceptual framework of the relationship between economic downturns, undernourishment, and social protection.
Source: Based on "The State of Food Security and Nutrition in the World 2019" (FAO et al., 2019)

nutritious foods in Myanmar (Maffioli et al., 2023).

Specifically, social protection schemes during economic shocks can play a particular relevant role. The discussion relies on weather increasing social protection benefits may be important to mitigate negative effects on nutrition, and which are the more effective schemes for this. Cash and food transfers can be flexible enough and effective in urgent situations, also more integrated programs can help to generate awareness and knowledge to better manage and cope with these situations. Certain evidence and experiences are available on this; however, these are not conclusive (Gentilini, 2022; Slater et al., 2014).

To date, there is no evidence of the impact of social protection on child and adult PoU during economic downturns. This study's objective is to comprehensively evaluate the mitigating effects of social protection and labour programs on the prevalence of undernourishment during economic downturns, using a cohort of 46 low- and middle-income countries over the period 2001–2019.

2. Methods

2.1. Study design and sample

This country-level longitudinal study includes yearly data from 2001 to 2019 for 46 LMICs (as defined by the World Bank country income classification 2022). The countries included in the cohort were LMICs for which data on the *PoU* and *SPL coverage* observations were available during the study period. This resulted in a cohort of five low-income, 17 lower-middle-income, and 24 upper-middle-income countries (appendix B), representing 848 country-years.

2.2. Variables and data sources

The primary outcome of the study is *PoU* from the Food and Agriculture Organisation of the United Nations (FAO) Statistics database (FAOSTAT). Additionally, we gathered the per capita *GDP* per capita from the World Bank Development Indicators database, and *SPL coverage* from the World Bank's Atlas of Social Protection Indicators of Resilience and Equity (ASPIRE).

Because we required a consistent indicator available across a large set of LMICs for an extended period, we considered *GDP* per capita *growth* (annual %) as the most robust indicator, which is also commonly used to express the general state of a country's entire economy. For this study, a country was considered in an economic downturn if its GDP per capita decreased in comparison with the previous year (Kose et al., 2020; Maruthappu et al., 2017; Ng et al., 2015). Then, economic downturns are represented with a dummy variable that assigns the value of 1 when the GDP per capita (constant USD, 2015) growth was negative for a country-year.

The *PoU* is expressed as a percentage of total country population "whose habitual food consumption is insufficient to provide the dietary energy levels that are required to maintain a normal active and healthy life" (United Nations, 2023). This indicator is yearly estimated by FAO for the entire population at country-level since 2000. In the statistical model, *PoU* was introduced with a one-year lead to the independent variables to express the lag effect the exposition variables would have on undernourishment. No lag, two year, and three year lag effects were analysed in the sensitivity analyses.

The *SPL coverage* represents the percentage of the population covered by any ongoing SPL program in the country. This indicator is generated based on data from nationally representative household surveys, collected by the national statistical offices of each country, which is then harmonized by the World Bank's ASPIRE (World Bank, 2023b). An interaction term between *economic downturns* and *SPL coverage* was included to estimate the mitigating effect of *SPLs* on *PoU* during *economic downturns*.

Relevant covariates were included in the analysis to control for possible confounding effects, namely: occurrence of a *natural disaster*, occurrence of a *conflict-war*, percentage of *arable land*, percentage of individuals having access to *basic sanitation*, *variation in food production*, percentage of the population in *poverty*, and *population growth*. Time dummies for the years within the study period were also added to the model to adjust for time variant events across countries.

A national state of emergency due to a *natural disaster or conflict-war* (domestically or internationally) were extracted from the Varieties of Democracy (V-dem) Project database and express the mean dichotomous answer of several experts' opinion (existence vs. non-existence of emergency state in each country-year). Percentage of the individuals having access to *basic sanitation* was obtained from the World Bank Development Indicator database. We included *poverty* as the percentage of the population living on less than $2.15, $3.65, or $6.85 a day in 2017 (measured as purchasing power parity) in low, lower middle-, or upper middle-income countries respectively, extracted from the World Bank Development Indicator database. Percentage of *arable land* indicates the percentage of the county's land that can be dedicated to food crops, extracted from FAOSTAT. *Per capita food production variability* (constant 2014–2016 international dollars per capita) corresponds to the variability of the per capita production of food value in constant 2014–2016 international dollars (I$), extracted from FAOSTAT. *Population growth* is the percentage growth rate of the country, extracted from the World Bank Development Indicator database. All references of the used datasets are provided in the Supplementary Materials (appendix E p.14).

Out of the 874 potential observations in the sample (i.e., 19 years across 46 countries), there were significant missing data for SPL coverage and poverty, with missing rates of 67.05% and 41.76%, respectively. Consequently, these variables were linearly interpolated and extrapolated, maintaining the values of the nearest year with available data. These techniques have been previously employed in panel data studies (Rasella et al., 2013). The analysis ultimately considered 848 observations (i.e., discarding 26 observations, representing 3% of the potential sample), because the sample had a few observations with missing data for variables *Basic Sanitation, Arable Land* and *Food Production Variation*.

2.3. Statistical analysis

We used one of the most robust models for impact evaluation with panel data: a two-ways fixed-effects linear model to control for both unit-specific time-invariant unobserved variables that could not be controlled otherwise (i.e., by using the random effects), and for time-specific and time variant (but unit-invariant) unobserved variables across countries (Khandker et al., 2010). Panel data models were conducted with standard errors (clustered by country), which are robust for autocorrelation and heteroscedasticity (Arellano and Honoré, 2001). Equation (1) (eq. (1)) describes our model:

$$PoU_{it+1} = \beta_0 + \beta_1\, EC_{it} + \beta_2\, SP_{it} + \beta_3\, I_t + \beta_4\, X_{it} + \beta_t\, T_t + \alpha_i + \varepsilon_{it} \qquad \text{(eq.1)}$$

Where i = country, t = year, *PoU* = prevalence of undernourishment, *EC* = economic downturn dummies, *SP*= SPL coverage, I = interaction term (*EC* x *SP*), X = set of covariates (i.e., natural disasters, conflict-war, arable land, food production variation, basic sanitation, poverty, population growth), T = year fixed effects, α = country fixed effects, and ε = error term.

The regressions were weighted by the population of each country in 2019. Subgroups analyses of country income-level were conducted. In order to maintain the number of observations that could ensure adequate statistical power, only two strata were created: middle-income countries (MICs), and lower middle- and low-income countries (LMLICs). A strata of only low-income countries (LIC) has not been created due to its insufficient statistical power.

Several additional sensitivity analyses and robustness checks were conducted, included in the Supplementary Materials (appendix D). First, we ran the regression without including a lag effect, then including a

two year, and three-year lag effect. Second, we added one additional year to the definition of economic downturn (after the first *economic downturn* year). Third, varying the sample of countries, we excluded the ones that do not account for at least two observations of the *SPL coverage* and excluded countries that do not account for at least four observations of the *SPL coverage*. Fourth, we linearly extrapolated the *SPL coverage* instead of keeping the nearest observation. Fifth, we utilized different covariates combinations (e.g., adding other variables not used in the main model specification, adding the covariates one by one, among others).

Moreover, an impact estimationof the SPL coverage on the PoU in the countries under study was determined by computing the difference between the estimated number of undernourished individuals predicted by the main model estimations and the number predicted when setting the *SPL coverage* to zero over the whole study period. Based on (eq. (1)), 1000 predictions of the *PoU* for both scenarios were conducted using Montecarlo simulations by varying the β1, β2, and β3 coefficients in each simulation - sampling them from a normal distribution with mean in their point estimate and standard deviation being the corresponding standard error of the estimate. Then, the average simulated *PoU* were computed for both scenarios (and 2.5–97.5 percentiles for the Uncertainty Intervals). Lastly, these were multiplied by the country's population number to obtain the total undernourished people in both scenarios and its difference (i.e., the prevented number of undernourished people).

3. Results

Table 1 shows the descriptive analysis of the variables under study during the period 2001–2019. LMICs have made progress towards food security over the whole period. *SPL coverage* also expanded across the analysed countries. The mean *PoU* showed a decreasing trend over the study period, going from 15.30% to 8.58%. Inversely, the *SPL coverage* increased, starting at 34.34%–43.81%. Country-years with an *economic downturn* represented 13.84% of the sample during the study period, with a higher value in 2019 (31.98%) than in 2001 (17.83%). While the proportion of *natural disasters* by year increased from 0.98% to 2.65%, war-conflict decreased from 5.70% to 1.89%. Although *basic sanitation* notably increased (from 52.85% to 71.59%), the percentage of *arable land* remained stable around 21.46–22.24%. *Food production variation* and *population growth* averages also remained stable. On the other hand, *poverty* substantially reduced from 36.40% to 17.58%.

The main results of the estimated model are presented in Table 2. Accounting for the covariates, the *economic downturn*, *SPL coverage*, and the interaction term were significant. We found that the *PoU* increased 4.55%-points after a year of *economic downturn*. A 1%-point increase in *SPL coverage* led to a decrease of 0.05%-point in *PoU*. After an economic downturn, a 1%- point increase in *SPL coverage* would result in an additional decrease of 0.07%-point in *PoU*.

Table 2
Estimations Main Results, 2001–2019 sampled low- and middle-income countries.

	Coef.	[95% Confidence Interval]
Economic Downturn	4.55 **	1.29 to 7.81
SPL Coverage (percentage from 0 to 100%)	−0.05 **	−0.10 to −0.00
Interaction term (SPL Coverage*Economic Downturn)	−0.07 **	−0.12 to −0.01
Natural Disasters	6.14 **	0.92 to 11.36
Conflicts-war	0.65	−2.19 to 3.48
Arable Land (%)	−1.00 **	−1.67 to −0.33
Food Production Variation (%)	0.06 **	0.01 to 0.10
Basic Sanitation (%)	−0.21 **	−0.04 to −0.01
Poverty rate (%)	0.03	−0.12 to 0.17
Population Growth	0.95	−1.13 to 3.03
Constant	45.77 **	32.95 to 58.60
Year:		
2002	−0.25	−1.31 to 0.80
2003	−0.39	−2.15 to 1.37
2004	−0.43	−2.67 to 1.81
2005	−0.83	−3.56 to 1.90
2006	−0.92	−3.91 to 2.07
2007	−0.95	−4.38 to 2.47
2008	−1.61	−5.91 to 2.68
2009	−2.35	−7.06 to 2.36
2010	−2.44	−7.78 to 2.90
2011	−2.26	−7.86 to 3.34
2012	−2.16	−8.10 to 3.79
2013	−2.13	−8.52 to 4.26
2014	−2.08	−8.86 to 4.71
2015	−2.25	−9.15 to 4.65
2016	−2.00	−9.01 to 5.01
2017	−1.61	−8.67 to 5.46
2018	−0.58	−7.69 to 6.54
2019	−0.09	−7.40 to 7.22
# of observations	848	
# of countries	46	

Note: Fixed Effect, Clustered Standard Errors, weighted by country population; SPL = social protection and labour programs, **p < 0.05, *p < 0.1.

Table 3 shows the subgroup results. *Economic downturns* were significant on *PoU* in both MICs ($\beta_1 = 3.00$), and LMLICs ($\beta_1 = 6.06$). SPL coverage ($\beta_2 = -0.08$) and the interaction term ($\beta_3 = -0.10$) on *PoU* were significant for the LMLICs group, but only significant for the 90% confidence interval for MICs ($\beta_2 = -0.03$; $\beta_3 = -0.04$). Similar general trends to the main results can be appreciated for both of the sub-groups, however, there was a stronger effect of *economic downturns*, *SPL coverage*, and the interaction between the two, on *PoU* in the poorer group of countries (LMLICs).

All the sensitivity analyses and robustness checks (appendix D) showed effect estimates consistent with the above results.

Table 1
Descriptive Statistics: mean and standard deviations 2001, 2010, 2019.

Variable	Unit	2001		2010		2019		Percentage of change (2001–2019)
		Mean	SD	Mean	SD	Mean	SD	
PoU	Population %	15.30	10.55	10.48	6.58	8.58	6.10	−43.92
Economic Downturn	Proportion of country-years	0.18	0.39	0.10	0.31	0.32	0.47	77.78
SPL Coverage	Population %	34.34	23.50	40.37	22.73	43.81	18.89	27.58
Natural Disasters	Average index value (0–1)	0.01	0.06	0.01	0.04	0.03	0.06	200.00
Conflict-war	Average index value (0–1)	0.06	0.12	0.03	0.08	0.02	0.05	−66.67
Arable land	Land %	21.46	17.50	21.50	16.32	22.24	16.74	3.63
Food Production Variation	I$ per person, constant 2014-16	12.36	11.15	14.08	18.37	12.86	12.10	4.05
Basic Sanitation	Population %	52.85	27.88	62.54	25.95	71.59	25.31	35.46
Poverty	Population %	36.40	14.94	23.38	14.22	17.58	14.34	−51.70
Population Growth	%	1.64	0.93	1.51	0.85	1.37	0.83	−16.46

Note: 2001–2019 sampled low- and middle-income countries, weighted; PoU = prevalence of undernourishment, SPL = social protection and labour programs, I$ = international dollars, SD= Standard Deviation.

Table 3
Estimations Subgroups, 2001–2019 by country income-level aggregations.

	Middle Income Countries (MICs)		Lower Middle- and Low-Income Countries (LMLICs)	
	Coef.	[95% Confidence Interval]	Coef.	[95% Confidence Interval]
Economic Downturn	3.00 **	0.43 to 5.57	6.06 **	2.91 to 9.21
Coverage of SPL's (percentage from 0 to 100%)	−0.03 *	−0.07 to 0.00	−0.08 **	−0.14 to −0.01
Interaction term (SPL Coverage*Economic Downturn)	−0.04 *	−0.09 to 0.00	−0.10 **	−0.16 to −0.05
Natural Disasters	7.00 **	1.38 to 12.60	6.42	−7.28 to 20.11
Conflicts-war	0.74	−3.33 to 4.81	1.94	−2.01 to 5.89
Arable Land	−0.58 **	−0.88 to −0.28	−1.13 **	−1.896 to −0.36
Food Production Variation (%)	0.03 **	0.01 to 0.06	0.12 **	0.02 to 0.21
Basic Sanitation (%)	−0.33 **	−0.42 to −0.23	−0.15	−0.50 to 0.19
Poverty (%)	0.11 **	0.01 to 0.21	0.11	−0.13 to 0.36
Population Growth	0.67	−1.48 to 2.81	−0.12	−3.11 to 2.87
Constant	39.61 **	30.74 to 48.48	53.87 **	38.92 to 68.83
Year:				
2002	0.20	−0.43 to 0.83	−0.40	−2.18 to 1.37
2003	0.25	−1.02 to 1.52	−0.51	−3.26 to 2.25
2004	0.32	−1.44 to 2.08	−0.65	−3.91 to 2.61
2005	0.26	−1.84 to 2.35	−1.29	−5.04 to 2.46
2006	0.43	−1.74 to 2.60	−1.39	−5.12 to 2.34
2007	0.75	−1.66 to 3.16	−1.34	−5.42 to 2.74
2008	0.67	−1.90 to 3.24	−2.36	−7.53 to 2.81
2009	0.46	−1.99 to 2.92	−2.83	−8.01 to 2.34
2010	0.73	−1.95 to 3.40	−3.37	−9.32 to 2.58
2011	1.08	−1.71 to 3.88	−2.71	−8.83 to 3.41
2012	1.38	−1.56 to 4.32	−2.52	−9.22 to 4.18
2013	1.60	−1.61 to 4.81	−2.47	−9.77 to 4.83
2014	1.86	−1.55 to 5.28	−2.52	−10.46 to 5.41
2015	1.90	−1.46 to 5.26	−3.23	−10.93 to 4.47
2016	2.19	−1.41 to 5.79	−2.73	−10.54 to 5.07
2017	2.57	−1.25 to 6.39	−2.17	−10.04 to 5.69
2018	3.55 *	−0.68 to 7.79	−0.95	−8.93 to 7.03
2019	4.19 *	−0.17 to 8.55	−0.49	−8.91 to 7.93
# of observations	753		418	
# of countries	41		22	

Note: Fixed Effects, Clustered Standard Errors, weighted by country population; SPL = social protection and labour programs, **p < 0.05, *p < 0.1.

Table 4 shows the impact results of SPL coverage. The total number of undernourished person-years predicted by the model was 4082 (UI 95%: 3145–5020) million for the entire period. The total number of undernourished person-years predicted by the model in the hypothetic scenario of zero *SPL coverage* scenario was 5088 (UI 95%: 4907–5273) million for the entire period. Consequently, the total number of undernourished person-years prevented by *SPL coverage* was 1007 (UI 95%: 156–1855) million, representing 24.67% of the total predicted number of undernourished person-years.

For the LMLICs subgroup, the total number of undernourished person-years predicted by the model was 3191 (UI 95%: 2703–3680) million for the entire period. The total number of undernourished person-years predicted by the model in the hypothetic scenario of zero *SPL coverage* was 3783 (UI 95%: 3713–3853) million for the entire period in LMLICs. Consequently, the total number of undernourished person-years in LMLICs prevented by *SPL coverage* was 592 (UI 95%: 146–1037) million, representing 18,55% of the total predicted number of undernourished person-years.

For MICs subgroup, the total number of undernourished person-years predicted by the model was 3465 (UI 95%: 2826–4102) million for the entire period. The total number of undernourished person-years predicted by the model in the hypothetic scenario of zero *SPL coverage* was 4080 (UI 95%: 3943–4217) million for the entire period in LMLICs. Consequently, the total number of undernourished person-years in LMLICs prevented by *SPL coverage* was 616 (UI 95%: 44–1190) million, representing 17,78% of the total predicted number of undernourished person-years.

4. Discussion

Our study demonstrated that the economic downturns over the last two decades significantly increased the prevalence of undernourishment in LMICs. Moreover, countries with higher coverage of social protection not only managed to decrease undernourishment throughout this entire period, but also effectively mitigated the negative repercussions of economic downturns, preventing any increase in undernourishment rates. According to our estimates, social protection has been able to prevent more than one billion undernourishment cases in the countries under study over the last two decades. Furthermore, in the poorest countries, economic downturns had a significantly larger impact, and social protection had stronger preventing and mitigating effects. To the best of our knowledge, this study is the first to estimate the effects of social protection over undernourishment on a global scale, suggesting that strong social protection system could play an important role on the food security and nutritional status of populations in the future.

According to recent FAO statistics, the PoU in the world was estimated to be 9.2% in 2022, however, when considering only lower middle-income countries, this figure goes up to 13.4%, and to 28.3% if considering low-income countries (FAO, 2023). The report also states that one of the reasons for the past years rise on undernourishment was

Table 4
Impact estimations, 2001–2019 in million person-years (UI 95%).

Impact Estimations,	N° of Undernourished: Real Social Protection Data Scenario	N° of Undernourished: Population Zero Social Protection Coverage Scenario	N° of Persons Saved from Undernourished due to Social Protection (SPL coverage and Inter effect)	N° of Persons Saved from Undernourished due to Social Protection, solely SPL coverage effect	N° of Persons Saved from Undernourished due to Social Protection, solely Interaction effect with Economic Downturns
Total Sample (N°C: 46)	4082 (3145–5020)	5088 (4907–5273)	1007 (156–1855)	848 (61–1634)	159 (22–297)
MICs (N°C: 41)	3465 (2826–4102)	4080 (3943–4217)	616 (44–1190)	519 (1–1039)	96 (0–204)
LMLICs (N°C: 22)	3191 (2703–3680)	3783 (3713–3853)	592 (146–1037)	540 (104–973)	52 (24–80)

Note: UI= Uncertainty Intervals; MICs = Middle Income Countries, LMLICs = Lower Middle- and Low-Income Countries, SPL = social protection and labour programs; Inter = Interaction term; N°C= Number of countries. For the Total Sample impact estimations, Table 2 coefficients were used and for the MICs and LMLICs, the estimations from Table 3 where used.

the simultaneous and unequal income loss across countries, with the lowest income countries associated with the bigger falls. Our results support the hypothesis that undernourishment is positively associated with economic downturns. Economic downturns reflect households' income loss which translates to food inaccessibility (Aziz et al., 2021; Fathelrahman et al., 2022; Headey and Ruel, 2022; Saccone, 2021; Smith and Haddad, 2014). As a country's economy decreases, unemployment rises and wages are diminished, reducing households' food purchasing capacity. Low-income households have less capacity to cope with income loss. SPL can mitigate negative income shocks as they provide access to food through cash, in-kind transfers, among others (FAO et al., 2019). The stronger impact of economic downturns on undernourishment in the poorest countries is also expected. They have a higher number of people living in extreme poverty and are less resilient to economic downturns (FAO et al., 2019; McCann et al., 2023).

Our analysis also shows that SPLs could reduce undernourishment even during non-downturn periods. These results are congruent with our theoretical framework, and with the existing evidence on the importance of social protection on food insecurity, consumption of nutritious foods, diverse diets, and child and maternal mortality (Loopstra et al., 2016; Maffioli et al., 2023; Rasella et al., 2021). Moreover, our results suggest that SPLs have a particularly strong mitigating effect during periods of economic downturns, especially in LMLICs. These results are consistent with previous studies that demonstrated the mitigating effect of conditional cash transfers during economic downturns on child hospitalization and mortality rates (Rasella et al., 2018), and on the overall mortality rate of the population (Hone et al., 2019).

The impact of SPL on the PoU during both economic downturns and non-downturn periods underscores the urgent need to bolster social protection in the current era, marked by a multitude of compounding global crises. The world finds itself amidst one of the most uncertain and volatile periods in its history. The combined repercussions of the COVID-19 pandemic, the conflict in Ukraine, and the challenges posed by climate change have given rise to what is now termed the "three Cs" (Hughes et al., 2021). A new term, "polycrisis," has emerged to characterize the present era. It refers to a set of different crises that when interacting generate an increased cumulative impact than when existing alone (Heading et al., 2023). Although these crises are of diverse origins and dynamics, they all share a common element: they disproportionately affect the most vulnerable, leading to heightened levels of poverty and global inequality (Rasella et al., 2024). From a public health perspective, the deterioration of socio-economic conditions and essential factors influencing well-being will increase undernourishment, illness, and mortality.

Moreover, even before the current polycrisis era, achieving the 2030 SDG targets related to undernourishment appeared unlikely (FAO et al., 2022). Given these circumstances, our results strongly support the implementation of targeted increases in social protection measures, particularly in poor countries. While SPL coverage has increased in the last two decades, even during the COVID-19 pandemic and current food price crisis, the coverage among the poorest segments of the population remains low in LMICs (Fan et al., 2014). Given this, our analysis reinforces the 2023 International Food Policy Research Institute's Global Food Policy Report which recommends to "invest in incorporating shock-responsive designs into social protection programming to scale up support faster and more effectively during emergencies" (Fan et al., 2014). In line with contracyclical fiscal policy, legislation could be set to guarantee specific contracyclical social protection schemes to automatically react to economics shocks without depending on any circumstantial political will. This would require a strong social protection structure. Expansions of cash or food transfers schemes would benefit from already set infrastructure and know-how capacities of the system bureaucracy, while populations would be more accustomed to navigating the system.

This study has limitations. The first is that all the estimations refer to associations between economic downturns, SPL and PoU, rather than a causal effect of the first two over the last. Secondly, even if the use of a two-ways fixed effects multivariable model, together with the wide range of sensitivity analyses, ensure the robustness of the effect estimates, they cannot be interpreted at the individual level. It's important to recognize that the epidemiological inference can only be made at the aggregate level. This means that the primary estimates should be interpreted solely as the impact of economic downturns or the extent of SPL coverage on the PoU in the population, rather than as the effect of receiving individual-level social protection benefits. Nevertheless, this feature can also be considered a strength of the study. This aggregate-level approach allows us to capture not only the individual-level effects on beneficiaries but also the spillover effects of these programs on non-beneficiaries and on the broader impoverished communities where social protection initiatives are implemented. Another limitation of the study is the heterogeneity in the characteristics and implementation strategies of SPL policies and programs between countries, which limits the interpretability of the results at the country-level. However, the primary goal of our study was to investigate the impact of social protection programs as macro-policies designed to alleviate poverty and address socio-economic vulnerabilities in LMICs.

In conclusion, our study shows that economic downturns have the potential to significantly increase the prevalence of undernourishment in LMICs. Nonetheless, high levels of social protection coverage have the capacity to mitigate this effect, particularly in the poorest countries. During the current era of polycrisis, the expansion and strengthening of social protection systems in LMICs could significantly improve the food security and nutritional status of the population, preventing large numbers of undernourishment cases and contributing to the achievement of health and nutrition-related Sustainable Development Goals.

Declaration of interest statement

All authors declare that they have no conflict of interest to disclose.

CRediT authorship contribution statement

G. Barreix Sibils: Writing – original draft, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. **N. Brachowicz:** Writing – review & editing, Supervision, Methodology, Conceptualization. **N.J. Silva:** Writing – review & editing, Resources, Methodology. **E. Landin:** Writing – review & editing, Methodology, Formal analysis. **I. Macicame:** Writing – review & editing, Supervision, Conceptualization. **M. Naidoo:** Writing – review & editing, Investigation, Conceptualization. **G. de Sampaio Morais:** Writing – review & editing, Methodology, Formal analysis. **D. Rasella:** Writing – review & editing, Writing – original draft, Supervision, Resources, Methodology, Formal analysis, Conceptualization.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

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