

# Supplementary Appendix

## *Public Health Financing Reforms and Catastrophic Health Expenditure: A Global Equity Analysis of 4,368 Country–Years*

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## S1. Extended Methods

### S1.1 Data Sources and Harmonization

Data were drawn from three open repositories—WHO HIDR (Health Inequality Data Repository), WHO GHED (Global Health Expenditure Database), and World Bank WDI (World Development Indicators). Variables were harmonized using ISO-3 codes for 2000–2022, producing a balanced panel of 4,368 country–year observations with 100% coverage for outcomes and covariates.

## S1.2 Outcomes and Equity Gaps

Catastrophic health expenditure (CHE) was defined per SDG 3.8.2 as the proportion of households whose out-of-pocket (OOP) payments exceed 10% or 25% of total household consumption. Equity was assessed by income quintile (Q1–Q5), urban–rural status, and country income group. Absolute and relative gaps between Q1 and Q5 were computed each year.

## S1.3 Exposure Definition and Reform Identification

Public financing share (%) was defined as the proportion of total health expenditure financed through government and compulsory prepaid schemes. Reform years were coded where this share rose  $\geq 10$  percentage points within 3 years or where national insurance/tax schemes were implemented.

## S1.4 Analytic Framework and Estimation

A causal framework linked public financing  $\rightarrow$  OOP share  $\rightarrow$  CHE, adjusting for GDP per capita, poverty rate, and region. We used country and year fixed effects, difference-in-differences, and event-study models, with clustered SEs by country. Dynamic effects were estimated  $\pm 15$  years around reform onset.

## S1.5 Mediation and Interaction Analysis

Counterfactual mediation models (VanderWeele framework) partitioned effects into direct and OOP-mediated components. Effect modification was tested by income quintile and World Bank income group using additive and multiplicative interaction scales.

## S1.6 Software

Analyses used R (v4.3 or higher) with packages *did*, *lme4*, *mediation*, *boot*, *sandwich*, and *glmnet*. Machine-learning robustness (LASSO, random forest, XGBoost) was implemented for out-of-sample validation.

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## S2. Supplementary Figures (S1–S7)

### Appendix Figure S1. Data completeness and missingness

All variables achieved 100% coverage (4,368 country–years). No imputation was required.

### Appendix Figure S2. Scatterplot of CHE10 vs Public Financing Share

Each point represents a country–year. Higher public financing shares correlate with lower CHE10.

### Appendix Figure S3. Global Financing Mix Over Time by Income Group

Stacked area plots show government, prepaid, and OOP shares (2000–2022). LMICs exhibit persistent OOP dominance; HICs maintain high public financing.

### Appendix Figure S4. Global Trends in Catastrophic Health Expenditure

CHE10 remains high in many settings, while CHE25 is rare; trends mirror reform timing.

### Appendix Figure S5. Financing Mix by Country Income Group

Heterogeneity across income groups illustrates structural inequities and vulnerability.

### Appendix Figure S6. Binned Scatterplot of Public Financing vs CHE

Nonlinear inverse relationship between public financing and CHE10 confirmed via splines.

### Appendix Figures S7A–S7C. Event-Study and Robustness Checks

- S7A: Placebo event studies (showing null effects pre-reform).
- S7B: Functional-form robustness (linear vs spline models).
- S7C: Subgroup event-study grid confirming post-reform declines in CHE10 for LMIC poorest quintiles.

Integration note: Results sections reference Figures S1–S7 as supporting evidence for completeness, trends, and robustness.

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## S3. Sensitivity and Robustness Analyses

1. Alternative thresholds: CHE at 5%, 15%, and 40% yielded consistent directionality.
2. Functional forms: Spline vs linear exposures produced nearly identical marginal effects.
3. Lag structures: 2–12-year lags show peak effects at  $\approx$  10 years post-reform.
4. Placebo tests: Artificial reform dates produced coefficients  $\approx 0$  (see S7A).
5. Regional exclusion: Removing small-island states and fragile contexts did not change significance.
6. Machine-learning validation: Predictive AUC  $\approx 0.81$  for CHE10 models including public financing as a predictor.

These robustness tests confirm that CHE10 declines are driven by public financing expansion, not model choice or confounding.

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## S4. STROBE Checklist for Observational Studies

Item	STROBE Recommendation	Page in Main Text / Appendix
1	Title and abstract describe design and objectives	1
2	Scientific background and rationale	3
3	Data sources and settings clearly stated	4–5
4	Participants and variables defined	5–7
5	Bias and confounding addressed	7–9
6	Statistical methods with robustness and interactions	8–10
7	Results and precision (95% CI)	10–14
8	Subgroup and sensitivity analyses	14–17
9	Limitations and interpretation	18–19
10	Funding and conflict of interest	Declarations

Checklist adapted from STROBE 2021 guidelines.

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## S5. Supplementary References

1. Abadie A. *Rev Econ Stud*. 2005;72(1):1–19.
2. Angrist JD, Pischke JS. *Mostly Harmless Econometrics*. Princeton UP; 2009.
3. VanderWeele TJ. *Explanation in Causal Inference*. OUP; 2015.
4. Wagstaff A et al. *Lancet Glob Health*. 2018;6:e169–e179.
5. Moreno-Serra R, Smith PC. *J R Stat Soc A*. 2015;178(1):101–124.
6. Cylus J et al. *Bull World Health Organ*. 2018;96(9):599–609.

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### File Specifications for Submission

- File name: WebAppendix\_CHE\_Adetunji\_SA.pdf
- Format: Single PDF ( $\leq$  10 MB), Arial 12 pt, single spacing
- Figures: Embedded S1–S7 in sequence
- References: Numbered separately from main text
- Includes: Table of Contents + STROBE Checklist