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Hardcore smoking among daily smokers in male and female adults in 27 countries: a secondary data analysis of Global Adult Tobacco Surveys (2008-2014)

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Background "Hardcore smokers" (HCS) who do not want to quit make it more difficult for tobacco control efforts to further reduce smoking prevalence. We aimed to quantify the burden of HCS among daily smoking adult males and females in 27 countries.

Methods We used Global Adult Tobacco Survey (GATS) data to estimate the prevalence of HCS ie, daily smokers who smoke within 30 minutes after waking up, smoke ≥10 cigarettes per day, have not made any quit attempts during previous 12 months or have no intention to quit at all or during the coming 12 months. For each GATS country, we estimated sex-wise, weighted and age-adjusted prevalence of daily smoking and HCS.

Results Overall weighted population prevalence (%) of HCS was highest in Greece (21.0), followed by Russia (13), Poland (9.4), Romania (9.0), and Ukraine (8.9) and lowest in Nigeria (0.4). Estimated number of HCS (in millions) was highest in China (35.8) followed by India (28.2), Russia (18.5), Indonesia (16.1) and lowest in Panama (0.03). The proportion (%) of daily smokers classified as HCS was highest in Greece (56.2%) followed by Russia (42.2%), Ukraine (37.2) and Poland (36.2) and lowest in Mexico (8.29). Overall, proportion of HCS was higher among males in all countries. However, in Greece, Russia, Romania, Ukraine and Poland both population prevalence of HCS among women and proportion of HCS among daily smoking women was higher than in other countries.

Conclusions At the country-level, a higher daily smoking rates also suggest a higher proportion of HCS. Countries with greater burden of HCS pose greater challenges to tobacco control efforts specifically towards tobacco cessation interventions. Interventions to reduce tobacco use and smoking-related mortality may need to be altered in populations with high proportions of HCS.

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Tobacco use, particularly cigarette smoking including environmental tobacco smoke is still a substantial contributor to the global disease burden (*1*). Smoking prevalence is decreasing worldwide, particularly in developed countries, although rate of decline has slowed down in recent years (*2*). The sustained presence of heavy smokers who are more addicted and less able to quit (*3*) has led to emergence of "hardening hypotheses" (*4*). Light smokers are more likely to quit than the heavy smokers, thus leading over time to a decrease in light smokers and a relative increase in heavy smokers. Over time these heavy smokers become much harder to reach, and it becomes more difficult for them to quit (*5*), leading to a "hardened" population of smokers who are more resistant to quit. However, it has also been argued that the process of 'hardening' may not occur due to dynamic nature of cohorts of smokers arising from changes in subpopulations of quitters, smokers who die and new smokers (*6*).

The 'hardening hypothesis' has been tested using data on smoking behaviours in United States (*7*-*9*), Australia (*10*) England (*11*, *12*), Norway (*13*) and Italy (*14*). The 'hardening hypothesis' has also been evaluated in several studies using varying definitions for 'hardcore smoker' (HCS). In general, HCS was defined based on the constructs of duration and intensity of smoking, time to smoke the first cigarette of the day, number of quit attempts made, intention to quit, and knowledge about harms of smoking (*6*, *15*). Additionally, empirical evidence for the 'hardening hypothesis' has been evaluated using repeated cross-sectional survey data (*16*, *17*) and national population monitoring data (*16*). Based on Global Adult Tobacco Survey (GATS), HCS was defined using different constructs and prevalence, and factors associated HCS were reported (*18*, *19*). A study from Poland assessed factors associated with HCS including the constructs listed above to define HCS (*18*) while another study from Bangladesh, India and Thailand tested the association of HCS with socio-demographic factors only (*19*).

Studying the population prevalence of HCS and the proportion of current daily smokers who are HCS helps design tobacco control policies and set up support services for smoking cessation targeted at the 'hardened' smokers (*20*). In this paper, we use a five-item construct for HCS based on definitions used in previous studies. We report sex-specific, country-wise proportions of HCS among the current daily smokers, population prevalence of HCS and estimated total number of HCS in 27 GATS countries.

METHODS

We used publicly available data of the Global Adult Tobacco Surveys (GATS) (http://nccd.cdc.gov/gtssdata/Ancillary/DataReports.aspx?CAID=2), a series of nationally representative, cross-sectional household surveys done as a part of worldwide Global Tobacco Surveillance System (GTSS) to monitor tobacco use among various population groups. The GATS uses a standardised questionnaire to assess tobacco use behaviours among civilian, non-institutionalised individuals aged 15 years and above (*21*). In each GATS country, the residents of all regions were eligible to be sampled by a stratified multi-stage probability sampling technique. Within a selected geographic location, households were selected at random and within a selected household, all eligible persons were interviewed using a handheld device used for rostering and data collection, and one household member was selected at random for the interview. The implementing agencies in each country adapted the core questionnaire to suit the local tobacco use context. In all countries interviews were done privately by either a male or female interviewers, except for India, Bangladesh, Indonesia and Qatar interviewers were of same gender as the respondent. Further details about survey instrument, methodology etc. are published elsewhere (*21*). The sample sizes, response rates by sex are given in **Table 1**.

Main outcome variable

Based on previous studies respondents were defined as HCS, if they satisfied the following five criteria (*8*): 1) is a current daily smoker; 2) smokes 10 or more cigarettes per day; 3) smokes their first cigarette within 30 minutes after waking up; 4) has not made any quit attempts during 12 months prior to the date surveyed; and 5) has no intention to quit smoking at all or during the next 12 months.

Table 1. Survey characteristics, sex-wise and country-wise distribution of smoking characteristics and weighted prevalence of daily smoking in 27 GATS countries

COUNTRY	SURVEY YEAR	SAMPLE SIZE (% OF TOTAL SAMPLE)	MEDIAN AGE (IQR)	SMOKING STATUS (NUMBER AND %)			WEIGHTED PREVALENCE AND 95% CI OF DAILY SMOKING
				DAILY SMOKER	NON-DAILY SMOKER	NON-SMOKER	
Men (≥15 years):							
Argentina	2012	2985 (44.9)	56 (37, 70)	681 (22.8)	271 (9.1)	2033 (68.1)	21.89 (17.32-26.47)
Bangladesh	2009	4468 (46.4)	35 (25, 45)	1972 (44.1)	185 (4.1)	2311 (51.7)	40.69 (38.50-42.87)
Brazil	2008	18039 (45.8)	38 (27, 51)	3513 (19.5)	524 (2.9)	14002 (77.6)	18.91 (18.18-19.63)
Cameroon	2013	4049 (60.9)	31 (23, 42)	79 (2.0)	6 (0.1)	3969 (97.9)	9.11 (7.63-10.61)
China	2010	6603 (49.4)	46 (36, 59)	3303 (50.0)	469 (7.1)	2831 (42.9)	45.35 (42.73-47.97)
Egypt	2009	10062 (48.1)	34 (25, 47)	3904 (38.8)	189 (1.9)	5969 (59.3)	35.85 (34.52-37.17)
Greece	2013	2092 (48.0)	48 (35, 67)	1037 (49.6)	27 (1.3)	1028 (49.1)	49.7 (46.42-52.99)
India	2009	33767 (48.7)	35 (26, 45)	8164 (24.2)	2084 (6.2)	23519 (69.7)	18.35 (17.43-19.27)
Indonesia	2011	3948 (47.5)	38 (28, 52)	2335 (59.1)	385 (9.8)	1228 (31.1)	56.74 (53.82-59.65)
Kazakhstan	2014	2085 (47.1)	39 (28, 52)	795 (38.1)	118 (5.7)	1172 (56.2)	36.91 (34.20-39.63)
Kenya	2014	2077 (47.1)	35 (26, 46)	341 (16.4)	82 (3.9)	1654 (79.6)	11.60 (9.71-13.50)
Malaysia	2011	2104 (49.5)	41 (29, 55)	873 (41.5)	82 (3.9)	1149 (54.6)	39.87 (36.51-43.23)
Mexico	2009	6160 (45.2)	36 (27, 50)	654 (10.6)	744 (12.1)	4762 (77.3)	11.81 (10.61-13.02)
Nigeria	2012	5058 (51.8)	31 (24, 45)	323 (6.4)	91 (1.8)	4644 (91.8)	5.55 (4.60-6.51)
Pakistan	2014	3782 (48.2)	35 (24, 46)	811 (21.4)	67 (1.8)	2904 (76.8)	20.59 (18.88-22.30)
Panama	2013	7679 (45.3)	39 (27, 54)	298 (3.9)	477 (6.2)	6904 (89.9)	4.37 (2.98-5.76)
Philippines	2009	4740 (48.9)	37 (27, 50)	1887 (39.8)	420 (8.9)	2433 (51.3)	38.24 (36.35-40.13)
Poland	2009	3867 (49.3)	47 (32, 60)	1309 (33.9)	116 (3.0)	2442 (63.1)	33.52 (31.58-35.46)
Qatar	2013	4237 (50.5)	33 (26, 41)	799 (18.9)	178 (4.2)	3260 (76.9)	16.51 (14.95-18.07)
Romania	2011	2070 (45.8)	56 (40, 70)	657 (31.7)	50 (2.4)	1363 (65.8)	34.85 (32.27-37.43)
Russia	2009	6217 (54.5)	46 (32, 58)	3486 (56.1)	300 (4.8)	2431 (39.1)	54.98 (53.15-56.80)
Thailand	2011	8781 (42.6)	47 (35, 60)	3525 (40.1)	368 (4.2)	4888 (55.7)	42.04 (40.17-43.90)
Turkey	2012	4470 (45.4)	43 (30, 59)	1593 (35.6)	189 (4.2)	2688 (60.1)	37.33 935.38-39.27)
Uganda	2013	3853 (45.3)	31 (24, 42)	400 (10.4)	79 (2.1)	3374 (87.6)	8.69 (7.49-9.88)
Ukraine	2010	4076 (50.0)	51 (35, 66)	1866 (45.8)	168 (4.1)	2042 (50.1)	45.48 (43.55-47.420
Uruguay	2009	2634 (47.2)	47 (32, 65)	677 (25.7)	134 (5.1)	1823 (69.2)	24.85 (22.45-27.25)
Viet Nam	2010	4356 (43.9)	40 (29,53)	1794 (41.2)	377 (8.7)	2185 (50.2)	38.74 (36.88-40.61)
Women (≥15 years):							
Argentine	2012	3660 (55.1)	37 (27, 54)	505 (13.8)	193 (5.3)	2962 (80.9)	12.74 (9.79-15.69)
Bangladesh	2009	5161 (53.6)	37 (27, 48)	66 (1.3)	10 (0.2)	5085 (98.5)	1.33 (0.87-1.79)
Brazil	2008	21386 (54.2)	38 (27,54)	2560 (12.0)	406 (1.9)	18420 (86.1)	11.52 (10.98-12.06)
Cameroon	2013	2594 (39.1)	30 (23, 44)	18 (0.7)	8 (0.3)	2568 (99.0)	0.46 (0.20-0.71)
China	2010	6751 (50.6)	47 (37, 60)	197 (2.9)	41 (0.6)	6513 (96.5)	2.0 (1.44-2.55)
Egypt	2009	10862 (51.9)	38 (28, 49)	53 (0.5)	9 (0.1)	10800 (99.4)	0.45 (0.24-0.67)
Greece	2013	2267 (52)	47 (34, 65)	573 (25.3)	30 (1.3)	1664 (73.4)	23.91 (21.05-26.76)
India	2009	35529 (51.3)	36 (27, 48)	1059 (3.0)	289 (0.8)	34181 (96.2)	2.44 (2.06-2.82)
Indonesia	2011	4357 (52.5)	38 (29, 50)	90 (2.1)	45 (1.0)	4222 (96.9)	1.82 (1.29-2.34)
Kazakhstan	2014	2340 (52.9)	41 (29, 56)	77 (3.3)	30 (1.3)	2233 (95.4)	3.17 (2.24-4.10)
Kenya	2014	2331 (52.9)	31 (24, 45)	20 (0.9)	6 (0.3)	2305 (98.9)	0.60 (0.14-1.06)
Malaysia	2011	2146 (50.5)	40 (28, 53)	25 (1.2)	9 (0.4)	2112 (98.4)	0.69 (0.32-1.06)
Mexico	2009	7457 (54.8)	37 (26, 52)	202 (2.7)	221 (3.0)	7034 (94.3)	3.67 (2.88-4.47)
Nigeria	2012	4707 (48.2)	34 (25, 45)	12 (0.3)	3 (0.1)	4692 (99.7)	0.28 (0.099-0.46)
Pakistan	2014	4049 (51.8)	32 (24, 44)	79 (2.0)	6 (0.1)	3964 (97.9)	1.99 (0.02-2.52)
Panama	2013	9283 (54.7)	42 (28, 58)	69 (0.7)	152 (1.6)	9062 (97.6)	1.24 (0.69-1.79)
Philippines	2009	4961 (51.1)	36 (27, 48)	360 (7.3)	102 (2.1)	4499 (90.7)	6.86 (5.94-7.78)
Poland	2009	3973 (50.7)	44 (31, 57)	870 (21.9)	121 (3.0)	2982 (75.1)	21.0 (19.54-22.47)
Qatar	2013	4161 (49.5)	38 (29) (45)	52 (1.2)	50 (1.2)	4059 (97.5)	1.66 (1.02-2.300
Romania	2011	2447 (54.2)	50 (36, 65)	301 (12.3)	48 (2.0)	2098 (85.7)	14.49 (12.70-16.29)
Russia	2009	5189 (45.5)	43 (29, 55)	786 (15.1)	235 (4.5)	4168 (80.3)	16.26 (14.38-18.14)

Table 1. Continued

COUNTRY	SURVEY YEAR	SAMPLE SIZE (% OF TOTAL SAMPLE)	MEDIAN AGE (IQR)	SMOKING STATUS (NUMBER AND %)			WEIGHTED PREVALENCE AND 95% CI OF DAILY SMOKING
				DAILY SMOKER	NON-DAILY SMOKER	NON-SMOKER	
Thailand	2011	11825 (57.4)	46 (33, 58)	328 (2.8)	70 (0.6)	11427 (96.6)	2.11 (1.75-2.47)
Turkey	2012	5381 (54.6)	42 (31, 56)	520 (9.7)	110 (2.0)	4751 (88.3)	10.67 (9.59-11.75)
Uganda	2013	4655 (54.7)	30 (23, 43)	71 (1.5)	19 (0.4)	4565 (98.1)	1.31 (0.91-1.7)
Ukraine	2010	4082 (50.0)	46 (32, 59)	289 (7.1)	74 (1.8)	3719 (91.1)	8.88 (7.60-10.15)
Uruguay	2009	2947 (52.8)	45 (31, 61)	488 (16.6)	95 (3.2)	2364 (80.2)	16.42 (14.77-18.07)
Viet Nam	2010	5569 (56.1)	40 (28, 52)	73 (1.3)	16 (0.3)	5480 (98.4)	1.21 (0.75-1.68)

CI – confidence interval, IQR – interquartile range

Statistical analyses

All the analyses were done on Stata/IC version 10 (Stata Corp LLC, College Station, TX, USA). Descriptive statistics were calculated for current daily smoking and five constructs of HCS including average of number of cigarettes smoked per day. The proportion of current daily smokers who were HCS was calculated for men, women and both sexes. To adjust for complex sampling design used in GATS, we used country sample weights to estimate prevalence rates and 95% confidence intervals (95% CI). We used total and sex-wise population aged 15 years above from United Nations census data to estimate the number (in millions) male and female HCS in each GATS country. As a sensitivity analysis, we also estimated age-adjusted rates of current daily smoking and HCS, adjusted to the world population standard (*22*).

RESULTS

Table 1 shows the year of survey followed by sex-specific sample size, median age of respondents and smoking status for each country. A total of 344,329 adults (164259 men and 180070 women) were surveyed, median age of the respondents varied between 31-55 years for men and 30-61 years for women. The weighted prevalence of current daily smoking among men was highest in Indonesia (57%) and Russia (55%), and lowest in Panama (4%) and Nigeria (6%). Among women current daily smoking prevalence was considerably lower: <1% in Nigeria, Egypt, Cameroon, Kenya and Malaysia and less than 5% in 12 countries; over 15% in Russia, Uruguay Poland and Greece (Table 1).

In all countries, the weighted population prevalence HCS was considerably higher among men than women, and in nine countries HCS prevalence was higher than 10% (Table 2). Among men, Greece (30.9%) had the highest prevalence, followed by Russia (23.8%) while in Argentina, Qatar, Panama, Cameroon, Kenya, Uganda, Mexico and Nigeria HCS prevalence was much lower (2.71-0.81%). However, in 25 countries the weighted population prevalence of HCS among women was less than 5.0% and in 17 of these 25 countries HCS prevalence was <1.0%; Poland (6.8%), and Greece (11.4%) had higher prevalence for women. (Figure 1 shows weighted prevalence of current daily smoking and HCS in each country).

Overall (both sexes), proportion of daily smokers who were defined as HCS was higher in Greece, Cameroon, Russia, Ukraine, Romania and Poland (36.2-56.2%), in other countries the proportion was between 30% and 10%, except Mexico (8.3%). The proportion of male HCS was over 55% in Greece, and in Russia, Ukraine, Poland and Romania it was nearly 40%, whereas in most other countries it ranged between 30-15%. In all countries except Qatar, Bangladesh and Nigeria, the proportion of HCS was higher among males where prevalence of current daily smoking was also low. In both sexes, proportion of daily smokers who were defined as HCS tended to be higher among countries with higher prevalence of daily smoking (Figure 2).

Overall in 27 GATS countries there were an estimated 111 million HCS (101.6 million men and 12.4 million women, Table 3). Among the GATS countries, four countries together accounted for nearly 70% of all HCS: China (30 million), India (21 million), Russia (16 million) and Indonesia (11 million). China and India had largest burden of HCS in terms of absolute number of HCS due

Table 2. Weighted prevalence rates of HCS and distribution (number and %) of the HCS constructs among the daily smokers in 27 GATS countries

	WEIGHTED PREVALENCE OF HCS (95% CI)	MEAN STICKS PER DAY	≥10 STICKS PER DAY	NO QUIT ATTEMPT IN LAST 12 MONTHS	NO INTENTION TO QUIT AT ALL OR NEXT 12 MONTHS	SMOKE WITHIN 30 MINUTES AFTER WAKING UP
Men (≥15 years)						
Argentina	2.31 (1.54-3.08)	15.26	499 (73.3)	554 (58.2)	721 (75.7)	219 (32.2)
Bangladesh	7.46 (6.21-8.71)	12.33	1220 (61.9)	1126 (52.2)	1358 (63)	881 (44.7)
Brazil	4.67 (4.29-5.05)	14.96	2316 (68.1)	2546 (60.8)	1977 (80.5)	2195 (62.5)
Cameroon	1.55 (0.86, 2.23)	8.76	95 9 (33.9)	218 (58.0)	258 (68.6)	83 (28.9)
China	5.12 (4.40-5.85)	17.24	2694 (81.6)	1044 (69.6)	3172 (84.1)	1840 (55.7)
Egypt	6.4 (5.72-7.08)	16.74	3114 (79.8)	2541 (62.1)	3004 (73.4)	1402 (35.9)
Greece	30.91 (27.78-34.04)	20	866 (83.5)	906 (85.2)	927 (87.1)	795 (76.7)
India	4.46 (4.03-4.90)	10.62	3721 (45.6)	7159 (69.9)	8004 (78.1)	5370 (65.8)
Indonesia	13.09 (10.95-15.24)	12.38	1545 (66.2)	1948 (71.6)	2427 (89.2)	906 (38.8)
Kazakhstan	10.52 (8.83, 12.21)	16.73	552 (77.0)	675 (73.9)	775 (84.9)	422 (53.1)
Kenya	1.97 (1.07, 2.86)	9.36	142 (42.8)	193 (45.6)	241 (57.0)	256 (75.1)
Malaysia	8.15 (6.46-9.85)	14.38	654 (74.9)	564 (59.1)	842 (88.2)	417 (47.8)
Mexico	1.15 (0.78-1.52)	10.02	268 (41.0)	789 (56.4)	922 (66.0)	180 (27.5)
Nigeria	0.81 (0.38-1.23)	8.9	105 (32.5)	235 (56.8)	284 (68.6)	168 (52.0)
Pakistan	5.54 (4.60, 6.48)	13.69	521 (65.4)	668 (76.1)	740 (84.3)	399 (49.2)
Panama	1.53 (0.83-2.23)	12.77	118 (39.6)	393 (50.7)	600 (77.4)	130 (43.6)
Philippines	10.49 (9.26-11.73)	11.48	1176 (62.3)	1259 (54.6)	1831 (79.4)	1124 (59.6)
Poland	12.27 (11.04-13.51)	17.84	1141 (87.2)	1006 (70.6)	992 (69.6)	817 (62.4)
Qatar	2.71 (2.08-3.33)	14.64	554 (69.3)	635 (65.0)	601 (61.5)	298 (37.3)
Romania	13.74 (11.87-15.61)	17.04	567 (86.3)	466 (65.9)	547 (77.4)	471 (71.7)
Russia	23.8 (22.01-25.58)	17.77	2892 (83.0)	2727 (72.0)	3334 (88.1)	2357 (67.6)
Thailand	12.19 (10.98-13.39)	12.24	2267 (64.3)	2535 (65.1)	3303 (84.8)	2093 (59.4)
Turkey	8.05 (7.00-9.11)	20.36	1398 (87.8)	1034 (58.0)	1143 (64.1)	666 (41.8)
Uganda	0.98 (0.59, 1.38)	6.95	287 (59.9)	192 (48.0)	346 (72.2)	278 (69.5)
Ukraine	16.65 (15.25-18.06)	17.25	1622 (86.9)	1343 (66.0)	1552 (76.3)	1231 (66.0)
Uruguay	4.37 (3.24-5.50)	17.11	500 (73.9)	465 (57.3)	550 (67.7)	285 (42.1)
Viet Nam	9.88 (8.84-10.92)	14.92	1268 (70.8)	1037 (47.8)	1550 (71.4)	1167 (65.1)
Women (≥15 years):						
Argentina	1.59 (0.78-2.39)	11.39	296 (58.6)	378 (54.2)	515 (73.8)	145 (28.7)
Bangladesh	3.82 (3.16-4.49)	8.57	21 (31.8)	49 (64.5)	60 (78.9)	33 (50.0)
Brazil	2.33 (2.08-2.59)	12.39	1474 (59.6)	1619 (54.6)	1272 (78.6)	1399 (54.6)
Cameroon	0.09 (-0.001, 0.19)	5.35	4 (23.5)	9 (34.6)	19 (73.1)	9 (50.0)
China	0.12 (0.04-0.19)	12.64	135 (68.5)	49 (59.8)	196 (82.4)	105 (53.3)
Egypt	0.05 (0.0027-0.09)	7.98	17 (32.1)	34 (54.8)	46 (74.2)	22 (41.5)
Greece	11.39 (9.57-13.21)	15	471 (82.2)	501 (83.1)	516 (85.6)	367 (64.0)
India	0.31 (0.21-0.40)	7.27	275 (26.0)	939 (69.7)	1086 (80.6)	625 (59.0)
Indonesia	0.22 (0.0591-0.37)	8.01	29 (32.2)	86 (63.7)	121 (89.6)	25 (27.8)
Kazakhstan	0.38 (0.06, 0.7)	10.49	30 (49.2)	75 (70.1)	85 (79.4)	34 (44.2)
Kenya	0.013 (-0.01, 0.04)	5.8	2 (25.0)	9 (34.6)	10 (38.5)	14 (70.0)
Malaysia	0.03 (0.012-0.07)	9.84	15 (60)	19 (55.9)	28 (82.4)	7 (28)
Mexico	0.22 (0.051-0.38)	8.35	56 (27.7)	192 (45.4)	252 (59.6)	62 (30.7)
Nigeria	0.042 (0.017-0.10)	18.83	5 (41.7)	8 (53.3)	12 (80.0)	7 (58.3)
Pakistan	0.2 (0.02, 2.5)	7.45	23 (30.3)	63 (74.1)	74 (87.1)	23 (29.1)
Panama	0.2 (0.047-0.36)	7.8	19 (27.5)	112 (50.7)	183 (82.8)	25 (36.2)
Philippines	0.74 (0.44-1.03)	6.88	116 (32.2)	222 (48.1)	349 (75.5)	163 (45.3)
Poland	6.78 (5.91-7.66)	15.49	742 (85.3)	676 (68.2)	654 (66.0)	502 (57.7)
Qatar	0.64 (0.20-1.08)	11.65	26 (50.0)	60 (58.8)	69 (67.6)	26 (50.0)
Romania	4.6 (3.47-5.72)	13.52	226 (75.1)	215 (61.6)	263 (75.4)	188 (62.5)
Russia	3.99 (3.14-4.85)	11.43	532 (67.7)	677 (66.3)	855 (83.7)	369 (46.9)
Thailand	0.45 (0.30-0.60)	8.61	140 (42.7)	253 (63.6)	320 (80.4)	163 (49.7)
Turkey	1.98 (1.53-2.42)	15.12	361 (69.4)	350 (55.6)	382 (60.6)	200 (38.5)
Uganda	0.06 (-0.013, 0.14)	3.47	4 (5.6)	52 (57.8)	71 (78.9)	46 (64.8)
Ukraine	2.39 (1.69-3.08)	11.3	189 (65.4)	222 (61.2)	260 (71.6)	150 (51.9)
Uruguay	2.3 (1.53-3.06)	12.96	312 (64.2)	317 (54.4)	384 (65.9)	158 (32.4)
Viet Nam	0.31 (0.14-0.49)	10.25	30 (41.1)	55 (61.8)	67 (75.3)	40 (54.8)

HCS – hardcore smoking, CI – confidence interval

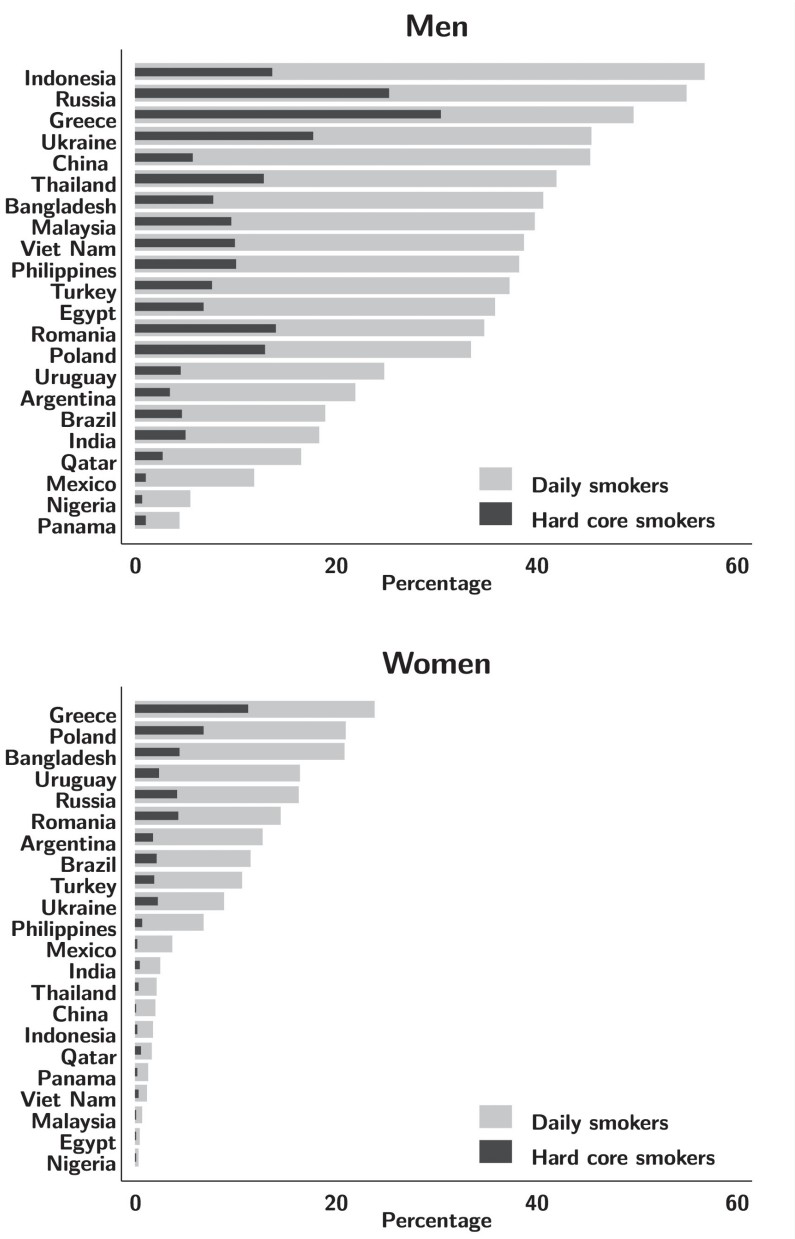

Figure 1. Proportions of HCS among daily smoking men and women in 27 GATS countries.

to their large population sizes. India and China had relatively lower prevalence of current daily smoking than Greece and eastern European countries of GATS which had very high current daily smoking prevalence. Age-standardization led to similar estimated prevalence for both daily smoking and HCS, compared to crude estimates (see Table S1 in **Online Supplementary Document**).

DISCUSSION

The prevalence of HCS and the proportion of daily smokers defined as 'hardcore' varied widely between 27 GATS countries and sexes. In general, we found that proportion of daily smokers defined as 'hardcore' was higher among countries with a higher prevalence of current daily smoking. In terms of absolute numbers China, India, Russia and Indonesia have very large numbers of HCS, whereas Russia has highest proportion of daily smokers defined as 'hardcore'. In all GATS countries, women ranked lower than men in prevalence of HCS and number of HCS. Both prevalence of HCS and the proportion of HCS among current daily smokers were higher in high-income and upper-middle-income GATS countries, Qatar being an exception to this.

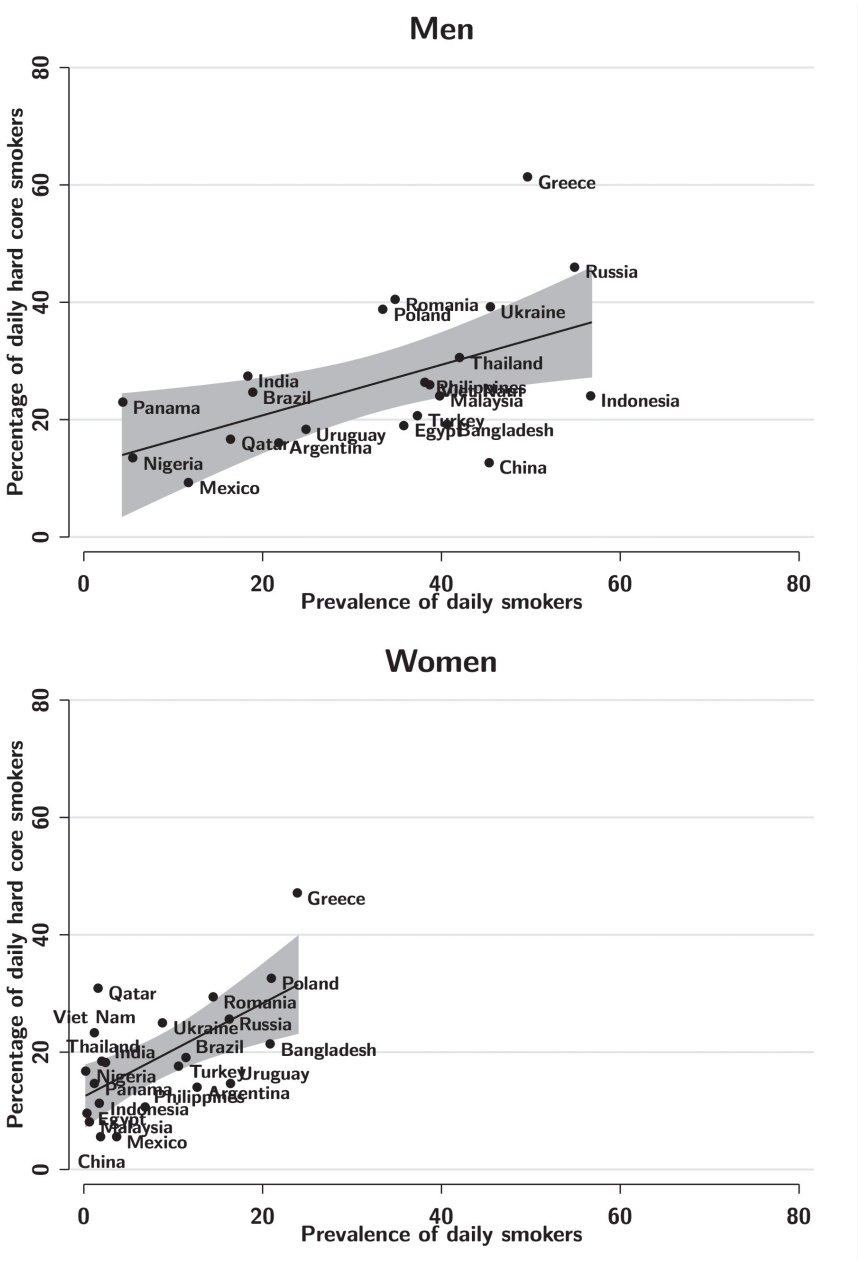

Figure 2. Scatter diagram for relationship of percentage of HCS and prevalence of daily smoker among men and women in 27 GATS countries. Comparison of prevalence of daily smoker with percentage of HCS by each country can also be found in Table S1 in **Online Supplementary Document**.

A strength of our analysis was a robust survey design of GATS, which generates nationally representative samples of men and women. The standardised methodology and survey instrument of GATS enabled us to construct a definition of HCS for cross-country comparison (*23*). Nevertheless, estimates reported in this paper should be interpreted with caution against the possible limitations inherent in GATS design. Self-reported smoking behaviour is known to lead to under-estimates due to smoking-related stigma (*24*). Furthermore, social desirability bias related to quit attempts and intentions to quit may have resulted in underestimation of HCS (*25*). Both duration of smoking as well as smoking intensity (ie, daily number of cigarettes smoked) indicate nicotine addiction but duration of smoking could not be computed in many low-income and lower-middle-income GATS countries because of missing data on age of smoking initiation. The surveys we analysed were implemented at different time periods, smoking patterns change over time and are sensitive to country-specific tobacco control pol-

Table 3. Estimated number of HCS and their 95CIs in 27 GATS countries by both sexes and sex-wise

COUNTRY	TOTAL NUMBER HCS (BOTH SEXES)			NUMBER OF MALE HCS			NUMBER OF FEMALE HCS		
	ESTIMATES	95% CIS		ESTIMATES	95% CIS		ESTIMATES	95% CIS	
Argentina	600,767	426,451	775,083	347,841	231,894	463,788	255,510	125,344	384,068
Bangladesh	3,596,984	3,154,423	4,048,961	3,471,427	2,889,753	4,053,100	1,819,390	1,505,045	2,138,498
Brazil	3,388,870	3,012,329	3,750,929	3,270,889	3,004,735	3,537,043	1,742,445	1,555,488	1,936,881
Cameroon	102,667	59,033	145,017	99,426	55,165	143,045	5,777	-64	12,196
China	29,676,736	25,786,527	33,566,945	28,801,771	24,751,522	32,908,274	658,744	225,071	1,043,012
Egypt	1,630,698	1,481,549	1,779,847	1,620,481	1,448,305	1,792,657	11,222	666	21,713
Greece	1,980,614	1,821,070	2,140,158	1,416,617	1,273,168	1,560,066	553,263	464,858	641,669
India	20,541,066	18,696,562	22,469,411	19,129,782	17,285,431	21,017,025	1,269,425	859,933	1,637,968
Indonesia	11,224,127	10,243,707	12,221,452	11,039,063	9,234,358	12,852,202	186,353	50,061	313,412
Kazakhstan	393,981	328,093	461,213	351,459	291,825	411,093	14,205	1,420	177,561
Kenya	252,969	138,220	365,110	255,229	138,627	370,535	1,706	919	525
Malaysia	863,312	705,414	1,021,210	859,365	681,165	1,038,619	2,989	1,195	7,272
Mexico	526,817	383,140	678,476	441,100	299,181	583,019	91,221	21,147	157,564
Nigeria	351,291	171,561	522,851	331,155	155,357	502,865	17,141	6,938	40,812
Pakistan	3,831,873	3,191,048	4,485,777	3,720,310	3,089,066	4,351,554	17,039	1,704	212,993
Panama	20,982	11,817	29,906	18,435	10,001	26,869	2,462	567	4,345
Philippines	3,449,610	3,092,329	3,806,891	3,227,957	2,849,464	3,609,527	228,130	135,645	317,533
Poland	3,039,755	2,803,689	3,279,055	1,894,431	1,704,525	2,085,882	1,145,704	998,688	1,294,408
Qatar	29,551	23,401	35,358	35,948	27,591	44,173	2,442	763	4,122
Romania	1,523,880	1,341,014	1,708,438	1,119,847	967,437	1,272,257	403,960	304,726	502,315
Russia	15,649,954	14,684,652	16,603,190	13,031,482	12,051,383	14,006,105	2,629,798	2,069,565	3,196,621
Thailand	3,277,696	3,011,216	3,544,175	3,150,351	2,837,642	3,460,475	123,535	82,356	164,713
Turkey	2,798,306	2,477,374	3,113,608	2,258,669	1,964,060	2,556,084	559,270	432,163	680,727
Uganda	88,860	53,316	124,403	86,213	51,904	121,403	5,385	-1,167	12,564
Ukraine	3,485,824	3,195,011	3,776,637	2,959,780	2,710,910	3,210,428	514,390	363,732	662,895
Uruguay	84,635	68,895	100,376	53,530	39,688	67,372	31,174	20,738	41,475
Viet Nam	3,216,745	2,879,506	3,553,985	3,118,793	2,790,499	3,447,086	103,190	46,602	163,106
Total	**115,628,570**	**103,241,349**	**128,108,462**	**10,6111,349**	**92,834,654**	**119,492,544**	**12,395,870**	**9,274,104**	**15,770,969**

HCS – hard-core smoking, CI – confidence interval

icies (*2*); hence our results should be interpreted in the context of the local tobacco control environment in the GATS countries.

The prevalence of HCS among high-income countries has been well reported and ranged from 16% in the UK (*11*) to 6% in Norway (*13*). Our estimates varied widely and ranged from 21% in Greece to 0.4% in Nigeria. However, our estimates of HCS are not comparable to those from high-income countries due to heterogeneity in the constructs these studies used to define a HCS (*15*). Given the relationship, we identified between daily rates of smoking and HCS, our estimates may also differ from high-income countries because the prevalence of daily smoking differs as well. Two prior GATS-based studies used different definitions for HCS and reported a population prevalence of HCS of 3.1% (India), 3.8% (Bangladesh) and 6.0% (Thailand) (*19*) whereas 10.0% in Poland (*18*) which were nearly same as our estimates.

The hardening hypothesis has implications for tobacco control, since when the prevalence of smoking decreases it would make sense to target HCS to achieve further reductions (*5*). Studies on HCS have primarily been based on cross-sectional data (*12*, *14*, *18*, *19*). Additional studies that have examined sequential cross-sectional surveys have provided some evidence against the 'hardening theory' (*13*, *17*, *26*); however, one study reported that hardening may be occurring in the UK (*5*). Nevertheless, we are only able to provide cross-sectional estimates of HCS for 27 GATS countries. Some GATS countries have a huge burden of estimated population who are HCS, mainly among men in China, India, Russia and Indonesia. These

estimate numbers have implications for tobacco control since smoking cessation can help to avoid a substantial tobacco-attributable mortality, particularly in low-and-middle-income countries (LMIC) currently experiencing epidemic levels of smoking (*27*). Moreover, these numbers have implications for healthcare services in LMICs which typically neither provided smoking cessation services (*28*) nor implemented tobacco-related training programs healthcare professionals (*29*) as per the recommendations of FCTC Article 14 or the FCTC Article 14 guidelines. LMICs with higher burden of HCS and low quit rates are likely to require larger healthcare costs to implement smoking cessation services.

Tobacco control strategies should consider smoking intensity, duration of smoking, and time to smoking first cigarette, as these factors are known to be associated with tobacco dependence (*30*). More intensive and universal measures should be undertaken to achieve higher quit rates among all daily smokers (*5*). Reaching out to the hardcore smokers who lack motivation (don't want to quit) and have severe nicotine addiction (can't quit) (*17*) requires a more holistic approach. Motivational interviewing maybe one of the approaches to help smokers decide to quit (*31*), as it is well known that smokers who are in contemplation stages are more likely to remain tobacco-free (*32*). HCS constructs in most studies including ours do not include socio-economic deprivation and mental health which are associated with "hardening" (*14*). As smoking is also known to be common among those with socio-economic deprivation (*33*) wider community level interventions, such as health promotion and socio-economic development may not only help cessation but could also potentially help to decrease smoking initiation (*34*).

In addition to conflicting reports on the 'hardening hypotheses', there is also a lack of consensus on uniform definitions of hardening across the published literature. Hence, there is a need for further studies defining HCS based on all the four domains of constructs described by Edwards et al (*17*). Current conflicting literature, mainly from developed countries, has tested the 'hardening hypothesis' with sequential cross-sectional surveys (*10*, *11*, *13*, *16*, *17*, *26*); cohort studies on daily smokers who cannot quit would confirm the hardening hypothesis and examine the changes in proportion of HCS over time.

CONCLUSIONS

HCS constitute a fifth to third of daily smokers in some GATS countries, which presents challenges to tobacco control efforts. As the proportion of HCS tends to increase with the prevalence of daily smoking, efforts should be made to counter smoking initiation. Further HCS also poses a challenge to health services in LMIC where smoking cessation services are sub optimal. Future studies should include all four domains of HCS to better understand about "hardening hypothesis" in LMIC.

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