Research Article

A longitudinal analysis of MPOWER implementation, 2008-2018

Les Hagen[1], Gholamreza Heydari[2], Fadi Hammal[1] [a]

[1] Action on Smoking & Health (ASH Canada); University of Alberta School of Public Health, [2] Tobacco Prevention & Control Research Center, National Research Institute of Tuberculosis & Lung Diseases, Shahid Beheshti University of Medical Sciences

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Background

In 2008, the World Health Organization (WHO) introduced *MPOWER*-a package of evidence-based, high-impact policy measures to help countries reduce tobacco use. These measures align with selected articles within the World Health Organization's Framework Convention on Tobacco Control (FCTC), a global public health treaty to prevent and reduce tobacco use.

Methods

Observational longitudinal study involving 195 countries that submitted biannual national reports between 2008 and 2018. To report changes in MPOWER scores, countries were assessed using a validated checklist of the seven MPOWER indicators and a maximum possible unweighted composite score of 34 points. Covariate analysis was conducted among selected health, sociopolitical, and economic indicators.

Results

176 out of 195 countries improved their MPOWER scores between 2008 and 2018, with two achieving full implementation (Brazil and Turkey). Twenty-three (23) countries representing 11.2% of the global population recorded an MPOWER scoring increase of at least 10 points between 2008 and 2018. The overall mean 10-year scoring increase was 5.1 points or a relative improvement of 27.1%. In 2018, 20 countries representing 10.4% of the global population excelled in MPOWER implementation by receiving a total composite score of at least 30 of 34 possible points. The MPOWER elements with the highest degree of implementation in 2018 include *Warn* (package), *Protect* (smoking ban) and *Enforce* (ad ban). Several covariates were positively associated with higher levels of MPOWER implementation, including *cigarette affordability,* the *existence of national tobacco control objectives,* the *human development index score*, the *national corruption index score, national literacy rates* and the *political regime index score.*

Conclusions

MPOWER implementation increased markedly between 2008 and 2018 in all seven WHO regions and countries representing all four World Bank income classifications. However, only two countries achieved full implementation by 2018. More work is needed to improve MPOWER implementation. Countries with low-income levels, compromised human development, reduced literacy rates, higher rates of corruption, and autocratic political regimes appear to struggle more with MPOWER implementation.

The need to implement effective tobacco control programs is undeniable due to the significant and well-established health hazards of smoking.[1] Tobacco use remains the leading preventable cause of morbidity and mortality from chronic diseases worldwide, resulting in over eight million deaths annually, and the rate of morbidity and mortality is rising globally due to an increase in smoking-related diseases.[2,3] Therefore, the first and the most crucial strategy to confront this global pandemic is the comprehensive implementation of effective tobacco control policies and pro-

a All authors contributed equally to this work.

grams.[4–7] To achieve this objective, the WHO negotiated the Framework Convention on Tobacco Control (FCTC) in 2003—representing the world's first public health treaty. As of July 2021, 182 countries representing 90% of the global population have ratified the FCTC.[7] The implementation of the FCTC is credited with preventing an estimated 49 million smoking-attributable deaths within the first ten years of its implementation.[5,6] In 2008, a policy and program measures package based on critical articles of the FCTC was developed to help promote and guide FCTC implementation. This package includes six main components, namely: *Monitor tobacco use and prevention policies, Protect people from tobacco smoke, Offer help to quit tobacco use, Warn people about the dangers of tobacco, Enforce bans on tobacco advertising, promotion and sponsorship*, and *Raise taxes on tobacco* (MPOWER; *to empower*).[8,9] Experience has revealed that implementing the six strategies mentioned above can reliably decrease the consumption and reduce the consequences and complications of tobacco use in middle- and high-income countries.[10–13] Some studies have reported that an analysis of MPOWER implementation by countries may create a competitive challenge between countries to improve their status on tobacco control through international peer pressure.[14–18]

The objectives of this study are to use results from the 2008 to 2018 MPOWER scores to (i) Report national MPOWER scores to allow countries to benchmark, measure, monitor, compare and stimulate MPOWER implementation; and (ii) Identify independent factors that influence MPOWER implementation.

METHODS

STUDY DESIGN

The design of this study was based on previous observational analyses of bi-annual MPOWER reports.[14–18] The data for all MPOWER reporting periods from 2008 to 2018 was retrieved from the WHO Global Health Observatory.[19] The data for each country was represented using seven measurable variables, reflecting all MPOWER components, including two indicators for *Warn* (package warnings and mass media campaigns). All variables have a gradient range of 0-4 (5 gradients) except for *Monitor,* which has a range of 0-3 (4 gradients) for a maximum possible score of 34 (4 + (5×6) = 34). The scoring is based on previously published methodology.[13]

VARIABLES AND DATA SOURCES

The primary data source was the *WHO Global Health Observatory (GHO)*[20] which includes all the MPOWER national results collected between 2008 and 2018. The GHO also includes national datasets for (1) tobacco smoking prevalence,[21] (2) government objectives on tobacco control,[22] (3) national cigarette affordability,[23] (4) the annual tobacco control budget of each country,[24] (5) the existence of a government tobacco control agency,[25] and (6) the number of tobacco control staff employed by national governments.[25] All variables, except smoking prevalence, were used for the covariate analysis. Smoking prevalence and its relationship to MPOWER scores have been examined and reported by others.

The secondary data source was *Our World in Data* (OWID),[26] an online repository of numerous health, social, political and economic indices and datasets. The OWID indices selected for this study included (1) literacy rates on a scale of 0 to 100[27]; (2) the political regime scale from a full democracy to full autocracy[28]; (3) the United Nations human development index which includes life expectancy, education, and gross national income with an aggregate score between 0 and 1[29]; and (4) the World Bank's four national income classifications including low income, low-middle, upper-middle, and high income.[30]

Per capita tobacco control budgets for each country were calculated by dividing a country's annual budget for tobacco control in equivalent U.S. dollars by its total population size. The standard currency reported by the U.S. Department of Treasury was used for any country without its currency reported in the GHO database. The total population for all countries was obtained from the World Development Indicator Databank (WDI) of the World Bank. For all country currencies without a standard average equivalent of 1 USD in the U.S. Department of Treasury database, an average rate (March 31st, June 30th, September 30th, and December 31st) was calculated from historical currency tables.[31]

STATISTICAL ANALYSIS

The results were organized by the six WHO regions and by the four World Bank national income classifications to allow for geopolitical and economic analysis. Missing or incomplete data in the WHO report received a score of zero in our analysis.

The association between MPOWER scores and potential covariates was analysed using chi-square for categorical variables and student t-test and repeated measure ANOVA for continuous variables to check between and within subjects' differences. Paired tests were used for the difference in the mean between years, and predictive modelling was performed using traditional forecasting methods. Analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 27.0 (IBM SPSS, Armonk, NY).

RESULTS

The WHO regional numerical breakdowns among the 195 countries represented in this study are Europe & Central Asia (51), Sub-Saharan Africa (48), Latin American & Caribbean (33), East Asia & Pacific (32), Middle East & North Africa (21), South Asia (8) and North America (2). The World Bank national income gradients among the 195 countries represented in this study are Low Income (29), Lower Middle Income (50), Upper Middle Income (56) and High Income (60).

MPOWER SCORING IN 2018

Twenty (20) countries achieved excellence in implementing MPOWER in 2018 by attaining at least 30 points out of a total of possible 34, including Brazil and Turkey (34 = perfect score); Australia, Ireland and New Zealand (33 points); Panama and United Kingdom (32 points); Costa Rica, Pakistan, Seychelles, and Thailand (31 points); Chile, Czechia, El Salvador, Georgia, Luxembourg, Norway, Republic of Moldova, Senegal and Spain (30 points). The total population of these 20 countries is about 800 million out of a total global population of 7.59 billion (10.5% of the world population). The 15 countries with the lowest levels of implementation include South Sudan (11 points); Monaco (12 points); Equatorial Guinea, Guinea-Bissau, Haiti, Malawi and Somalia (13 points); Central African Republic, Saint Kitts and Nevis, and Sierra Leone (14 points); Angola, Dominica, and Saint Vincent and the Grenadines (15 points); and Liberia and Sao Tome and Principe (16 points). **Table 1** contains the 2018 scores for each country.

MPOWER RANKINGS OF ALL NATIONS

The WHO regions reporting the highest levels of implementation in 2018 in mean country scores in order of ranking were (1) North America (27.0 points); (2) Europe & Central Asia (26.6 points); (3) East Asia & Pacific (25.4 points); South Asia (25.3 points); the Middle East & North Africa (24.3 points); Latin America & Caribbean (23.1 points) and Sub-Saharan Africa (20.1 points). The mean scores of countries according to national income levels are high-income (26.4 points), upper-middle-income (24.2 points), lower-middle-income (23.2 points), and low-income (19.3 points). MPOWER scoring changes by region appear in **Figure 1**, scoring changes by income level appear in **Figure 2**, and MPOWER rankings in 2018 appear in **Figure 3**.

The highest rates of implementation for the MPOWER variables in 2018 were (1) *Warn (package)* with a mean score of 3.86 out of a possible 5 points; (2) *Enforce (advertising bans)* with a mean score of 3.79 out of a possible 5 points; (3) *Offer* with a mean score of 3.70 out of a possible 5 points and (4) *Raise* with a mean score of 3.48 out of a possible 5 points. The lowest rates of implementation were (1) *Warn (mass media)* with a mean score of 2.84 out of a possible 5 points; (2) *Protect* with a mean score of 3.40 out of a possible 5 points; and (3) *Monitor* with a mean score of 2.81 out of a possible 4 points. These results can be found in **Table 2**.

CHANGES FROM 2008 TO 2018

NATIONAL IMPLEMENTATION

Twenty-three (23) countries recorded a minimum MPOWER scoring increase of at least 10 points between 2008 and 2018 (i.e., most improved scores), including Timor-Lest (15); Senegal (14); Costa-Rica, Pakistan, Seychelles, and Cambodia (13); El Salvador, Republic of Moldova, and Honduras (12); Brazil, Georgia, Russian Federation, Turkmenistan, Suriname, Guyana, and Namibia (11); and Turkey, Luxembourg, Argentina, Saudi Arabia, Chad, Fiji, and Nepal (10). Six (6) countries recorded a decline in MPOWER scores between 2008 and 2018 (i.e., least improved scores), including Guatemala and Malawi (-2) and Belgium, Djibouti, Dominica and Eritrea (-1). Thirteen (13) countries recorded no change in scores between 2008 and 2018, including Belize, Central African Republic, Cuba, Equatorial Guinea, Guinea, Haiti, Marshall Islands, Mauritius, Monaco, Niger, Saint Kitts, Syrian Arab Republic, and Uruguay. These results can be found in **Table 3**.

The mean point change rankings of WHO regions between 2008 and 2018 are (1) South Asia (7.25 points = 40.3% increase); (2) East Asia and Pacific (6.06 points = 31.3% increase); (3) Europe and Central Asia (5.51 points = 26.2% increase); (4) North America (5.50 points = 25.5% increase); (5) Latin America and Caribbean (5.30 points = 29.8% increase); (6) Middle East and North Africa (4.19 points = 20.9% increase) and (7) Sub-Saharan Africa (3.92 points = 24.3% increase). The mean point change rankings according to income level are (1) lower-middle income (5.7 points = 32% increase); (2) upper-middle income (5.3 points = 28% increase); (3) high income (5.2 points = 24% increase and (4) low income (3.6 points = 23% increase).

Repeated measure analysis showed that the estimated marginal means of MPOWER score has been increasing since 2008. This increase is observed across different levels of income and different WHO regions except for the bottom 20 countries in the 2018 MPOWER rankings. These low-performing countries reported declining scores after an initial increase between 2008 and 2012. However, paired test analysis revealed that the largest increase in MPOWER scoring occurred in the first reporting period following the introduction of the MPOWER measures in 2008. **Figure 4** reveals a significant increase in MPOWER score in 2008-2010 (range, 3.5 in the Southeast Asia region to 1.15 in the bottom 20 countries). This increase declined sharply from 2010-2012 (ranging from 1.7 in the top 20 countries to 0.41 in low-income countries). The 2014-2016 and 2016-2018 reveal largely insignificant increases in MPOWER scoring (ranging from 1.25 in the top 20 countries to -0.75 in Southeast Asia) (Figures 4, panels A-C).

Figure 5 shows projected dates for achieving full MPOWER implementation score stratified by countries' income levels. At the current implementation rate, high- and middle-income countries are projected to achieve full MPOWER implementation by 2040, led by high-income countries, which are forecast to reach the 34-point target by 2036. The projections also reveal that low-income countries are not expected to achieve full MPOWER implementation in the foreseeable future. While these trends are encouraging for most countries, they suggest that full MPOWER implementation is unlikely in many low-income countries.

IMPLEMENTATION OF MPOWER ELEMENTS

The highest degree of implementation of MPOWER elements between 2008 and 2018 was *Warn (packaging),* with a 1.17-point increase, reflecting a 10-year improvement of 43.7%. The second highest increase was *Protect,* with a 0.82-point rise, representing a relative change of 31.6%.

Table 1. MPOWER scores and rankings of 195 countries in 2008 and 2018

	Rank*		MPOWER score			
	2018	2008	2018	2008	Change	Relative change
Brazil	1	24	34	23	11	47.8%
Turkey	2	16	34	24	10	41.7%
Ireland	3	5	33	27	6	22.2%
Australia	4	1	33	28	5	17.9%
New Zealand	5	2	33	28	5	17.9%
Panama	6	8	32	26	6	23.1%
United Kingdom	7	6	32	27	5	18.5%
Costa Rica	8	97	31	18	13	72.2%
Pakistan	9	98	31	18	13	72.2%
Seychelles	10	99	31	18	13	72.2%
Thailand	11	17	31	24	7	29.2%
Senegal	12	136	30	16	14	87.5%
El Salvador	13	100	30	18	12	66.7%
Republic of Moldova	14	101	30	18	12	66.7%
Georgia	15	80	30	19	11	57.9%
Luxembourg	16	65	30	20	10	50.0%
Norway	17	25	30	23	7	30.4%
Czechia	18	18	30	24	6	25.0%
Chile	19	10	30	25	5	20.0%
Spain	20	11	30	25	5	20.0%
Russian Federation	21	102	29	18	11	61.1%
Turkmenistan	22	103	29	18	11	61.1%
Argentina	23	81	29	19	10	52.6%
Saudi Arabia	24	82	29	19	10	52.6%
Greece	25	45	29	21	8	38.1%
Vietnam	26	46	29	21	8	38.1%
Austria	27	35	29	22	7	31.8%
Estonia	28	36	29	22	7	31.8%
Bulgaria	29	26	29	23	6	26.1%
Canada	30	12	29	25	4	16.0%
Egypt	31	13	29	25	4	16.0%
Singapore	32	14	29	25	4	16.0%
Cambodia	33	154	28	15	13	86.7%
Suriname	34	123	28	17	11	64.7%
Madagascar	35	83	28	19	9	47.4%
Tonga	36	84	28	19	9	47.4%
Brunei Darussalam	37	66	28	20	8	40.0%
Cyprus	38	47	28	21	7	33.3%
Ecuador	39	48	28	21	7	33.3%
India	40	49	28	21	7	33.3%
Netherlands	41	50	28	21	7	33.3%
Philippines	42	51	28	21	7	33.3%
Denmark	43	37	28	22	6	27.3%
France	44	38	28	22	6	27.3%
Italy	45	39	28	22	6	27.3%
Croatia	46	27	28	23	5	21.7%

	Rank*		MPOWER score			
	2018	2008	2018	2008	Change	Relative change
Germany	47	28	28	23	5	21.7%
Slovakia	48	29	28	23	5	21.7%
Latvia	49	19	28	24	4	16.7%
Malta	50	20	28	24	4	16.7%
Portugal	51	21	28	24	4	16.7%
Romania	52	22	28	24	4	16.7%
Iran	53	7	28	27	1	3.7%
Mauritius	54	3	28	28	0	0.0%
Uruguay	55	4	28	28	0	0.0%
Timor-Leste	56	190	27	12	15	125.0%
Honduras	57	155	27	15	12	80.0%
Guyana	58	137	27	16	11	68.8%
Namibia	59	138	27	16	11	68.8%
Uganda	60	104	27	18	9	50.0%
Bangladesh	61	85	27	19	8	42.1%
Colombia	62	86	27	19	8	42.1%
Myanmar	63	87	27	19	8	42.1%
Qatar	64	88	27	19	8	42.1%
Belarus	65	67	27	20	7	35.0%
Ukraine	66	68	27	20	7	35.0%
Hungary	67	52	27	21	6	28.6%
Slovenia	68	53	27	21	6	28.6%
Finland	69	40	27	22	5	22.7%
North Macedonia	70	30	27	23	4	17.4%
Poland	71	31	27	23	4	17.4%
Chad	72	139	26	16	10	62.5%
Fiji	73	140	26	16	10	62.5%
Nepal	74	141	26	16	10	62.5%
Palau	75	124	26	17	9	52.9%
Indonesia	76	105	26	18	8	44.4%
Lebanon	77	106	26	18	8	44.4%
Republic of Korea	78	69	26	20	6	30.0%
Samoa	79	54	26	21	5	23.8%
Sweden	80	41	26	22	4	18.2%
Cook Islands	81	32	26	23	3	13.0%
Lithuania	82	33	26	23	3	13.0%
Jordan	83	23	26	24	2	8.3%
Albania	84	15	26	25	1	4.0%
Occupied Palestinian	85	125	25	17	8	47.1%
Niue	86	107	25	18	7	38.9%
United States of America	87	108	25	18	7	38.9%
Kuwait	88	70	25	20	5	25.0%
Yemen	89	71	25	20	5	25.0%
Kazakhstan	90	55	25	21	4	19.0%
Mongolia	91	56	25	21	4	19.0%
Serbia	92	57	25	21	4	19.0%
Switzerland	93	58	25	21	4	19.0%

	Rank*		MPOWER score			
	2018	2008	2018	2008	Change	Relative change
Sri Lanka	94	42	25	22	3	13.6%
Belgium	95	9	25	26	-1	-3.8%
Saint Lucia	96	156	24	15	9	60.0%
The Gambia	97	142	24	16	8	50.0%
Iraq	98	143	24	16	8	50.0%
Burkina Faso	99	126	24	17	7	41.2%
Bahrain	100	109	24	18	6	33.3%
Jamaica	101	110	24	18	6	33.3%
Peru	102	111	24	18	6	33.3%
China	103	89	24	19	5	26.3%
United Arab Emirates	104	90	24	19	5	26.3%
Kyrgyzstan	105	72	24	20	4	20.0%
Kenya	106	43	24	22	2	9.1%
Malaysia	107	34	24	23	1	4.3%
Antigua and Barbuda	108	170	23	14	9	64.3%
Solomon Islands	109	171	23	14	9	64.3%
Togo	110	172	23	14	9	64.3%
Azerbaijan	111	157	23	15	8	53.3%
Trinidad and Tobago	112	158	23	15	8	53.3%
Barbados	113	144	23	16	7	43.8%
Ghana	114	145	23	16	7	43.8%
Maldives	115	112	23	18	5	27.8%
Papua New Guinea	116	113	23	18	5	27.8%
Bolivia	117	91	23	19	4	21.1%
Congo	118	92	23	19	4	21.1%
Laos	119	93	23	19	4	21.1%
Venezuela	120	94	23	19	4	21.1%
Japan	121	73	23	20	3	15.0%
Montenegro	122	74	23	20	3	15.0%
Vanuatu	123	75	23	20	3	15.0%
Iceland	124	59	23	21	2	9.5%
Morocco	125	60	23	21	2	9.5%
Tunisia	126	61	23	21	2	9.5%
Tajikistan	127	159	22	15	7	46.7%
Kiribati	128	146	22	16	6	37.5%
Cameroon	129	127	22	17	5	29.4%
Armenia	130	114	22	18	4	22.2%
Benin	131	115	22	18	4	22.2%
Tuvalu	132	95	22	19	3	15.8%
Israel	133	62	22	21	1	4.8%
Bhutan	134	173	21	14	7	50.0%
Nauru	135	160	21	15	6	40.0%
Nigeria	136	161	21	15	6	40.0%
Afghanistan	137	147	21	16	5	31.3%
Micronesia	138	148	21	16	5	31.3%
Oman	139	149	21	16	5	31.3%
Paraguay	140	150	21	16	5	31.3%

	Rank*		MPOWER score			
	2018	2008	2018	2008	Change	Relative change
Libya	141	128	21	17	4	23.5%
The Democratic Republic of the Congo	142	116	21	18	3	16.7%
Eswatini	143	117	21	18	3	16.7%
Bosnia and Herzegovina	144	76	21	20	1	5.0%
Niger	145	63	21	21	0	0.0%
Djibouti	146	44	21	22	-1	-4.5%
Nicaragua	147	184	20	13	7	53.8%
Ethiopia	148	174	20	14	6	42.9%
Gabon	149	175	20	14	6	42.9%
Burundi	150	162	20	15	5	33.3%
Mali	151	163	20	15	5	33.3%
Uzbekistan	152	164	20	15	5	33.3%
Sudan	153	129	20	17	3	17.6%
Botswana	154	118	20	18	2	11.1%
Mexico	155	119	20	18	2	11.1%
South Africa	156	120	20	18	2	11.1%
Marshall Islands	157	77	20	20	0	0.0%
The Syrian Arab Republic	158	78	20	20	0	0.0%
Andorra	159	185	19	13	6	46.2%
Lesotho	160	165	19	15	4	26.7%
Mozambique	161	130	19	17	2	11.8%
United Republic of Tanzania	162	131	19	17	2	11.8%
Zambia	163	132	19	17	2	11.8%
Algeria	164	121	19	18	1	5.6%
Cabo Verde	165	122	19	18	1	5.6%
Cuba	166	96	19	19	0	0.0%
Eritrea	167	79	19	20	-1	-5.0%
Guatemala	168	64	19	21	-2	-9.5%
Côte d'Ivoire	169	176	18	14	4	28.6%
Comoros	170	166	18	15	3	20.0%
Zimbabwe	171	151	18	16	2	12.5%
Dominican Republic	172	133	18	17	1	5.9%
Democratic People's Republic of Korea	173	177	17	14	3	21.4%
Mauritania	174	178	17	14	3	21.4%
Rwanda	175	179	17	14	3	21.4%
Grenada	176	167	17	15	2	13.3%
San Marino	177	168	17	15	2	13.3%
Bahamas	178	152	17	16	1	6.3%
Belize	179	134	17	17	0	0.0%
Guinea	180	135	17	17	0	0.0%
Liberia	181	186	16	13	3	23.1%
Sao Tome and Principe	182	180	16	14	2	14.3%
Angola	183	187	15	13	2	15.4%
Saint Vincent and the Grenadines	184	181	15	14	1	7.1%
Dominica	185	153	15	16	-1	-6.3%
Sierra Leone	186	191	14	12	2	16.7%

	Rank*		MPOWER score			
	2018	2008	2018	2008	Change	Relative change
Saint Kitts and Nevis	187	182	14	14	0	0.0%
Central African Republic	188	183	14	14	0	0.0%
Guinea-Bissau	189	192	13	12	1	8.3%
Somalia	190	193	13	12	1	8.3%
Equatorial Guinea	191	188	13	13	0	0.0%
Haiti	192	189	13	13	0	0.0%
Malawi	193	169	13	15	-2	-13.3%
Monaco	194	194	12	12	0	0.0%
South Sudan	195	195	11	10	1	10.0%

*Rank is based on 2018 score and relative change to 2008 score

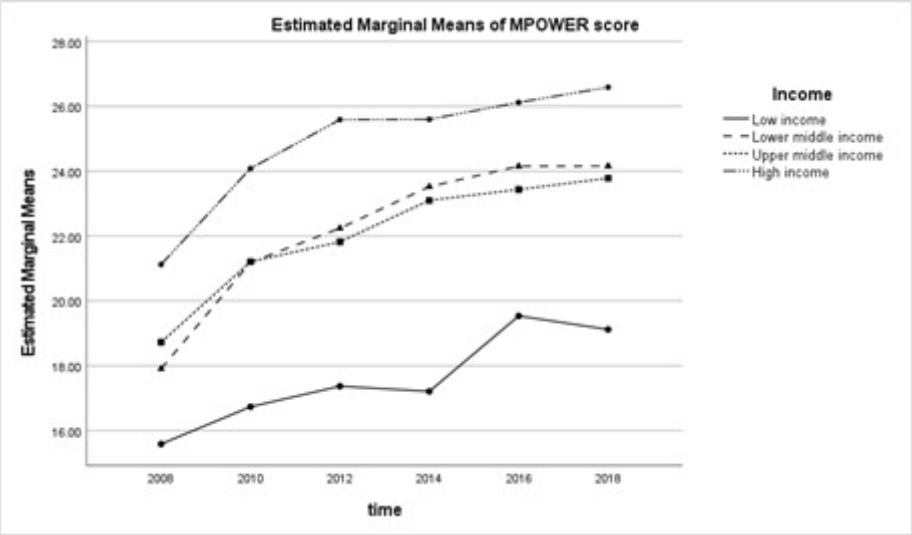


Figure 1. MPOWER score and country income level.

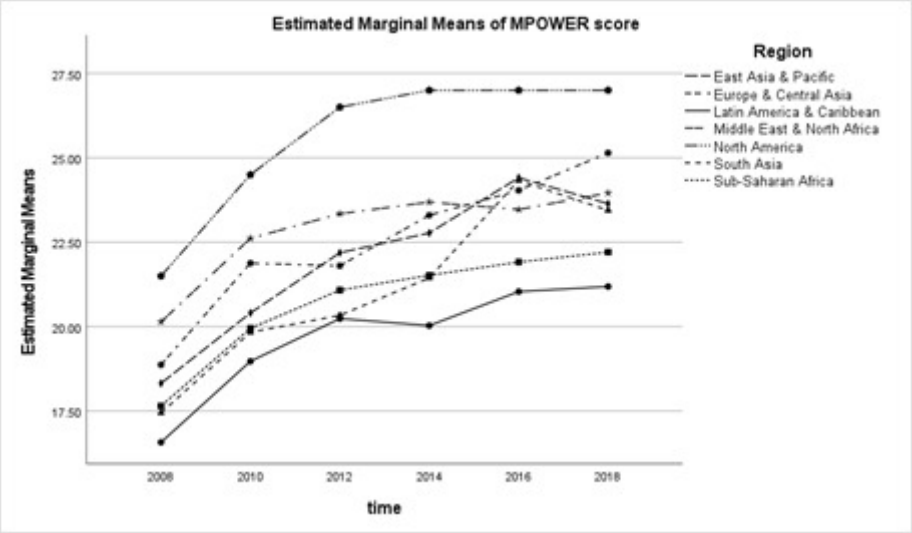


Figure 2. MPOWER score and WHO regions.

The third greatest improvement was 0.66 points for *Enforce (advertising ban)*, reflecting a relative rise of 20.9%. The fourth highest change was 0.34 points for *Offer*, representing a relative increase of 10.2%. The lowest degree of

Table 2. MPOWER element scoring change since 2008

	MPOWER 2008		MPOWER 2018		Point change				
	Mean	(S.D.)	Mean	(S.D.)	Mean	(S.D.)	*t*	*p-value*	Relative change
All countries (n=195)									
MONITOR	2.78	(1.04)	2.81	(1.10)	0.026	(0.96)	0.373	0.710	0.9%
PROTECT	2.58	(0.95)	3.40	(1.32)	0.815	(1.18)	9.663	**<0.001**	31.6%
OFFER help to quit	3.36	(0.79)	3.70	(0.85)	0.344	(0.75)	6.372	**<0.001**	10.2%
WARN - package	2.69	(0.91)	3.86	(1.23)	1.174	(1.07)	15.328	**<0.001**	43.7%
WARN - mass media	2.74	(1.35)	2.84	(1.37)	0.103	(1.82)	0.787	0.432	3.8%
ENFORCE ad bans	3.14	(1.08)	3.79	(1.06)	0.656	(1.01)	9.074	**<0.001**	20.9%
RAISE taxes	3.24	(1.08)	3.48	(1.10)	0.246	(0.81)	4.229	**<0.001**	7.6%
Most improved countries (n=10)									
MONITOR	2.60	(0.83)	3.10	(0.74)	0.50	(0.85)	1.86	0.096	19.2%
PROTECT	2.40	(0.52)	4.80	(0.42)	2.40	(0.52)	14.70	**<0.001**	100%
OFFER help to quit	3.10	(0.57)	4.10	(0.57)	1.00	(0.67)	4.74	**0.001**	32.3%
WARN- package	2.10	(0.32)	5.00	(0.00)	2.90	(0.32)	29.00	**<0.001**	138%
WARN- mass media	2.60	(1.08)	4.40	(0.97)	1.80	(1.48)	3.86	**0.004**	69.2%
ENFORCE ad bans	2.00	(0.00)	4.30	(0.48)	2.30	(0.48)	15.06	**<0.001**	115%
RAISE taxes	3.00	(1.05)	3.20	(0.63)	0.20	(0.63)	1.00	0.340	6.7%
Declining countries (n=6)									
MONITOR	3.00	(1.10)	2.00	(0.63)	-1.00	(0.89)	-2.74	**0.041**	-33.3%
PROTECT	3.00	(1.27)	2.67	(1.51)	-0.33	(0.82)	-1.00	0.360	-11.0%
OFFER help to quit	3.17	(1.17)	2.67	(1.03)	-0.50	(0.55)	-2.24	0.080	-15.8%
WARN - package	3.00	(1.27)	3.17	(1.47)	0.17	(0.41)	1.00	0.360	5.7%
WARN - mass media	2.17	(0.98)	2.17	(0.98)	--		--	--	--
ENFORCE ad bans	3.33	(1.51)	3.33	(1.51)	--		--	--	--
RAISE taxes	3.50	(1.05)	2.67	(1.63)	-0.83	(0.75)	-2.71	**0.042**	-23.7%

Note: Scores for "WARN - mass media" in 2008 were substituted with 2010 data due to the absence of 2008 data. The underlined showed the most and least improved/get worse

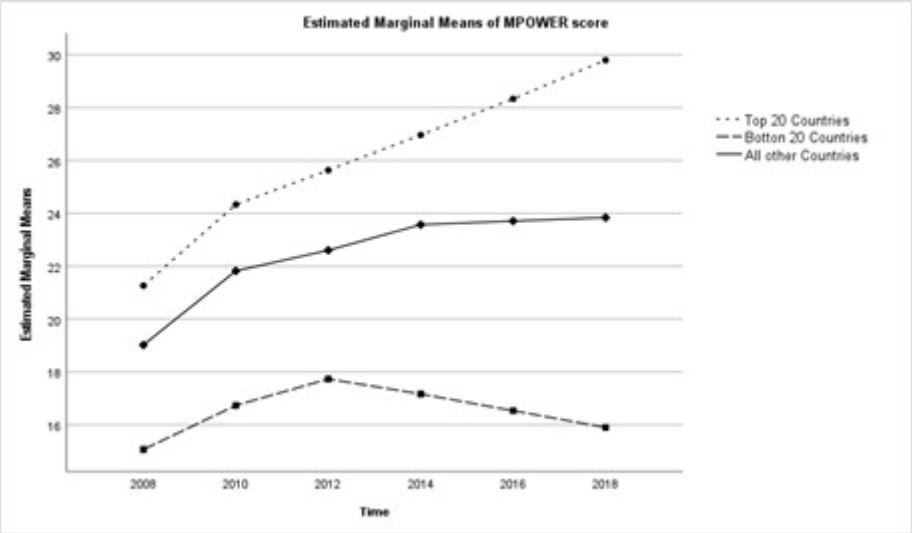


Figure 3. MPOWER score and top 20 and bottom 20 countries.

MPOWER implementation was *Monitor,* with a relative 10-year increase of 0.9%, reflecting a 0.03-point increase. The second lowest improvement was *Warn (mass media)*, reflecting a 0.10-point rise, or a relative change of 3.8%. The third lowest change was *Raise,* with a 0.25-point increase, representing a relative improvement of 7.6%. These results can be found in **Table 2**.

IMPACT OF COVARIATES

Several influential covariates were identified through selective analysis of health, social, political and economic indicators in the WHO Global Health Observatory and the *Our World in Data* online dataset repository. This study examined these indicators between the 20 best performing MPOWER countries and the 20 worst performing nations (Table 4). Covariates that appear to positively influence MPOWER implementation include *lower cigarette affordability* (*P=0.03; t=-2.30*), the overall tax score (*P<0.001; t=4.67*) the presence of *national tobacco control objectives* (*P=0.001, X^2=22.7*), the *human development index score* (*P<0.001; t=5.1*), the *national corruption index score* (*P<0.001; t=3.96*), the *political regime index score* (*P<0.001; t=5.76*), *and the national literacy rate* (*P=0.003; t=3.18*). Covariates that did not influence MPOWER implementation included a government tobacco control agency (*P=0.12; X^2=4.28*) and the number of tobacco control staff employed by the government (*P=0.78; t=1.85*).

DISCUSSION

For the first time since MPOWER was launched in 2008, two countries achieved a perfect score of 34 in the 2018 MPOWER rankings: Brazil and Turkey. Notably, neither country is ranked as a high-income country, which should motivate middle-income countries and high-income countries to implement MPOWER fully. Of the 20 top performing countries in 2018, 10 were ranked as high-income, seven were rated as upper-middle income, 3 were lower-middle income, and none were low-income nations. Together, these countries represent 10.4% of the world population. This modest degree of high MPOWER implementation is concerning, considering the large number of countries (182) that have ratified the FCTC. Of the 20 countries with the lowest MPOWER scores in 2018, 9 were ranked as low-income, two were rated as low-middle income, 5 were high-middle income, and 4 were high-income countries.

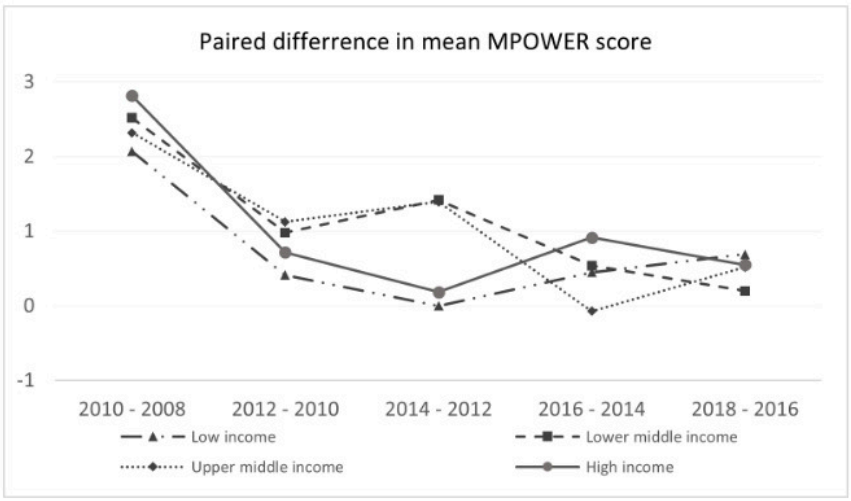
Of the 23 countries that achieved a minimum 10-point increase between 2008 and 2018, 3 were high-income countries, 12 were upper-middle income countries, 7 were lower-middle income, and 1 was a low-income nation. Nineteen (19) middle-income countries were among the 23 most improved nations for MPOWER implementation between 2008 and 2018. All WHO regions realised 10-year improvements in MPOWER scores, with the greatest progress achieved by South Asia, East Asia & Pacific, and Europe & Central Asia (Figure 2). Although high-income countries had the highest MPOWER rankings in 2018, middle-income countries are the top performers in achieving the most improved 10-year scores. MPOWER scores improved among all income gradients. However, lower- and upper-middle-income nations achieved more relative progress than high- and low-income countries. Unfortunately, the gap in MPOWER implementation between low-income and non-low-income countries is growing wider over time, perhaps due to external influences on MPOWER scores, such as compromised human development, more oppressive government regimes, and higher rates of corruption. Given these challenges, more work is justified to assist low-income countries with MPOWER implementation.

Regarding the 10-year implementation of MPOWER elements, *Warn (package)* was by far the most well-implemented policy measure with a 15.3 point scoring increase reflecting a relative rise of 44%, followed by *Protect (smoking ban)* (9.7 points = 32% increase) *with and Enforce (advertising ban)* (9.1 points = 21% increase). The most disappointing results were *Monitor* with a 1% increase, *Warn* (mass media) with a 4% increase and *Raise* (taxes) with

Table 3. Countries with notable MPOWER scoring change since 2008

Country	MPOWER score 2018	MPOWER score 2008	Point change	Relative change
Most improved (n=23)				
Timor-Leste	27	12	15	125%
Senegal	30	16	14	88%
Cambodia	28	15	13	87%
Costa Rica	31	18	13	72%
Pakistan	31	18	13	72%
Seychelles	31	18	13	72%
Honduras	27	15	12	80%
El Salvador	30	18	12	67%
Republic of Moldova	30	18	12	67%
Guyana	27	16	11	69%
Namibia	27	16	11	69%
Suriname	28	11	11	65%
Russian Federation	29	18	11	61%
Turkmenistan	29	18	11	61%
Georgia	30	19	11	58%
Brazil	34	23	11	48%
Chad	26	16	10	63%
Fiji	26	16	10	63%
Nepal	26	16	10	63%
Argentina	29	19	10	53%
Saudi Arabia	29	19	10	53%
Luxembourg	30	20	10	50%
Turkey	34	24	10	42%
Declining score (n=6)				
Malawi	13	15	-2	-13.0%
Guatemala	19	21	-2	-10.0%
Dominica	15	16	-1	-6.0%
Eritrea	19	20	-1	-5.0%
Djibouti	21	22	-1	-5.0%
Belgium	25	26	-1	-4.0%
No change (n=13)				
Mauritius	28	28	0	0.0%
Uruguay	28	28	0	0.0%
Niger	21	21	0	0.0%
Marshall Islands	20	20	0	0.0%
The Syrian Arab Republic	20	20	0	0.0%
Cuba	19	19	0	0.0%
Belize	17	17	0	0.0%
Guinea	17	17	0	0.0%
Central African Republic	14	14	0	0.0%
Saint Kitts and Nevis	14	14	0	0.0%
Equatorial Guinea	13	13	0	0.0%
Haiti	13	13	0	0.0%
Monaco	12	12	0	0.0%

A.



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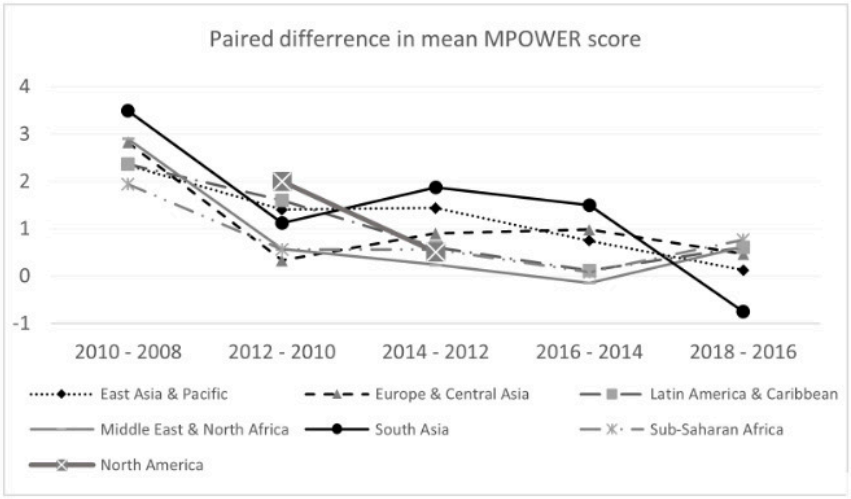

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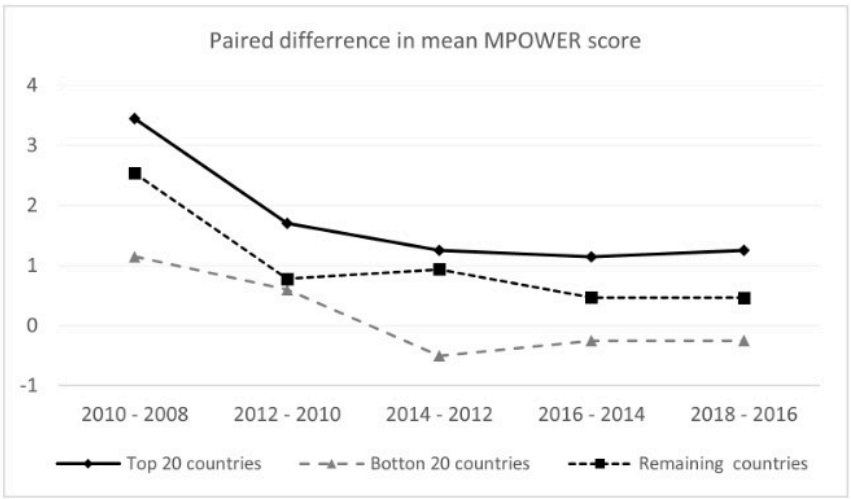

Figure 4. A: Trend in difference in mean MPOWER score by country income level. B: The difference in mean MPOWER score by WHO region. C: The difference in mean MPOWER score for top and bottom 20 countries.

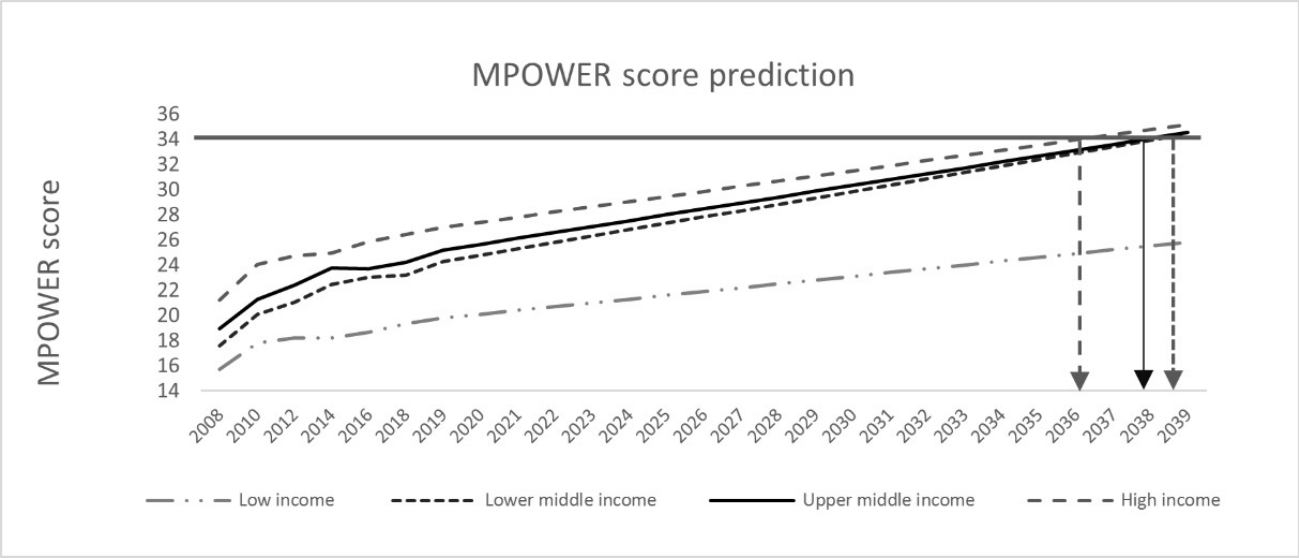

Figure 5. Estimated dates of full MPOWER implementation by country income level.

an 8% increase in implementation over ten years. Tobacco taxes are the single most effective means of reducing tobacco use. This vital tobacco control measure's relatively low implementation rate is disturbing and warrants further attention.

COVARIATES

The relationship between MPOWER and selected covariates was somewhat inconsistent and counter-intuitive. For example, tobacco control objectives and cigarette affordability are positively associated with MPOWER implementation, but the existence of a government tobacco control agency and government funding for tobacco control is not correlated. Similarly, socio-economic indicators such as the human development index, the national corruption index and the political regime index are positively associated with MPOWER implementation. High- and middle-income countries report higher rates of MPOWER implementation, and low-income countries report lower implementation rates. Further analysis of country demographics and social, political, and economic indicators and their relationship to MPOWER implementation is warranted.

LIMITATIONS

The MPOWER implementation results were self-reported to the WHO by participating nations and were validated by WHO regional offices in consultation with tobacco control experts in each country.[8,9] The scope of this study did not allow for any additional auditing or scrutiny of the national self-reports. Secondly, the MPOWER numerical scoring tables were obtained from the WHO Global Health Observatory. The numerical data does not appear in the MPOWER biannual reports, and there is potential for inconsistencies. Thirdly, MPOWER does not address all the possible influences on tobacco control and smoking behaviour, such as tobacco industry interference, which has been identified as the largest barrier to implementing FCTC globally.[32] Article 5.3 of the FCTC addresses tobacco industry interference, and another independent global index measures national adherence to this critical indicator.[33] In addition, MPOWER does not address any supply-side tobacco control measures nor the four established elements of the tobacco marketing mix, specifically *place* (point of sale) and *product* (design and production).[34] Finally, the authors selected the covariates subjectively based on their perceived potential impact on MPOWER scores.

CONCLUSIONS

Twenty-three (23) countries achieved MPOWER scoring improvements of at least 10 points out of a possible 34 between 2008 and 2018. Twenty countries achieved the highest MPOWER rankings in 2019, providing the best models for other countries to follow. Based on this study's projections, high- and middle-income countries will achieve full MPOWER implementation by 2040 at current adoption rates. Although MPOWER rates are increasing among low-income countries, the projected date of full implementation is uncertain. The approval of a new global strategy to accelerate FCTC implementation at the 8th Conference of the Parties held in Geneva in 2018 holds promise for further progress, especially if it is adequately resourced.[35]

The relative ranking of nations' implementation of WHO MPOWER tobacco control measures provides a global performance index to benchmark, monitor, measure, compare and stimulate MPOWER implementation and to promote tobacco use reduction among all countries.

Although this analysis is not exhaustive, it helps to identify common characteristics of countries that have achieved high levels of MPOWER implementation. The analysis also sheds light on independent covariates that influence MPOWER implementation. We encourage others to conduct further analyses. The increasing availability of public domain datasets provides further opportunities to enhance

Table 4. MPOWER scoring comparisons between highest 20 and lowest 20 performing countries

	Highest 20 countries		Lowest 20 countries		Measurement	
	n	%	n	%	Chi-square	P value
Income					**12.93**	**0.005**
Low-income country	--		9	45.0%		
Middle-low income	4	20.0%	2	10.0%		
Middle-high income	5	25.0%	5	25.0%		
High-income country	11	55.0%	4	20.0%		
WHO region					**12.12**	**0.02**
East Asia & Pacific	3	15.0%	1	5.0%		
Europe & Central Asia	9	45.0%	2	10.0%		
Latin America & Caribbean	5	25.0%	7	35.0%		
South Asia	1	5.0%	--			
Sub-Sahara Africa	2	10.0%	10	50.0%		
Middle East & North Africa	--		--			
North America	--		--			
Change in government tobacco control objectives					**22.70**	**<0.001**
Never had objectives	1	5.0%	9	45.0%		
Always had objectives	17	85.0%	2	10.0%		
Newly created objectives	2	10.0%	9	45.0%		
National agency for tobacco control 2018					4.28	0.12
Yes	9	45.0%	4	20.0%		
No	0	0.0%	2	10.0%		
Not reported	11	55.5%	14	70.0%		
Covariate	**Mean**	**SD**	**Mean**	**SD**	***t test***	**P value**
Human development index 2008	0.77	0.13	0.55	0.16	4.46	**<0.001**
Human development index 2016	0.80	0.12	0.57	0.15	5.10	**<0.001**
Per capita tobacco control budget	0.73	1.76	0.02	0.02*	0.55	0.59
Number of staff employed by national agency (last reported)	12.00	13.86	2.14	1.77§	1.85	0.78
Affordability 2018	3.26	1.93	6.74	6.41	-2.30	**0.03**
Affordability 2008	2.63	1.61	7.62	8.06	-2.71	**0.01**
Corruption 2012	56.55	19.45	34.71	18.26	3.30	**<0.001**
Corruption 2018	57.05	19.11	32.50	17.72	3.96	**<0.001**
Literacy rate (last reported)	92.56	13.23	71.72	25.54	3.18	**0.003**
Political regime 2014	8.68	1.80	2.36	4.20	5.76	**<0.001**
Overall tax score 2018	2.64	1.13	1.06	0.36	4.67	**<0.001**

*data from 2 countries, §data from 7 countries

the understanding of MPOWER and tobacco control implementation.

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None.

AUTHORSHIP CONTRIBUTIONS

L.H. conceived the study and wrote the draft manuscript based on previous publications by G.H. G.H. assisted with study design and writing. F.H. performed data analysis and assisted with study design and writing.

COMPETING INTERESTS

The authors have completed the Unified Competing Interest form at www.icmje.org/coi_disclosure.pdf (available upon request from the corresponding author) and declare no conflicts of interest.

CORRESPONDENCE TO:

Les Hagen, ASH Canada, PO Box 52117 RPO Garneau, Edmonton, Alberta, Canada T6G 2T5.

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