

Implementation of non-communicable disease policies from 2015 to 2020: a geopolitical analysis of 194 countries

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Summary

Background Non-communicable diseases (NCDs) are the leading cause of morbidity and mortality globally. We aimed to analyse trends in implementation of WHO-recommended population-level policies and associations with national geopolitical characteristics.

Methods We calculated cross-sectional NCD policy implementation scores for all 194 WHO member states from the 2015, 2017, and 2020 WHO progress monitor reports, and examined changes over time as well as average implementation by geographical and geopolitical region and income level. We developed a framework of indicators of national characteristics hypothesised to influence policy implementation, including democracy, corporate permeation (an indicator of corporate influence), NCD burden, and risk factor prevalence. We used multivariate regression models to test our hypotheses.

Findings On average, countries had fully implemented a third (32.8%, SD 18.2) of the 19 policies in 2020. Using aggregate policy scores, which include partially implemented policies, mean implementation had increased from 39.0% (SD 19.3) in 2015 to 45.9% (19.2) in 2017 and 47.0% (19.8) in 2020. Implementation was lowest for policies relating to alcohol, tobacco, and unhealthy foods, and had reversed for a third of all policies. Low-income and less democratic countries had the lowest policy implementation. Our model explained 64.8% of variance in implementation scores. For every unit increase in corporate permeation, implementation decreased by 5.0% (95% CI -8.0 to -1.9, $p=0.0017$), and for every 1% increase in NCD mortality burden, implementation increased by 0.9% (0.2 to 1.6, $p=0.014$). Democracy was positively associated with policy implementation, but only in countries with low corporate permeation.

Interpretation Implementation of NCD policies is uneven, but broadly improving over time. Urgent action is needed to boost implementation of policies targeting corporate vectors of NCDs, and to support countries facing high corporate permeation.

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Introduction

Non-communicable diseases (NCDs) account for more than 70% of global mortality.¹ Low-income and middle-income countries (LMICs) bear a disproportionate NCD burden, with a 1.5 times higher risk of premature mortality than high-income countries.^{2,3} In 2013, all 194 WHO member states endorsed a menu of cost-effective NCD so-called best-buy policies,⁴ and in 2015 UN member states unanimously committed to reduce premature NCD mortality by a third by 2030 as part of the Sustainable Development Goals.⁵

The COVID-19 syndemic⁶ has underlined the importance of controlling NCDs, because these conditions and their shared risk factors are associated with adverse COVID-19 outcomes.⁷ The increasing normalisation of national public health interventions, high-profile cases,^{8,9} and widespread disruption to NCD services¹⁰ has also widened the policy window¹⁰ for robust NCD prevention measures.

In 2015, WHO released its first NCD progress monitor,¹¹ reporting the extent to which 18 core NCD policies had been implemented in 194 countries. In 2017, a second progress monitor was released,¹² and our previous work showed that the proportion of implemented NCD policies rose between 2015 and 2017, with human capital and NCD burden as key predictive variables for implementation.¹³ Although we found a weak positive association between democracy and NCD policy implementation, Wigley and colleagues¹⁴ did a more detailed analysis using alternative data sources, finding a robust positive relationship that aligns with the broader literature on governance and health.¹⁵⁻¹⁷ Separate work has documented that big tobacco, alcohol, and processed-food corporations have often attempted to undermine the adoption of effective NCD policies¹⁸⁻²¹ and are disproportionately based in high-income democracies.²² This raises questions about the extent to which NCD policy implementation is associated with corporate influence over policy making processes.

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See [Comment](#) page e1479

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Research in context

Evidence before this study

WHO has produced three reports on the extent to which 19 policies on non-communicable diseases (NCDs) have been implemented in member states. We previously analysed data from 151 countries using the 2015 and 2017 reports, finding that just less than half of all policies had been implemented. Exploratory analyses also showed that NCD burden and human capital explained more than 50% of the variance in implementation scores. Our work supported the wider body of literature around the positive association between health-policy implementation and democracy, gross domestic product, and measures of general social development. McKee and Mackenbach have previously argued that implementation of health policy is driven by means, will, and background social, political, and economic factors. Document reviews from sub-Saharan Africa, Europe, and Asia have suggested that implementation of NCD policies is slow, uneven, and frequently opposed by vested industry groups.

Added value of this study

In this analysis of 194 countries, we used data from all three WHO reports and developed a conceptual model to structure investigation into the factors that influence policy implementation. Our framework explained 64.8% of the variance in global implementation scores. We found that

implementation is decreasing over time for several market-based policies, and overall policy implementation remains lower than 50%. This study advances our understanding of which countries are underperforming and overperforming compared with their regional, political, and economic peers, and identifies specific policies that are being systematically neglected at the global level. This study is the first to apply Lima and Galea's Corporate Permeation Index to a global NCD-policy dataset, and we find that corporate embeddedness is a major correlate for non-implementation.

Implications of all the available evidence

Countries with the highest corporate permeation and where the burden of NCDs is rising fastest are the least likely to have implemented WHO-backed NCD policies. The totality of evidence reaffirms the positive association between health-policy implementation and good governance, as implementation tends to be highest in democratic states with well resourced and managed health systems. While we report correlation rather than causality, the available evidence suggests that targeted efforts to support countries in introducing effective NCD policies (especially around commercial determinants) cannot be divorced from the much broader agenda of raising living standards, enlarging civil liberties, and improving governance.

WHO has now released its 2020 progress monitor,²³ reporting updated global implementation of 19 NCD policies. In this study, we aimed to advance our original analysis exploring the geopolitical characteristics associated with policy implementation on the basis of a new undergirding conceptual framework. We set out to do two comprehensive sets of analyses. First, to review the implementation of NCD policies in 194 countries in 2015, 2017, and 2020, and validate the WHO findings in a subset of countries. Second, to assess the association between NCD policy implementation and a framework of indicators, with particular attention to whether implementation is independently associated with measures of democracy and corporate influence.

Methods

NCD policy implementation scores

We transcribed the WHO NCD progress monitor reports from 2015, 2017, and 2020 into Excel. Following the internal WHO scoring approach and our previous method,¹⁷ we accorded 1 point for fully implemented policies, 0.5 points for partially implemented policies, and 0 points for policies reported as not implemented or when data were missing.

WHO has tightened the criteria for establishing whether policies are fully or partially implemented with each successive progress report. A new policy of tobacco mass-media campaigns was introduced in 2017 so that

the maximum possible score was 18 of 18 in 2015 and 19 of 19 in 2017 and 2020. Two new half points were made available in 2017 for partial implementation of salt and breastmilk policies, and in 2020 for physical activity mass-media campaigns. A full summary of the changes is presented in the appendix (section 2, pp 10–19).

Statistical analysis

For each of the 194 WHO member states we summed the total implementation scores for all NCD policies to create an overall aggregate policy implementation score, presented as a percentage for each year.

When doing statistical analyses across all 3 years, we removed the additional points that were introduced in 2017 and 2020, so that all 3 years had the same maximum scores.

We created a heat map to illustrate the extent of policy implementation by world region and in several prominent geopolitical blocs, selected by the authors on the basis of their perceived geopolitical importance, including the Organisation for Economic Co-operation and Development (OECD), the 27 EU countries (EU27), the Gulf states, the G20, former Soviet states, and Small Island Developing States. We generated a boxplot to display mean implementation score by World Bank income group, and we identified countries with aggregate scores more than 2 SDs higher and lower than the global mean.

See Online for appendix

Validation exercise

In response to informal feedback questioning the reliability of WHO implementation scores, we sought to validate WHO findings in a subset of countries. We note that WHO takes several steps to ensure the validity and reliability of country reports. Through a collaboration with the NCD Alliance, we worked with focal points in a maximum variation sample of 15 countries representing different geographical regions and income levels to assess implementation of each policy using the 2020 WHO criteria. We used descriptive statistics to compare these answers with the 2020 WHO-ascertained scores. Further details are provided in the appendix (section 3, pp 20–27).

Developing a conceptual framework for NCD policy implementation

To analyse which country-level characteristics are associated with NCD policy implementation, we developed a theoretical framework of factors likely to influence adoption of NCD policies. We used a process that built on the work of McKee and Mackenbach²⁴ and Baum and colleagues (appendix, section 4, p 28).²⁵

To test how well our conceptual model explains variance in policy implementation, we developed a framework of indicators to populate a multivariate regression model. Indicator selection was based on conceptual alignment with indicator domain, previous use in global health literature, internal validity, face validity, and data availability; we excluded indicators for which data were not available for at least two thirds of WHO member states. Agreement on the final list of indicators was reached by iterative group discussion between the coauthors, with independent review from Prof Martin McKee (London School of Hygiene & Tropical Medicine, London, UK). In total, 23 indicators were included, of which 15 were regarded as independent variables of interest and eight as controls. We provide a full summary of each indicator domain, definition, data type, source, global coverage, and rationale for inclusion or exclusion from the final framework (appendix, section 5, pp 29–36). When we could not obtain data for the exact year, we used the most recent available value with a 2010 cutoff.

Regression analyses

We analysed the association between NCD policy implementation score as the dependent variable and our framework of indicators (appendix p 3, and section 6, pp 37–38). Univariate and multivariate random-effects regression analyses are based on a panel composed of up to 194 countries for the years 2015, 2017, and 2020.

Our set of control variables was selected to account for factors that might be correlated with our independent variables of interest and NCD policy implementation, including gross domestic product (GDP) per capita, population older than 65 years, urbanisation, continent,

distance to ice-free coast, ethnolinguistic fractionalisation, legal origin, and Muslim population (to capture alcohol policy differences). In the literature, these variables represent a familiar set of controls for the economic, geographical, demographic, and cultural factors that might confound the results.²⁶

Because data on smoking prevalence and Corporate Permeation Index (CPI) were not available in every country, our regression results encompass 123–146 countries for the models that include these indicators. A complete description of the regression models and summary statistics are provided in the appendix (section 7, pp 39–50).

Identification of outliers

To identify outlying countries where implementation was strongly influenced by unmeasured variables, we created a prediction-based Bland-Altman plot,²⁷ charting the difference between WHO ascertained and predicted score (linear prediction for multivariate model including all independent variables of interest and control variables) against the average of the WHO ascertained and predicted policy scores. We set the limits at 5%.

Democracy and policy implementation

We examined whether democracy was associated with policy implementation in two ways. First, by comparing mean aggregate implementation scores between democracies and autocracies, defined using the Bjørnskov-Rode update and expansion²⁸ of Cheibub and colleagues²⁹ democracy-dictatorship dataset. Second, we did bivariate and multivariate regression using the Continuous Multiplicative Polyarchy Index produced by the Varieties of Democracy Institute, covering 172 countries.³⁰ The index captures the five key components of democratic rule, which are suffrage, elected officials, free and fair elections, freedom of civil and political association, and freedom of expression. We hypothesised that democratic countries would be more responsive to their citizens than less democratic countries, and therefore more likely to implement NCD policies. We also hypothesised that the positive effect of democracy would be attenuated in countries with high corporate permeation, measured using Lima and Galea's³¹ CPI. CPI approximates the extent to which corporations are embedded in the political, legal, social, economic, and cultural fabric of any given society.

Model robustness

We examined whether our baseline regressions were sensitive to two indicators of reliability in the reporting of policy data, which are missing data and the Hollyer, Rosendorff, and Vreeland Transparency Index, which captures the extent to which each country accurately reports policy-relevant data.³² In addition, we used multiple imputation to check whether our results are affected by a systematic difference between observed and non-observed data.

We also ran the multivariate model using a least absolute shrinkage and selection operator (also known as lasso) variable selection procedure that accommodates random effects. This reduces the number of regressors by discarding those that contribute little to the model fit. In addition, we produced correlation matrices to test for

collinearity between variables and coefficients (appendix, sections 8–10, pp 51–54).

We ran a sensitivity analysis to assess the effect of our predictors on non-implementation, represented by the number of policies for which a score of zero was registered (appendix, section 11, p 55).

On the basis of concerns that the CPI is comprised of a wide variety of indicators, we developed a new Corporate Political Influence Index (CPII) that focuses on variables capturing the ability corporations have to legitimately and illicitly influence policy (appendix, section 12, pp 56–57). We did a sensitivity analysis using CPII in place of CPI.

We used STATA (version 14.2) and R (version 4.0.2) for all statistical analyses. Our syntax and original data are available on GitHub. Ethical approval was not required.

Role of the funding source

The funders of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

Results

In 2020, on average 32·8% (SD 18·2) of all NCD policies had been fully implemented across all 194 WHO member states. Full or partial implementation was achieved in 61·1% (SD 22·6%) of all policies (figure 1).

Using our aggregate policy scores (which provide half points for partially implemented policies), mean implementation was 39·0% (SD 19·3) in 2015, 45·9% (19·2) in 2017, and 47·0% (19·8) in 2020. High-income countries with lower premature NCD mortality tend to have the highest implementation scores (appendix p 4).

Since 2015, mean implementation has risen for 14 policies, with the largest increases observed for so-called paper-based policies and cardiovascular therapies. Mean implementation has risen for all tobacco policies and fallen for all alcohol policies (figure 2; appendix p 5).

We ranked each country by 2020 score and showed the change in score over time, as well as the variability for each country across the 3 years (figure 3). Full results for each year are available in the appendix (section 23, pp 72–77).

In 2020, Norway and Turkey both attained scores higher than 2 SDs above the mean (17 of 19; in both cases corresponding to 15 fully implemented and four partially implemented policies). Equatorial Guinea (0·5 of 19; with one policy partially implemented), and Guinea Bissau and Sierra Leone (1 of 19; each with two policies partially implemented) attained scores lower than 2 SDs below the mean. As in 2015 and 2017, implementation was highest in the European and South American geographical regions and lowest in sub-Saharan Africa. In terms of geopolitical blocs, former Soviet states, OECD members, and the EU27 saw the highest levels of implementation (figure 4). Mean

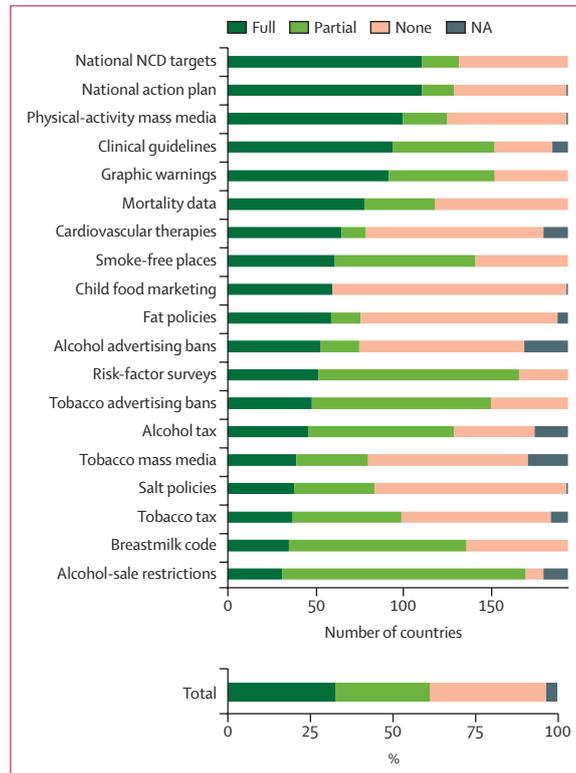


Figure 1: 2020 implementation status of each NCD policy across 194 countries Stacked bar charts are also available for 2015 and 2017 (appendix, sections 13 and 14, pp 58–59). NA=not available. NCD=non-communicable disease.

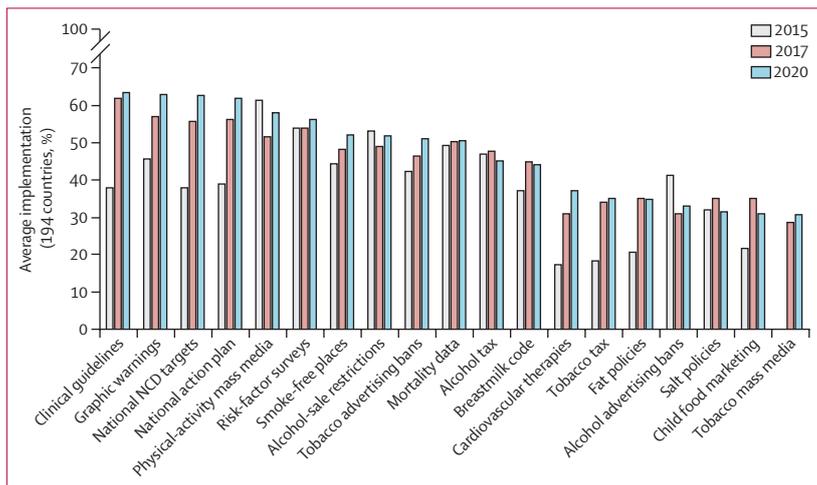


Figure 2: Mean implementation score for each NCD policy Tobacco mass-media policy was only introduced in 2017. NCD=non-communicable disease.

	2020 score	Change in score 2015–20*	Variability (SD) across 2015, 2017, and 2020		2020 score	Change in score 2015–20*	Variability (SD) across 2015, 2017, and 2020
Norway	17	6.0	3.06	Australia	10.5	-2.0	1.00
Turkey	17	6.5	3.28	Croatia	10.5	5.0	2.57
Iran	16	2.5	1.44	Greece	10.5	2.5	1.32
Turkmenistan	16	4.0	2.02	Kuwait	10.5	1.5	0.76
Finland	15.5	4.0	2.02	Morocco	10.5	5.5	2.78
France	15.5	2.5	1.32	New Zealand	10.5	-2.5	1.44
Chile	15	0.5	1.32	Panama	10.5	0.5	0.29
Costa Rica	15	-1.5	0.87	Peru	10.5	4.5	2.25
Czech Republic	15	2.5	1.44	Philippines	10.5	0.5	1.32
Estonia	15	6.0	3.21	Slovakia	10.5	3.5	1.80
Ireland	15	3.0	1.61	Switzerland	10.5	1.0	0.50
Kazakhstan	15	5.5	3.69	Tonga	10.5	3.0	1.89
Lithuania	15	2.5	1.26	Armenia	10	3.0	1.61
Moldova	15	5.0	2.52	Austria	10	2.5	1.26
Portugal	15	3.5	1.76	China	10	1.0	0.76
Slovenia	15	1.5	0.76	Ecuador	10	-2.0	1.32
Thailand	15	4.5	2.29	El Salvador	10	2.5	1.26
UK	15	-0.5	0.29	Indonesia	10	2.0	1.15
Belarus	14.5	2.0	1.04	Qatar	10	0.0	0.29
Brazil	14.5	-2.0	1.00	Albania	9.5	1.5	0.76
Georgia	14.5	9.0	4.93	Bangladesh	9.5	2.0	1.00
Saudi Arabia	14.5	5.5	3.18	Guatemala	9.5	3.0	1.53
Latvia	14	1.0	0.50	Hungary	9.5	-1.5	1.04
Russia	14	1.5	0.87	Iraq	9.5	2.0	1.76
Bulgaria	13.5	0.5	0.76	Jordan	9.5	0.0	2.02
India	13.5	1.5	2.02	Luxembourg	9.5	4.5	2.36
Maldives	13.5	4.5	2.25	Mexico	9.5	0.5	0.50
Brunei	13	0.0	0.00	Nepal	9.5	0.5	0.76
Canada	13	-0.5	0.50	Serbia	9.5	2.0	1.04
Colombia	13	-0.5	1.61	Tajikistan	9.5	-0.5	0.50
Italy	13	1.5	0.87	Cook Islands	9	4.5	2.25
South Korea	13	2.5	1.32	Guyana	9	3.5	1.80
Malta	13	0.5	0.29	Kiribati	9	2.5	1.44
Sri Lanka	13	3.0	1.53	Madagascar	9	-0.5	0.29
United Arab Emirates	13	4.0	2.00	Mauritius	9	3.5	2.57
Argentina	12.5	0.0	0.87	Senegal	9	4.0	2.08
Bahrain	12.5	1.0	1.26	South Africa	9	2.5	1.32
Belgium	12.5	2.0	1.32	Timor-Leste	9	3.5	1.80
Denmark	12.5	1.0	0.58	Tunisia	9	1.0	1.26
Germany	12.5	0.0	0.87	Bosnia and Herzegovina	8.5	1.0	0.76
Seychelles	12.5	4.5	2.25	Botswana	8.5	5.5	2.75
Spain	12.5	0.5	0.50	Ethiopia	8.5	5.0	2.50
Egypt	12	5.5	2.84	Honduras	8.5	1.5	0.76
Iceland	12	2.5	1.80	Kenya	8.5	1.0	0.50
Netherlands	12	2.0	1.15	Montenegro	8.5	1.5	0.87
Oman	12	4.0	2.02	Uganda	8.5	4.5	2.36
Poland	12	2.5	1.61	Venezuela	8.5	2.5	1.44
Ukraine	12	4.0	2.08	Burkina Faso	8	5.0	2.50
Israel	11.5	0.5	0.76	Cape Verde	8	5.5	3.50
Kyrgyzstan	11.5	0.5	1.61	Cuba	8	0.0	0.87
Malaysia	11.5	0.5	0.76	Dominican Republic	8	1.0	1.00
Mongolia	11.5	1.5	1.04	Fiji	8	-3.5	1.80
Romania	11.5	5.0	2.65	Pakistan	8	2.5	1.32
Singapore	11.5	-0.5	0.50	Palau	8	1.0	0.76
Sweden	11.5	2.5	1.32	Saint Lucia	8	3.0	1.50
Vietnam	11.5	2.0	1.32	Sudan	8	2.5	1.26
Azerbaijan	11	4.0	2.47	Trinidad and Tobago	8	3.0	1.61
USA	11	0.5	0.29	Afghanistan	7.5	3.5	3.01
Uruguay	11	1.5	1.26	Barbados	7.5	-0.5	0.76
Uzbekistan	11	1.5	1.26	Benin	7.5	1.5	1.04

(Figure 3 continues on next page)

implementation score rose with each successive World Bank income group ($p < 0.0001$; appendix p 6).

For our validation exercise, NCD Alliance focal points from Bangladesh, Brazil, Ghana, Kenya, Mexico, Sweden, and Vietnam conducted assessments, giving a participation rate of 60%. The COVID-19 pandemic prevented many of our NCD Alliance collaborators from reviewing the WHO ascertained scores. Focal points agreed with WHO assessments of official implementation for 83 (62%) of all 133 policies, with a negligible mean difference in scores. However, there was broader disagreement between WHO and NCD Alliance scores

with regard to whether these policies had actually been implemented in practice. Of the 102 policies for which data were available, 44 (43%) were discordant, with the NCD Alliance scores being lower than WHO ascertained scores in more than two thirds of cases (31 [70%] of 44; full results in the appendix section 15, pp 60–61).

In our regression analyses, all but one of our 15 independent variables of interest were significantly associated (at the $p < 0.05$ threshold) with the aggregate NCD policy implementation score in unadjusted bivariate analyses. In the fully adjusted bivariate analysis, we found a significant association at the $p = 0.05$ level in

	2020 score	Change in score 2015-20*	Variability (SD) across 2015, 2017, and 2020		2020 score	Change in score 2015-20*	Variability (SD) across 2015, 2017, and 2020
Bolivia	7.5	1.0	1.00	Micronesia	5.5	0.0	2.02
Cyprus	7.5	-1.0	0.76	Dominica	5	-0.5	0.76
Jamaica	7.5	-3.5	1.80	Eritrea	5	-1.0	1.26
North Macedonia	7.5	-1.0	0.58	Ghana	5	-0.5	2.47
Paraguay	7.5	-1.0	1.26	Guinea	5	0.0	0.87
Samoa	7.5	5.0	2.65	Lesotho	5	1.5	1.04
Suriname	7.5	-2.0	1.04	Mozambique	5	3.5	2.18
Vanuatu	7.5	4.5	2.75	Saint Kitts and Nevis	5	0.5	0.29
Antigua and Barbuda	7	4.5	2.25	Tuvalu	5	-3.5	2.02
Bhutan	7	-0.5	0.76	Cameroon	4.5	1.0	1.26
Chad	7	3.5	2.36	North Korea	4.5	0.0	0.87
Japan	7	-0.5	0.29	Grenada	4.5	0.5	0.50
Lebanon	7	1.5	1.50	Liberia	4.5	3.5	1.80
Myanmar	7	0.0	0.29	Nicaragua	4.5	-1.5	1.26
San Marino	7	3.5	1.76	Nigeria	4.5	1.0	0.58
Yemen	7	1.5	0.87	Niue	4.5	1.0	0.50
Laos	6.5	3.0	2.08	Zambia	4.5	-1.0	0.76
Tanzania	6.5	5.0	2.57	Andorra	4	-0.5	0.29
Belize	6	2.5	1.32	Comoros	4	0.5	0.29
Burundi	6	4.0	2.18	Congo (Brazzaville)	4	0.5	1.61
Cambodia	6	0.0	0.58	Gabon	4	1.5	1.04
Eswatini	6	2.0	2.52	Marshall Islands	4	2.0	1.15
The Gambia	6	1.5	0.76	Syria	4	1.0	1.26
Mauritania	6	2.0	1.15	Central African Republic	3.5	-0.5	2.47
Namibia	6	1.5	0.87	Monaco	3.5	0.0	1.44
Nauru	6	2.5	1.61	Somalia	3.5	0.5	0.29
Niger	6	0.5	0.29	Algeria	3	-4.5	2.75
Papua New Guinea	6	0.5	1.32	Malawi	3	0.5	0.29
Rwanda	6	1.5	1.04	Mali	2.5	0.0	2.02
Saint Vincent and the Grenadines	6	0.5	0.50	Zimbabwe	2.5	-2.5	1.26
Solomon Islands	6	1.5	0.76	South Sudan	2	2.0	1.00
Togo	6	-2.5	1.44	Angola	1.5	0.5	0.29
The Bahamas	5.5	1.0	0.58	Haiti	1.5	1.5	0.76
Côte d'Ivoire	5.5	4.0	2.02	São Tomé and Príncipe	1.5	0.0	0.29
Djibouti	5.5	3.0	1.61	Guinea-Bissau	1	0.0	0.29
Democratic Republic of the Congo	5.5	2.0	1.32	Sierra Leone	1	-0.5	0.50
Libya	5.5	0.0	0.00	Equatorial Guinea	0.5	-1.5	0.76

Figure 3: NCD policy implementation scores, ranked by aggregate score in 2020

On the colour-coded spectrum, green indicates higher values and red indicates lower values. NCD=non-communicable diseases. *Change in score (SD) is calculated using only the points available in 2015 across all 3 years. This method removed new points that were made available in 2017 and 2020 to enable fair comparison and prevent artefactual inflation over time.

seven indicators, comprising political corruption, corporate permeation, government health expenditure, universal health coverage (UHC) service coverage, NCD mortality burden, smoking prevalence, and mean war mortality (figure 5; appendix, section 16, pp 62–63).

Our adjusted multivariate model explained 64.8% of variance in NCD policy scores and highlights the high degree of collinearity between the variables, given that only corporate permeation and NCD mortality burden remained statistically significant in the fully adjusted model. For every unit increase in corporate permeation (range -5.9 to 6.2, median 0.15), implementation decreased by 5.0% (95% CI -8.0 to -1.9, p=0.0017) and for every 1% increase in NCD mortality burden, implementation increased by 0.9% (0.2 to 1.6, p=0.014).

We presented a prediction-based Bland-Altman plot for 2020 policy implementation using WHO ascertained scores and scores predicted by our multivariate model for each country, using the 23 indicators in our framework (figure 6). Turkey and Chile performed better than would be expected. Algeria and Cyprus were the outlying underperformers.

Democracies had a mean aggregate policy implementation score of 8.4 (SD 3.4), whereas autocracies

had a mean of 7.0 (3.5, p<0.0001 when comparing the two groups). However, democracy was only positively associated with policy implementation in the unadjusted bivariate analysis (p<0.0001).

In the adjusted model, we found that every 0.1 unit increase in the democracy indicator (Multiplicative Polyarchy Index ranging from 0 to 1, median 0.32, IQR 0.04–0.62) was associated with an 18.5% increase in policy implementation score (95% CI -2.4 to 43.9, p=0.087).

For the 146 countries with available data, corporate permeation was negatively associated with overall NCD policy implementation (0.19 in the adjusted model, p=0.0016; appendix p 7). The negative association between CPI and implementation diminishes as income increases; for countries with a GDP higher than US\$ 45 000 per capita (2011 purchasing power parity) the effect of CPI is statistically indistinguishable from zero, based on an interaction model using all covariates.

The mean 2015 CPI score was 5.5 (SD 2.2) in democracies and 6.6 (SD 1.5) in autocracies (p<0.0001 for the comparison between both groups). We found that democracy was only positively associated with NCD policy implementation in the 23.9% of countries

	Former Soviet states	OECD	EU27	G20	Gulf states	SIDS	World Bank income category				WHO region					
							High	Upper middle	Lower middle	Low	AFR	WPR	AMR	EMR	SEAR	EUR
n	15	36	27	43	6	38	57	60	46	31	46	27	35	22	11	53
National NCD targets	93%	49%	44%	59%	100%	63%	55%	68%	70%	55%	58%	67%	70%	64%	100%	52%
Mortality data	90%	100%	98%	93%	50%	50%	89%	61%	23%	2%	8%	41%	80%	27%	14%	91%
Risk-factor surveys	83%	68%	61%	67%	58%	45%	59%	61%	57%	42%	39%	69%	51%	55%	68%	66%
National action plan	93%	58%	57%	63%	100%	59%	63%	64%	64%	52%	47%	65%	60%	59%	100%	68%
Tobacco tax	37%	76%	81%	74%	25%	18%	59%	39%	18%	8%	12%	33%	26%	27%	32%	66%
Smoke-free places	50%	49%	48%	52%	25%	46%	51%	62%	46%	45%	38%	59%	66%	48%	59%	52%
Graphic warnings	90%	92%	100%	92%	58%	50%	79%	63%	61%	37%	40%	70%	66%	45%	68%	83%
Tobacco advertising bans	57%	46%	54%	51%	92%	42%	50%	49%	52%	55%	54%	54%	33%	68%	50%	52%
Tobacco mass media	40%	53%	41%	48%	33%	21%	44%	27%	32%	13%	18%	39%	24%	34%	41%	38%
Alcohol-sale restrictions	53%	44%	44%	47%	58%	49%	47%	54%	54%	52%	50%	43%	54%	70%	64%	46%
Alcohol advertising bans	83%	49%	44%	41%	42%	12%	35%	33%	35%	26%	21%	13%	11%	57%	55%	54%
Alcohol tax	63%	43%	35%	37%	33%	45%	40%	47%	47%	48%	45%	41%	46%	59%	41%	42%
Salt policies	50%	68%	67%	64%	92%	13%	59%	33%	17%	0%	1%	28%	27%	43%	32%	58%
Fat policies	77%	92%	100%	88%	100%	11%	75%	29%	16%	0%	2%	11%	27%	43%	23%	79%
Child food marketing	67%	86%	78%	70%	33%	11%	60%	32%	13%	3%	0%	33%	23%	18%	36%	66%
Breastmilk code	53%	42%	50%	49%	58%	24%	42%	43%	47%	47%	46%	26%	37%	52%	59%	50%
Physical activity mass media	87%	94%	100%	95%	75%	63%	88%	70%	33%	18%	21%	54%	77%	36%	50%	91%
Clinical guidelines	93%	82%	78%	81%	92%	51%	72%	66%	62%	45%	47%	61%	69%	52%	86%	75%
Cardiovascular therapies	60%	76%	76%	69%	83%	37%	69%	43%	13%	2%	5%	44%	26%	36%	36%	69%
Total	69%	67%	66%	65%	64%	37%	60%	50%	40%	29%	29%	45%	46%	47%	53%	63%

Figure 4: 2020 mean implementation scores for each policy across geopolitical blocs

On the colour-coded spectrum, green indicates higher values and red indicates lower values. AFR=African region. AMR=region of the Americas. EMR=Eastern Mediterranean region. EUR=European region. NA=not available. NCD=non-communicable diseases. OECD=Organisation for Economic Co-operation and Development. SEAR=South-East Asia region. SIDS=Small Island Developing States. WPR=Western Pacific region.

with corporate permeation scores lower than 4.4. In countries with average or higher than average corporate permeation (mean ≥ 5.9 , SD 2.1), the association between democracy and implementation was disannulled. With increasing corporate permeation, democracy becomes negatively associated with policy implementation, but this is not significant (figure 7).

In our sensitivity analysis, the same pattern held true with our new CPII (appendix, section 12, pp 56–57); however the 95% CI decreased to below 0 in countries with higher corporate political influence (ie, democracy becomes negatively associated with NCD implementation when corporate influence over politics exceeds a threshold).

Our lasso analysis selected 11 variables to be used in a predictive model, comprising corporate permeation, NCD mortality burden, female educational attainment, GDP per capita, population older than 65 years, ethnolinguistic fractionalisation, year dummy variables for 2015 and 2019, and South American continent, European continent, and African continent (full results reported in the appendix, section 9, pp 52–53). Only corporate permeation ($p=0.0019$), NCD mortality burden ($p=0.026$), and the dummy variables for 2015 ($p=0.026$) and 2019 ($p=0.049$) were significant. Because of scarce data coverage, the model was limited to 123 countries.

Using multiple imputation to estimate missing individual policy scores and covariate values allowed

us to produce a balanced panel for 191–194 countries. Reassuringly, our regression results based on this imputation procedure are consistent with our baseline results (full results reported in the appendix, section 7, pp 42–50).

We used correlation matrices to test for collinearities between the variables and between the coefficients produced by the multivariate model (appendix, sections 8–10, pp 51–54). These matrices suggest that democracy and political corruption are correlated, although existing research indicates that they are only strongly correlated since the 1990s.³³ Corporate permeation appears to be capturing unique information. As a variable, the percentage of the population older than 65 years is correlated with many of the other independent variables, especially NCD mortality burden, female educational attainment, government health spending, UHC, and democracy.

Discussion

Using our aggregate policy scores, mean implementation of NCD policies has risen from 39.0% in 2015 to 45.9% in 2017 and 47.0% in 2020. Overall, just under a third of the WHO-backed NCD policies had been fully implemented in 2020.

The rise in mean implementation hides the fact that progress has reversed for a third of all policies since 2015. Besides graphic warnings on tobacco packaging, the

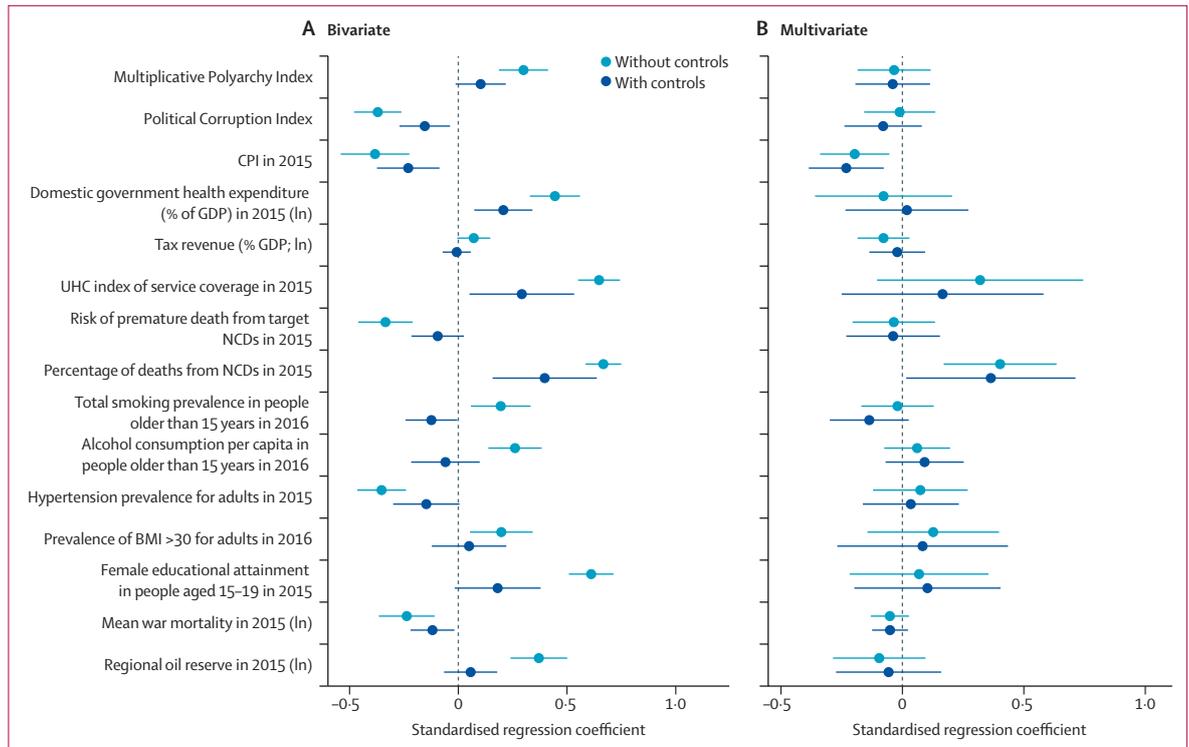


Figure 5: Regression analyses for NCD policy implementation

Control variables include GDP per capita, urbanisation, population older than 65 years, average distance to nearest ice-free coast, ethnolinguistic fractionalisation, percentage of the population that was Muslim, legal origin, and continent. All variables were standardised. Spikes represent 95% CIs. For the bivariate models (A), the results for smoking prevalence and CPI cover 143–146 countries, and the remaining models cover 172–191 countries. The two multivariate models (B) cover 123 countries. CPI=Corporate Permeation Index. Ln=natural logarithm. NCD=non-communicable diseases. UHC=universal health coverage.

most widely implemented interventions were paper-based clinical guidelines, plans, and targets, while those targeting junk food, salt, alcohol advertising, and other tobacco measures were the least widely implemented. The majority of policies targeting tobacco, alcohol, and unhealthy foods had not been fully implemented in 2020. The disparity between plans on the one hand, and policies targeting risk factors on the other hand might be partly explained by the fact that paper-based policies do not threaten powerful vested interests. WHO has invested considerable resources in supporting countries to develop and report paper-based policies.³⁴ Although plans, targets, guidelines, and survey data are undeniably important, our findings suggest that these elements are not associated with implementation of policies to address risk factors. We welcome the growing institutional shift in emphasis towards implementation research,³⁵ and call for greater investment from the wider NCD community in supporting countries as they seek to tailor interventions to their unique populations and overcome implementation barriers.

Chile, Norway, and Turkey are outperforming their peers, and Algeria was identified as an outlying underperformer. At the level of geopolitical blocs, former Soviet states performed well, as did OECD and EU27 countries. Our work highlights sub-Saharan Africa, Small

Island Developing States, European microstates, and low-income autocracies with high corporate permeation as requiring the greatest support.

Our new conceptual model explained 64·8% of the variance in policy implementation scores. Most variables in our framework of indicators were significantly associated with implementation in the bivariate analysis at a p value threshold of 0·05, and two variables retained significant association in our fully adjusted multivariate model, NCD mortality burden and corporate permeation. Our findings suggest that countries with a high proportion of NCD deaths implement high numbers of NCD policies, even after adjusting for income level, geographical region, democracy, and risk factor prevalence. NCD mortality burden (percentage of all deaths) is highest in high-income countries, but rising fastest in low-income and lower-middle-income countries, as with absolute number of NCD deaths.³⁶ However, these rises are largely driven by population growth and decreases in deaths from other causes, so that NCD mortality rates are actually falling in most low-income countries. Focusing on sub-Saharan Africa, deaths from dementia and many cancers have risen since 2010; however at the same time there have been significant improvements in preventing and managing cardiovascular disease, diabetes, and chronic pulmonary

disease. Continued gains will be harder to sustain as Africa's demographic transition drives the rising incidence of cancers and dementia and strains fragile health systems. Our work highlights disproportionately low rates of implementation of policies to constrain NCD risk factors in this region.

On the basis of the observation that multinational corporations frequently oppose, subvert, and undermine NCD policy implementation,^{18,21,22,37} we hypothesised that policy implementation would be inversely associated with the extent to which corporations are able to influence policy makers. An ideal metric would have explicitly included lobbying as part of corporate permeation; however, much of this activity is (deliberately) unmeasured or hard to measure. We supplemented our measure of political corruption with Lima and Galea's CPI, which aims to capture the "degree to which corporate power is embedded in the social, political, and cultural fabric of a country".³¹ This composite metric of 25 indicators is available for 146 countries, and although it does not cover lobbying, it does include measures of corporate corruption, bribery, and government official favouritism. Perhaps counterintuitively, corporate permeation is lowest in rich, stable democracies such as the UK and the USA (appendix, section 18, p 65).

We found that CPI was negatively associated with NCD policy implementation, implying that corporations influence policy making processes in countries where they are deeply embedded within the fabric of society, irrespective of whether they actually wield their power. This point aligns with contemporary conceptualisations of corporate power that extend from visible to hidden and invisible means of exerting influence through access to policy making processes and the legitimisation and delegitimisation of public discourses.²⁰

In terms of CPI and international trade, the metric partially captures the effect of multinationals in accounting for restrictions on campaign financing by foreign companies, the amount of foreign direct investment, and trade barriers. LMICs tend to have higher permeation scores, suggesting that policy makers in those countries are more exposed to influence by foreign companies. This observation remains the case for the alternate permeation index that we constructed for the sake of robustness (appendix, section 12, pp 56–57). Future research should consider the temporal association between border trade agreements and policy implementation.

We found that the mean 2015 corporate permeation score was 5.5 in democracies and 6.6 in autocracies. Some political scientists have argued that democracy promotes the implementation of health policies because democratic leaders must win the support of a wider share of the population than autocratic leaders, and because they permit the openness necessary to receive policy relevant feedback from citizens.^{33,38} Quantitative analyses have consistently shown a positive association between

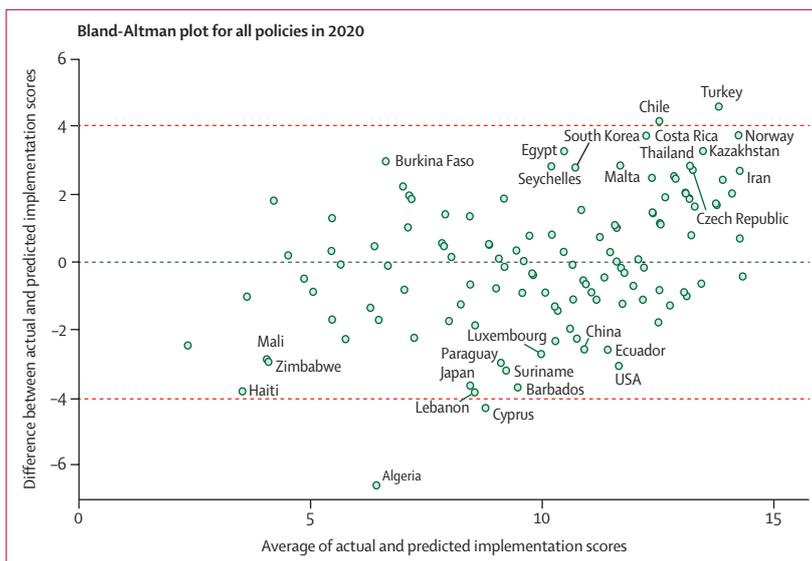


Figure 6: Predicted and actual 2020 implementation scores for all policies

$n=123$ countries. Points below the zero line do worse than predicted, and those above the zero line do better than predicted. 95% of all points lie between the dashed lines. Predicted values are based on a regression model with all covariates. The concordance correlation coefficient for actual versus predicted implementation score is 0.780 (95% CI 0.749–0.823; $p<0.0001$).

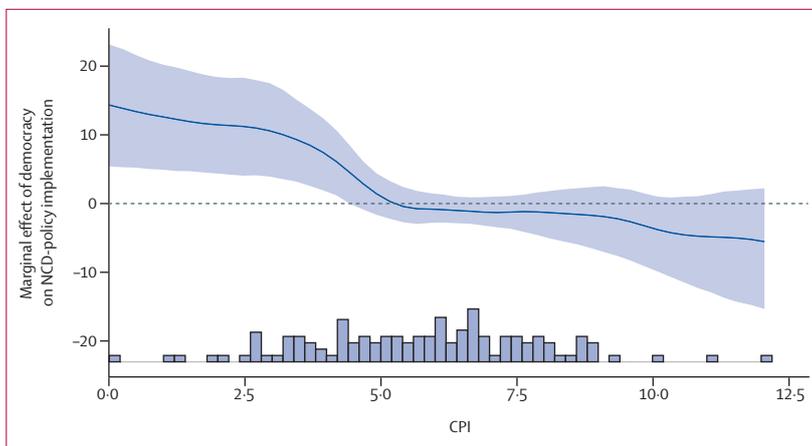


Figure 7: Marginal effect of democracy on overall policy implementation for each level of the CPI

The band represents the 95% error margin. All the covariates from the multivariate analysis were included in the regression model. The histogram captures the frequency of observations for each level of the index. The estimated effect should be treated with caution in cases in which there are no or few observations. The CPI was rescaled such that the lowest level of permeation is equal to zero. Results are produced using the kernel estimator from version 1.1.3 of the R package Interflex. A linear model is provided in the appendix (section 17, p 64). 123 countries were included in this analysis. CPI=Corporate Permeation Index. NCD=non-communicable disease.

democracy and health policy implementation.^{14–16,39} Our analysis found that democracy was positively associated with policy implementation in an unadjusted bivariate model; however, we found no significant association once we added controls. In addition, we found that the positive effect of democracy was nullified in countries with above-average corporate permeation. This finding suggests that the beneficial effects of democracy on NCD policy making only hold in countries where

corporate influence is held in check. In this respect, the political and commercial determinants of health are inextricably linked.

Not all policies are equally effective at combating NCDs, and our aggregate scores measure breadth of policy implementation rather than effectiveness. Awarding half a point to cover all degrees of partial implementation potentially adds bias and renders radically different policy scenarios as equivalent. We were limited by the available data and followed the approach used by WHO in this area. When it comes to selecting the most cost-effective NCD policies for a given context, ideally, countries should strive to implement a tailored package of NCD policies to meet the unique burden facing their domestic population.⁴⁰ Countries that scored well in our analysis might not necessarily be appropriately addressing the needs of their populations, and this point is particularly true for LMICs.⁴¹

WHO has gradually tightened the criteria for achieving full implementation for 11 of the NCD policies which artificially depresses scores over time. To standardise the implementation criteria, we stripped out new policies introduced in 2017 and 2020 to allow fairer comparison when performing time-series analyses and presented aggregate scores as percentages for individual years. This can bias the results by artificially deflating scores for 2017 and 2019; however, our sensitivity analysis that used simple percentage implementation of all policies in each year showed negligible differences (appendix, section 22, p 66).

We did not have data for every country-year, with missing data accounting for 3.3% of all policy measures in 2020, and we did not always have covariate data for matched years; however, missing data checks suggest that our findings are robust.

Many of the NCD policy indicators are self-reported and data quality varies between countries. Although WHO uses a robust approach to validating data, in reality little is known about enforcement in many settings. The validation exercise conducted with our NCD Alliance collaborators was hampered by the COVID-19 pandemic, but provides a degree of reassurance that WHO ascertained scores broadly align with civil society assessments. We note that the official implementation of any given policy in law is less important than enforcement of these policies in practice. Our validation exercise suggests that the WHO scores could provide an overly optimistic account of the extent to which populations are being protected from NCD risk factors.

A major limitation of using quantitative indicators for international comparisons is that important historical and contextual factors are imperfectly accounted for. Further qualitative and mixed methods research should aim to explore the cultural, historical, and political national circumstances that influence the contemporary NCD policy environment. Country-specific work is also required to assess the unique relationships between

governments and nationally important industries, such as tobacco in Zimbabwe and rum in Barbados.

Our decision to populate our framework with indicators that were available for more than two in three countries prioritised inclusion and coverage above conceptual precision. Furthermore, metrics for corporate influence, and particularly for lobbying, are intrinsically difficult to measure because firms seek to keep much of this activity clandestine. Both CPI and our new CPII use 2015 data. These metrics are slow moving, but might not accurately reflect the political reality in 2020.

A final important limitation is that this study follows the lineaments of the increasingly outmoded 4×4 conceptualisation of NCDs.⁷ We used this type of conceptualisation because the WHO recommended policies primarily address the four main behavioural risk factors driving cardiovascular disease, cancers, chronic lung disease, and diabetes. As the *Lancet* Commission on Reframing NCDs and Injuries for the Poorest Billion (*Lancet* NCDI Poverty Commission) has shown, these risk factors and conditions largely omit the major drivers of morbidity and mortality for the world's poorest people.⁴³ We recommend that future progress reports expand to capture policies pertaining to mental health, substance use, and road traffic injuries to align with the Sustainable Development Goals.⁵ Ideally, WHO would leverage its reporting processes to encompass the broader policies targeting NCDs and injuries for people living in poverty.

Our analysis highlights the collection of countries that underperform even after controlling for GDP, governance, and corporate permeation. This group deserves special attention to understand and mitigate their barriers to effective policy implementation. Implementation research is required in all countries to understand the unique factors that determine receptiveness, uptake, and sustained adoption of as yet unimplemented NCD policies.

Although the upward trend of policy implementation is encouraging, we found that fewer than half of all NCD policies had been implemented in 2020, and policies that target commercial determinants are being rescinded in many settings. Further work is needed to understand the complex ways in which corporations influence the policy making process in democracies and autocracies alike. Even more urgent work is needed to support countries in meeting their longstanding international commitments to protect their populations by implementing NCD policies.

Contributors

LNA and HH conceived the manuscript. LNA, SW, and HH designed the analysis. SW and HH did the analysis with input from LNA. LNA wrote the paper with substantial input from SW and HH. All authors have directly accessed and verified the data reported in the research paper, and all authors had access to the data and accept responsibility for submitting the article for publication.

Declaration of interests

We declare no competing interests.

Data sharing

All data used in the analyses are available on GitHub (<https://github.com/drlukeallen/NCD-Policy-Implementation>).

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