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Prevalence and determinants of dual and poly-tobacco use among males in 19 low-and middle-income countries: Implications for a comprehensive tobacco control regulation

Daniel Tzu-Hsuan Chen *, Christopher Millett, Filippos T. Filippidis

Public Health Policy Evaluation Unit, School of Public Health, Imperial College London, United Kingdom

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ABSTRACT

Despite their implications for tobacco control, data on concurrent dual (using two tobacco products) and poly-tobacco use (using more than two products) are relatively scarce globally. This study aimed to estimate the prevalence of dual and poly-tobacco use among men in 19 low-and middle-income countries (LMICs) and assess potential associations with individual and country level factors. Data from 19 LMICs were obtained from the most recent wave of the Demographic and Health Survey (DHS), collected between 2015 and 2016 comprising 235,975 men aged 15–49 years. The prevalence of current single, dual and poly-tobacco use were estimated using available sample weights. Mixed-effect multilevel models were used to estimate associations of individual and country level factors with tobacco use. Results showed that the prevalence of dual or poly-tobacco use among men was highest in Timor Leste (27.1%), Nepal (18.3%), Lesotho (13.2%) and India (9.3%). Factors associated with dual and poly-tobacco use were older age, low academic achievement, low income status, being divorced, living in urban areas and high frequency of media use. Among country-level characteristics, national wealth was not associated with dual and poly-tobacco use. Implementation of MPOWER measures was inversely associated with single tobacco use; this was not the case for dual and poly-tobacco use. Findings suggest that dual and poly-tobacco use are common among men especially in South-East Asian countries. This study highlights the need for MPOWER measures to be expanded and strengthened to address all tobacco products and explicitly consider dual and poly use.

1. Introduction

Tobacco use is an important risk factor for non-communicable diseases globally. Since 2005, when the World Health Organization Framework Convention on Tobacco Control (WHO FCTC) entered into force, global efforts on tobacco control have been scaled up worldwide (World Health Organization, 2019a). Under the FCTC, the WHO introduced the MPOWER measures to support tobacco control policy implementation. These contributed to the decline of smoking prevalence, especially in high income countries (Ng et al., 2014). However, low-and middle-income countries (LMICs) which bear the major burden of tobacco-related diseases have not been equally successful in achieving substantial decreases in smoking prevalence (Southeast Asia Initiative on Tobacco Tax of the Southeast Asian Tobacco Control Alliance, 2016). More than 80% of all smokers live in LMICs (Bilano et al., 2015) with the vast majority being male (Allen et al., 2017). The tobacco industry has been targeting these countries which may have limited capacity to counteract tobacco industry influence and implement comprehensive tobacco control policies, thus compounding cross-country inequalities in smoking (Thomas et al., 2008; White et al., 2009).

While manufactured cigarettes remain the most commonly used tobacco product among adults worldwide (Ng et al., 2014), the proliferation of alternative tobacco products such as waterpipe, smokeless tobacco and cigars opens another avenue for traditional cigarette smokers to either switch to or smoke cigarettes in combination with other tobacco products (Hu et al., 2016). Smokers concurrently using two (dual users) or more than two tobacco products (poly-tobacco users) have become increasingly common in recent years (Sinha et al., 2016), a phenomenon which is more pronounced in low-income countries (Agaku et al., 2014). In South-East-Asia, between 2006 and 2012, about 63.6% of men were reported to be currently using at least one tobacco product, with 7.5% being dual users (Sinha et al., 2016). An analysis of

* Corresponding author at: Room 319, Reynolds Building, Imperial College London, St. Dunstan's Road, London W6 8RP, United Kingdom.
E-mail addresses: thc17@ic.ac.uk (D.T.-H. Chen), c.millett@imperial.ac.uk (C. Millett), f.filippidis@imperial.ac.uk (F.T. Filippidis).

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poly-tobacco use in 44 countries showed substantial regional and socioeconomic differences in the profile of poly-tobacco users (Agaku et al., 2014). For example, males living in South-East Asia, Western Pacific and the African regions are more likely to be poly-tobacco users relative to Europe, with greater variability of product use observed among smokers in low-income areas (Agaku et al., 2014; Palipudi et al., 2012). This has major implications for public health. Cigarette smokers who use multiple tobacco products may be faced with increased health risks and nicotine addiction compared to exclusive cigarette smokers (National Center for Chronic Disease et al., 2014). Therefore, it is critical that poly-tobacco use is explicitly addressed in the efforts to curb the tobacco epidemic in LMICs.

Understanding the socio-ecological variations in multiple tobacco product use, including individual level socio-economic factors and contextual social and cultural characteristics across countries may provide essential information to enhance regional integration of tobacco control policies and to strengthen their impact across and within countries. Several studies have previously examined the sociodemographic determinants of various forms of tobacco use (Agaku et al., 2014; Hosseinpoor et al., 2011; Palipudi et al., 2012; Sinha et al., 2016; Sreeramareddy et al., 2014) with a general focus on developing countries. However, the prevalence and determinants of dual and poly-tobacco use are poorly described, and there is currently a limited understanding of poly-tobacco use among smokers in LMICs, and it is currently unclear how tobacco control measures affect the use of alternative tobacco products especially in the context of dual and poly-tobacco product use within these regions. Therefore, the present study aims to provide a more comprehensive view of the prevalence of tobacco use patterns in 19 LMICs. We also aim to investigate the relationship of individual and country-level factors associated with dual and poly-tobacco use considering the variations in social, economic conditions and MPOWER policies across countries.

2. Methods

2.1. Data source

Data from 19 LMICs from the latest available Demographic and Health Surveys (DHS) wavewere used in this analysis. It included countries from all WHO regions: African region ($n = 10$), American region ($n = 2$), South-East Asian region ($n = 4$), European region (n = 1), Eastern Mediterranean region (n = 1), and the Western Pacific region (n = 1) (Supplementary Fig. 1). These surveys were conducted between 2015 and 2016 by country-level research organizations and funded by the USAID. The DHS uses a multistage stratified random sampling with Population Proportional to Size (PPS) technique, thus the samples are nationally representative. Eligible respondents in the reproductive age group (15 to 49 years old) were sampled, although in some countries only married persons were selected. The selected household members were interviewed face-to-face by trained interviewers using standard questionnaires, translated in appropriate local languages. Procedures were standardized across all studied countries and strict quality control measures were employed to maintain data quality. The methodological details and further information on DHS have been presented in official reports (Corsi et al., 2012). We analyzed a total of 234,537 male respondents aged 15 to 49 years old from 19 LMICs (India: 15–54 years old) for which tobacco use data was available. Country level information was accessed online from the 2017 WHO report on the global tobacco epidemic (World Health Organization, 2017) and the (World Bank, 2019).

2.2. Measures

2.2.1. Tobacco product types

In DHS, tobacco products assessed in each country's survey varied. All 19 countries collected data on cigarettes, chewing tobacco, snuff and pipes (except for Myanmar). Other products assessed include cigars (12 countries excluding Cambodia, Kenya, Zimbabwe, Lesotho, Ghana, Guatemala, Afghanistan); gutkha/paan masala with tobacco, khaini and bidis in India; betel quid with tobacco in Nepal, Timor Leste, Tanzania and Burundi; kreteks in Timor Leste, Tanzania and Burundi; water pipes (hookah) in 10 countries (excluding Cambodia, Myanmar, Timor Leste, Zimbabwe, Lesotho, Ghana, Angola, Guatemala and Afghanistan).

2.2.2. Current dual and poly-tobacco use

Pattern of tobacco use is the main outcome variable of the study. Respondents were first asked: "do you currently smoke or use any other type of tobacco?". Those who responded "yes" to this question were defined as current tobacco users, whereas those who reported "no" to this question were identified as non-tobacco users. Individuals who responded positively to this question were then asked to select from a list the type(s) of tobacco products that they currently smoke or use. Individuals currently using two different tobacco products were deemed dual tobacco users, while poly-tobacco users were defined as concurrently using three or more tobacco products at the time of the survey. In contrast, single tobacco users were those who reported currently using only one tobacco product.

2.2.3. Covariates

Independent predictor variables included individual and country level characteristics. Individual level factors included age (continuous variable), education level (no education, primary, secondary, higher), marital status (never married, partnered [married or living with partner], widowed, divorced [separated or no longer living together]), residential area (urban or rural), occupation (not working, professional, service, agriculture, household and manual worker), wealth index (divided into quintiles from 1 [lowest] to 5 [highest]), and media use (dichotomised as low or high frequency media use).

The household wealth index was constructed by the DHS team separately for each country. The wealth index was determined according to the household asset score, indicating ownership of a variety of household items and facilities. Within each country, the respondents were ranked according to the score of the household in which they were interviewed and the sample score was then divided into quintiles from one (lowest) to five (highest) reflecting their household wealth status (Rutstein and Johnson, 2004).

Media use has been identified as an important determinant of tobacco use (Bhaumik et al., 2015; Lovato et al., 2011). Four variables assessing frequency of mass media use were examined, including whether or not the respondents read newspapers/magazines, watched television, listened to the radio and used the internet for at least once a week. (1 [less than once a week; 2 [at least once a week]). An additive score of the frequencies of all four types of media used was calculated and subsequently recoded into a binary variable indicating low (scoring from 1 to 4) and high (scoring from 5 to 8) frequency of media use.

At the country level, indicators of national wealth and components of the MPOWER score were included. The MPOWER is a set of six cost-effective and high impact measures suggested by WHO in accordance with the FCTC, to assist countries in reducing the demand for tobacco products at country level (World Health Organization, 2019b). Data were extracted from the 2017 WHO report on the global tobacco epidemic (World Health Organization, 2017) to correspond to the surveyed countries and years. The MPOWER score was the number of the MPOWER key components implemented at the highest level in each country, ranging from 0 (none at the highest level) to 6 (all measures implemented at the highest level). National wealth data was obtained from the World Bank database (World Bank, 2019). The purchasing power parity (PPP) of a country indicates GDP per capita measured in international dollars and adjusted for costs and inflation. PPP per thousand dollars of each country corresponding to the survey year was used in the analysis.

2.3. Statistical analysis

Data were weighted according to the cluster sampling design of the surveys using strata and primary sampling unit at the country level to allow the sample to be nationally representative (Lavrakas, 2008). We used the "svyset" and "svy" commands in Stata 13.0 (StataCorp LP.,TX) to account for the complex multistage sampling design of the DHS. Weighted estimates of prevalence of single, dual and poly-tobacco use for each country together with 95% confidence intervals (CI) were calculated.

Due to the hierarchical design of the data, multilevel models for categorical responses were used to estimate the factors associated with different use patterns (non-smokers, single, dual, poly-tobacco users) at the individual (level 1) and country level (level 2). Age, education, marital status, occupation, residential area, wealth index, and media use were the level 1 variables; national wealth and MPOWER score were the level 2 variables. All multilevel regression models were fitted by the Bayesian Markov Chain Monte Carlo (MCMC) estimation method to produce less-biased estimates for multivariate nominal models (Browne, 2019) using the runwlwin command to fit multilevel models in MLwiN software from within Stata (Leckie and Charlton, 2013). The MLwiN 3.04 (Charlton et al., 2019) is a software package specialized for fitting multilevel models. To quantify the cross-country variation in different tobacco use patterns, the intra-class correlation coefficients (ICC) were calculated to indicate the variance at the country level as a percentage of the total variance (Merlo et al., 2006). Multilevel analyses were constructed through a stepwise approach. Firstly, we estimated an intercept-only model (model 1) to identify the ICC, then a country level model (model 2) and an individual level model (model 3) to examine separately the single level effect of individual and contextual factors on tobacco use patterns. Lastly, we fitted a multilevel regression model adjusted for all variables (integrated model). In model comparison, we compared the Bayesian deviance information criterion (DIC) values and favoured the model with lowest DIC. For all the models, both age and age squared were included to allow for a non-linear association between age and the respective outcome. Given the large sample size of the Indian survey in relation to the other countries, we carried out a sensitivity analysis excluding Indian data.

Following a reviewer's request, additional multilevel models were fitted to examine the association between MPOWER measures and two types of dual or poly-tobacco use: dual or poly-tobacco use including cigarettes; and dual or poly-tobacco use of non-cigarette products only. Both models were adjusted for the same set of independent variables mentioned above.

3. Results

3.1. Prevalence of single, dual and poly-tobacco use

Among all tobacco products, cigarettes were the most popular in all countries (Table 1). The overall prevalence of current cigarette smoking among men (including both exclusive cigarette users and dual or poly-users who smoked cigarettes) was highest in Armenia (59.4%), Lesotho (41.3%) and most South-East Asian countries. Prevalence of other smoked tobacco products (i.e. pipes, cigars, waterpipes, bidis and kretek) was highest in South-East Asian, European and Eastern Mediterranean countries in contrast to African countries where prevalence was relatively low. Highest overall prevalence of current pipe use was 6.1% in Lesotho; cigar use was highest in Myanmar at 14.3%; waterpipe use in Armenia at 1.4%; bidi use in India at 14.3% and kretek use in Timor Leste at 23.1%. Smokeless tobacco use (chew, snuff, betel quid with tobacco) among men ranged from nearly no users in Armenia and African countries to substantial prevalence in Asian countries such as Afghanistan (17.7% chew, 14.2% snuff), Nepal (25.8% chew, 16% betel quid), Timor Leste (2% chew, 7.9% betel quid) and India (2.3% chew, 14.9% gutkha and 12.4% khaini). All these estimates include exclusive as well as dual or poly users. The prevalence of current dual or poly-tobacco use among men varied widely. It was highest in the South-East Asian (15.2%), Eastern Mediterranean (7.1%) and the Western Pacific regions (4.1%). In contrast, it was generally low in the African region (2.2%) and Central America (0.7%). Individual countries reporting the highest prevalence of poly-tobacco use were Timor Leste (6.3%), Nepal (3.2%), and India (1.9%) (Fig. 1).

3.2. Factors associated with dual and poly-tobacco use

Table 2 presents the results of the integrated multilevel regression model of different tobacco use patterns among male adults in 19 LMICs. The intermediate steps of the multilevel regression model (model 1 to 3) are shown in Supplementary Table 1. The intercept only model indicates a strong degree of country-level variance in single, dual and poly-tobacco use, with high ICC values, meaning the multilevel approach is warranted. The low DIC together with the decreased ICC of the full regression model which integrates both individual and country level factors, shown in Table 2, indicates balanced goodness of fit and model complexity.. Controlling for both country and individual level covariates, higher education (Relative Risk Ratio [RRR] = 0.55; 95%CI: 0.46–0.66), household wealth (RRR = 0.16; 95%CI: 0.14–0.19) and living in rural areas (RRR = 0.78; 95%CI: 0.71–0.85) were associated with lower risk ratios of poly-tobacco use compared to no tobacco use., Conversely, divorced men (RRR = 2.29; 95%CI: 1.61–3.15), manual (RRR = 2.42; 95%CI: 2.11–2.79) and service workers (RRR = 2.34; 95% CI: 2.01–2.70) and those reporting high frequency of media use (RRR = 1.39; 95%CI: 1.22–1.58) showed higher risk ratios of being poly-tobacco users in comparison to non-users. The direction and magnitude of association were fairly similar for dual and single tobacco users in comparison to non-tobacco users as well.

At the country level, higher national wealth does not seem to be associated with higher relative risk of being a dual or poly-tobacco product user in comparison to being a non-user. Implementation of more MPOWER policies at the highest level was inversely associated with single use (RRR = 0.74; 95%CI: 0.72–0.77), but positively associated with dual and poly-tobacco use, compared to use of no tobacco products. In sensitivity analyses excluding Indian data, similar findings were observed in relative risks for MPOWER policies and individual level variables. Our additional analysis by type of dual/poly-tobacco use found no association between MPOWER implementation and dual or poly-tobacco use including cigarettes (RRR = 1.01; 95%CI: 0.99–1.03). However, a positive association was identified for dual or poly-tobacco use of exclusively non-cigarette products (RRR = 1.21; 95%CI: 1.20–1.22).

4. Discussion

Our analysis found that there is substantial variation in dual and poly-tobacco use among men between LMICs. We also found associations of sociodemographic factors, as well as tobacco control policies, with patterns of tobacco use. This study builds on previous studies by providing a more detailed and comprehensive view of the prevalence of dual and poly-tobacco use among the male population in 19 LMICs and examine the socio-demographic determinants of different tobacco use patterns (i.e., single product use, dual tobacco use, poly-tobacco product use) among smokers in different countries and economic contexts, which few studies have examined (Agaku et al., 2014; Palipudi et al., 2012; Sinha et al., 2016).

We identified patterns which highlight regional differences in use of tobacco products and these results were partially similar with previous findings (Allen et al., 2017; Sinha et al., 2016). Although cigarettes were the most common type of tobacco used, the prevalence of cigarette smoking varied widely with all assessed countries in South-East Asia, Europe and the Eastern Mediterranean region ranging from one-third to two-thirds of men. Other products, such as different types of smokeless

Table 1
Weighted prevalence of current tobacco use among male adults by different products and use patterns in 19 countries.

Prevalence of tobacco use (%) and 95% confidence interval														
Country	Year of survey	Number of male respondent	% cigarette	% pipe	% cigar	% chew	% snuff	% betel quid w/ tobacco	% water pipe (hookah)	% kreteks	% others	% Single [a]	% Dual[b]	% Poly[c]
Cambodia	2014/15	5190	31.85 (30.21–33.52)	0.05 (0.01–0.32)	–	1.93 (1.42–2.61)	3.01 (2.5–3.61)	–	–	–	0.04 (0.01–0.23)	28.55 (26.97–30.19)	4.08 (3.42–4.86)	0.05 (0.01–0.2)
India*	2015/16	112,122	13.68 (13.25–14.12)	0.19 (0.15–0.24)	0.48 (0.41–0.56)	2.33 (2.14–2.55)	0.09 (0.06–0.12)	–	0.64 (0.56–0.72)	–	0.46 (0.4–0.52)	29.53 (29.03–30.04)	7.59 (7.32–7.87)	1.87 (1.75–1.99)
Myanmar	2015/16	4737	31.74 (29.86–33.69)	–	14.34 (12.9–15.91)	1.21 (0.81–1.8)	0.94 (0.62–1.41)	–	–	–	0.08 (0.03–0.22)	34.04 (32.28–35.84)	6.48 (5.68–7.39)	0.42 (0.25–0.72)
Nepal	2016	4063	16.39 (14–17.42)	1.43 (1–2.04)	0.19 (0.08–0.46)	25.75 (23.6–28.02)	2.04 (1.32–2.71)	16.04 (14.32–17.93)	1.28 (0.88–1.86)	–	0.68 (0.26–1.75)	25.02 (23.1–27.03)	14.17 (12.63–15.88)	3.22 (2.61–3.97)
Timor-Leste	2016	4622	36.67 (33.03–37.6)	1.04 (0.7–1.55)	2.62 (1.87–3.68)	2.01 (1.43–2.82)	–	7.92 (6.79–9.22)	–	23.14 (20.6–25.89)	1.67 (1–2.75)	12.32 (0.11–0.14)	20.79 (18.64–23.12)	6.26 (5.16–7.58)
Ethiopia	2016	12,688	3.34 (2.6–3.98)	0.05 (0.02–0.14)	0.08 (0.05–0.14)	0.17 (0.09–0.3)	0.45 (0.16–0.58)	–	0.05 (0.02–0.13)	–	0.01 (0–0.04)	3.56 (2.93–4.33)	0.18 (0.1–0.32)	0.07 (0.03–0.18)
Kenya	2014	12,819	16.59 (15.6–17.62)	0.17 (0.11–0.26)	–	0.89 (0.71–1.12)	1.28 (1.04–1.58)	–	0.29 (0.15–0.57)	–	0.75 (0.52–1.07)	16.91 (15.94–17.92)	1.4 (1.11–1.75)	0.07 (0.04–0.15)
Tanzania	2015/16	3514	11.05 (9.74–12.52)	0.06 (0.01–0.22)	–	0.06 (0.01–0.26)	1.71 (1.27–2.3)	0.05 (0.01–0.38)	0.03 (0–0.22)	0.29 (0.15–0.57)	0.52 (0.22–1.2)	10.6 (9.29–12.06)	1.07 (0.77–1.49)	0.31 (0.12–0.79)
Zimbabwe	2015	8396	12.5 (11.6–13.44)	0.31 (0.19–0.49)	–	0.01 (0–0.05)	0.45 (0.32–0.65)	–	–	–	0.96 (0.73–1.25)	11.84 (11–12.73)	1.1 (0.85–1.4)	0.06 (0.02–0.18)
Malawi	2015/16	7478	8.96 (7.86–9.61)	0.08 (0.04–0.18)	0.14 (0.06–0.34)	–	0.22 (0.13–0.36)	–	0.16 (0.06–0.38)	–	0.6 (0.35–1.06)	8 (7.23–8.85)	0.76 (0.47–1.21)	0.11 (0.04–0.3)
Lesotho	2014	2931	41.34 (39.18–43.53)	6.13 (5.04–7.44)	–	1.17 (0.82–1.67)	0.72 (0.47–1.1)	–	–	–	6.3 (5.25–7.54)	29.1 (26.93–31.36)	12.94 (11.37–14.69)	0.23 (0.11–0.49)
Burundi	2016/17	7552	10.65 (9.81–11.56)	0.06 (0.02–0.16)	0.03 (0.01–0.11)	–	0.04 (0.01–0.1)	–	0.03 (0.01–0.13)	0.12 (0.06–0.25)	0.07 (0.03–0.16)	10.47 (9.63–11.37)	0.27 (0.16–0.44)	0 (0–0)
Ghana	2014	4388	4.78 (4.07–5.62)	0.54 (0.29–0.98)	–	0.34 (0.19–0.62)	0.94 (0.65–1.37)	–	–	–	0.64 (0.35–1.17)	5.56 (4.62–6.2)	0.9 (0.56–1.44)	0.03 (0–0.23)
Uganda	2016	5336	7.48 (6.61–8.44)	0.48 (0.19–1.25)	0.18 (0.08–0.41)	0.1 (0.06–0.19)	0.73 (0.5–1.05)	–	0.22 (0.08–0.56)	–	0.14 (0.06–0.34)	7.2 (6.43–8.05)	0.92 (0.56–1.5)	0.09 (0.02–0.31)
Angola	2015/16	5684	15.05 (13.45–16.03)	0.07 (0.02–0.24)	0.01 (0–0.05)	0.48 (0.23–1)	2.44 (1.85–3.21)	–	–	–	0.03 (0.01–0.14)	15.1 (13.89–16.41)	1.19 (0.84–1.68)	0.2 (0.06–0.72)
Guatemala	2014/15	11,145	21.47 (20.32–22.66)	0.04 (0.01–0.11)	–	0.03 (0.01–0.07)	0.15 (0.08–0.26)	–	–	–	0.06 (0.03–0.15)	21.31 (20.17–22.5)	0.2 (0.12–0.32)	0.01 (0–0.04)
Haiti	2016/17	11,886	7.6 (6.91–8.34)	0.36 (0.24–0.53)	0.42 (0.29–0.61)	0.04 (0.02–0.09)	2.23 (1.83–2.72)	–	0.07 (0.03–0.15)	–	0.45 (0.3–0.66)	8.59 (7.82–9.42)	1.01 (0.8–1.27)	0.17 (0.09–0.31)
Armenia	2015	2755	59.41 (57.05–61.73)	0.03 (0–0.23)	1.57 (1.09–2.28)	–	0.07 (0.02–0.29)	–	1.39 (0.94–2.06)	–	0.05 (0.01–0.33)	57.01 (54.64–59.35)	1.69 (1.21–2.36)	0.71 (0.39–1.28)
Afghanistan	2015/16	10,760	21.94 (20.53–23.41)	1.49 (1.01–2.18)	–	17.69 (15.95–19.57)	14.24 (11.96–16.89)	–	–	–	0.23 (0.14–0.39)	41.04 (38.93–43.19)	6.72 (5.61–8.01)	0.36 (0.13–1.01)

* India: % for gutkha/paan masala w/ tobacco = 14.92 (14.5–15.35); % for khaini (snus): 12.36 (11.99–12.75); % for bidis: 14.31 (13.93–14.70).
— indicates product not surveyed in corresponding country.
[a] Single tobacco use: individuals currently using only one tobacco product.
[b] Dual tobacco use:: individuals concurrently using two different tobacco products.
[c] Poly tobacco use: individuals concurrently using three or more tobacco products.

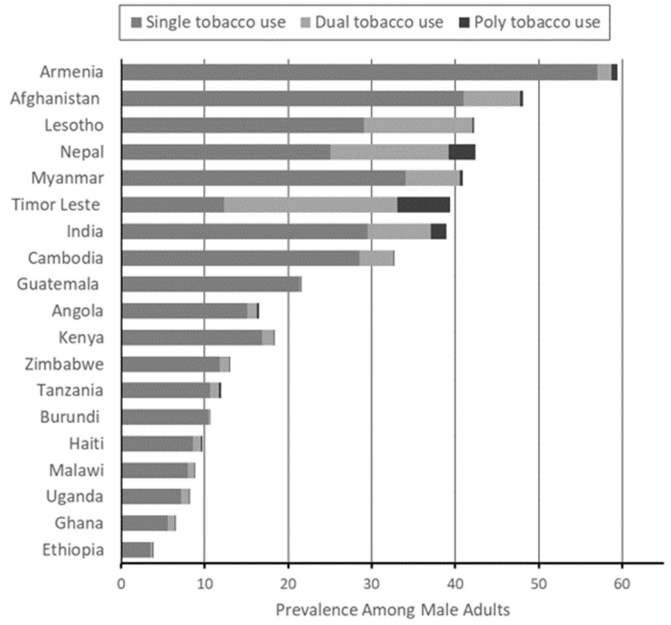

Fig. 1. Prevalence of different use patterns among male adults in 19 LMICs.
Note: all the percentages are estimated from the weighted analysis.

tobacco and products such as gutkha/paan masala with tobacco and khaini were very prominent among males in South Asia, in line with earlier studies (Allen et al., 2017; Zaman et al., 2014). These persisting regional patterns were also observed for dual and poly-tobacco suggesting a close link between a diversified tobacco market and high prevalence of dual and poly-tobacco use, as is the case in South East Asia (Agaku et al., 2014; Hosseinpoor et al., 2011; Palipudi et al., 2012; Sinha et al., 2016; Sreeramareddy et al., 2014). Our analysis did not investigate whether this is associated with either the availability or/and affordability of alternative tobacco products, but this is an important question for subsequent research.

Multilevel regression accounting for individual and country level factors indicated significant country-level variance in single, dual and poly-tobacco use which highlights the differences between countries. Results revealed that there was no association between national wealth and different tobacco use patterns which may indirectly suggest that the prevalence of dual and poly use also depends on non-economic factors, such as social and cultural characteristics that may influence the popularity of tobacco products. However, the current study did not include high-income countries, which would have provided more variability in national income and smoking prevalence.

In addition, we found that implementation of more MPOWER policies at the highest level was negatively associated with single tobacco product use, predominantly of manufactured cigarettes, among males in the LMICs assessed. This is to be expected, as MPOWER measures have been shown to reduce cigarette consumption (Dubray et al., 2015; Ngo et al., 2017). However, MPOWER measures were also positively associated with higher RRR of dual and poly-tobacco use compared to non-use. Although this seems counter-intuitive, differences in the legislative restrictions on manufactured cigarettes (mainly stricter) in contrast to other non-cigarette products may partly explain this. This assumption is also supported by the fact that MPOWER score was positively associated with dual or poly-tobacco use of non-cigarette products. Recent studies have identified gaps in regulatory policies between non-cigarette tobacco products and cigarettes (Siddiqi et al., 2017; Zaatari and Bazzi, 2019). Such gaps extend to taxation, warning labels, advertising bans, prohibition on flavours (Ngo et al., 2017) as well as cessation programmes (Siddiqi et al., 2017) and health messages that communicate comparative risks (Liu et al., 2015). These key measures may be very effective in reducing cigarette smoking at the population level (Dubray et al., 2015; Ngo et al., 2017), but should be strengthened to address all tobacco products.

Dual and poly-tobacco use may reflect price minimization strategies, especially among those of lower socio-economic status, or as means to circumvent existing laws on public smoking bans (Fu et al., 2014; McClave-Regan and Berkowitz, 2011). Additionally, they might elevate health risks for individuals who use multiple tobacco products and prevent them from successfully quitting tobacco use (National Center for Chronic Disease et al., 2014). Our findings indicate that men in LMICs, particularly in South Asia, seem to face this double burden. Importantly, this burden is higher among those in the poorest and less educated parts of society, thus perpetuating health inequalities within countries. Therefore, tobacco control efforts need to target alternative tobacco products in the context of dual and poly-tobacco use within LMICs. So far, MPOWER policies have been poorly applied to non-cigarette tobacco products in many countries and our findings highlight potential consequences of this (Zaatari and Bazzi, 2019).

Table 2
Multilevel regression of tobacco use patterns among male adults ($N = 234,537$) in 19 Low-and Middle-income Countries (Base Category: Non-Tobacco Use).

	Relative risk ratio (RRR) with 95% confidence interval		
	Integrated model		
	Single use	Dual use	Poly use
Fixed effects			
Intercept	0.00 (0.00–0.01)	0.00 (0.00–0.01)	0.00 (0.00–0.01)
National Wealth[a]	1.03 (0.91–1.17)	1.05 (0.85–1.29)	1.17 (0.91–1.47)
MPOWER[b]	0.74 (0.72–0.77)	1.34 (1.16–1.69)	1.54 (1.16–1.91)
Age	1.17 (1.16–1.18)	1.22 (1.20–1.24)	1.27 (1.24–1.31)
Age-squared	1.00 (1.00–1.00)	1.00 (1.00–1.00)	1.00 (1.00–1.00)
Education (ref. no school)			
Primary	0.96 (0.93–0.99)	0.96 (0.90–1.01)	1.14 (1.02–1.28)
Secondary	0.79 (0.76–0.82)	0.78 (0.74–0.83)	0.85 (0.76–0.95)
Higher	0.59 (0.56–0.62)	0.52 (0.48–0.57)	0.55 (0.46–0.66)
Marital status (ref. never married)			
Partnered	1.11 (1.07–1.15)	1.00 (0.94–1.06)	0.91 (0.81–1.02)
Widowed	1.52 (1.35–1.71)	1.36 (1.11–1.65)	1.34 (0.91–1.86)
Divorced	2.61 (2.41–2.82)	2.86 (2.45–3.29)	2.29 (1.61–3.15)
Occupation (ref. not working)			
Professional	1.29 (1.22–1.37)	1.37 (1.23–1.52)	1.47 (1.16–1.83)
Service	1.63 (1.56–1.70)	1.83 (1.7–1.97)	2.34 (2.01–2.7)
Agriculture	1.59 (1.53–1.66)	1.63 (1.52–1.74)	1.82 (1.58–2.09)
Household	1.89 (1.7–2.10)	2.22 (1.69–2.85)	1.72 (0.78–3.3)
Manual	1.86 (1.79–1.94)	2.08 (1.95–2.22)	2.42 (2.11–2.79)
Wealth index (ref. 1st quintile)			
2nd	0.79 (0.77–0.82)	0.79 (0.75–0.84)	0.66 (0.60–0.73)
3rd	0.66 (0.64–0.69)	0.57 (0.54–0.60)	0.46 (0.41–0.51)
4th	0.55 (0.53–0.57)	0.44 (0.41–0.46)	0.3 (0.26–0.33)
5th	0.42 (0.40–0.43)	0.28 (0.26–0.30)	0.16 (0.14–0.19)
Place of residence (ref. urban)			
Rural	0.86 (0.83–0.88)	0.78 (0.75–0.82)	0.78 (0.71–0.85)
Media Use (ref. no use)			
Low use	1.08 (1.04–1.12)	1.32 (1.24–1.40)	1.35 (1.19–1.51)
High use	1.00 (0.96–1.04)	1.29 (1.21–1.38)	1.39 (1.22–1.58)
Random effects			
Country-level variance			
Variance (SE)	0.96 (0.34)	2.88 (1.04)	5.08 (1.90)
ICC (%)	22.66	46.66	60.69
DIC		337,264.37	

Note 1: Non-tobacco use as the base category, reported in Relative Risk Ratio, RRR.
Note 2: The low DIC together with the decreased ICC in the model indicates balanced goodness of fit and model complexity.
ICC: intra-class correlation coefficients; DIC: Bayesian deviance information criterion.
[a] National Wealth: purchasing power parity (PPP) / thousands$.
[b] MPOWER: numbers of the MPOWER measures implemented to the highest level.

4.1. Strengths and limitations

To the authors' knowledge, this is one of the first studies that utilizes multilevel methodology to examine the relationship of individual and country-level factors with use of multiple tobacco products among men in LMICs. Our results might not fully reflect the situation in these countries at the time of publication due to the rapidly changing landscape and the introduction of new tobacco and nicotine products since the data were collected. However, we analyzed the most recent data available with large, nationally representative samples from 19 countries in the DHS datasets which increases our confidence that our findings reflect true associations in these countries. Although this may not fully apply to all LMICs, this is an adequate number of countries to produce unbiased estimates using the multilevel model (Paccagnella, 2011). However, several limitations should be noted. The analysis is limited by the fact that tobacco use was based on self-reported surveys. Furthermore, the availability of data on frequency of use varied widely across the 19 countries surveyed; data were available on some of the countries and for some of the products. Thus, we were not able to incorporate frequency data in our analysis.. Although questionnaires did not include all tobacco products in all countries, we assumed that all popular products were assessed in each country. Nevertheless, new emerging tobacco and nicotine products such as heated tobacco and e-cigarettes might complicate the tobacco market in LMICs in coming years. These were not surveyed and assessed here, presumably due to very low prevalence, but may need to be considered in future surveys. In the current study, we analyzed only male respondents. Although this excludes the female population, it is mostly men who smoke in the countries we examined (Agaku et al., 2014; Allen et al., 2017; Sinha et al., 2016). We used simplified measures for media exposure as well as for MPOWER policies, which may not fully capture the effects of specific tobacco control policies on dual and poly-tobacco use. Lastly, due to the analytical approach and the nature of the data, we were unable to identify causal associations; we were not able to study transitions from single to dual and poly-tobacco use and vice versa. Further studies should use longitudinal data to capture temporality and causal relationships.

5. Conclusion

In conclusion, this study underlines the importance of considering the role of alternative tobacco products in LMICs. Our findings highlight the need to strengthen tobacco control policies and interventions in LMICs with particular focus on regulating non-cigarette products which contribute to higher prevalence of dual and poly-tobacco use.

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Declaration of Competing Interest

None declared.

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Appendix A. Supplementary data

Supplementary table and figure to this article can be found online at https://doi.org/10.1016/j.ypmed.2020.106377.

References

Agaku, I.T., Filippidis, F.T., Vardavas, C.I., Odukoya, O.O., Awopegba, A.J., Ayo-Yusuf, O.A., Connolly, G.N., 2014. Poly-tobacco use among adults in 44 countries during 2008-2012: evidence for an integrative and comprehensive approach in tobacco control. Drug Alcohol Depend. 139, 60–70. https://doi.org/10.1016/j.drugalcdep.2014.03.003.

Allen, L., Williams, J., Townsend, N., Mikkelsen, B., Roberts, N., Foster, C., Wickramasinghe, K., 2017. Socioeconomic status and non-communicable disease behavioural risk factors in low-income and lower-middle-income countries: a systematic review. Lancet Glob. Health 5 (3), e277–e289. https://doi.org/10.1016/s2214-109x(17)30058-x.

Bhaumik, S., Arora, M., Singh, A., Sargent, J.D., 2015. Impact of entertainment media smoking on adolescent smoking behaviours. Cochrane Database Syst. Rev. 6 https://doi.org/10.1002/14651858.CD011720.

Bilano, V., Gilmour, S., Moffiet, T., d'Espaignet, E.T., Stevens, G.A., Commar, A., Tuyl, F., Hudson, I., Shibuya, K., 2015. Global trends and projections for tobacco use, 1990-2025: an analysis of smoking indicators from the WHO Comprehensive Information Systems for Tobacco Control. Lancet 385 (9972), 966–976. https://doi.org/10.1016/S0140-6736(15)60264-1.

Browne, W.J., 2019. MCMC Estimation in MLwiN, v3.03. University of Bristol.

Charlton, C., Rasbash, J., Browne, W.J., Healy, M., Cameron, B., 2019. MLwiN Version 3.03. University of Bristol.

Corsi, D.J., Neuman, M., Finlay, J.E., Subramanian, S.V., 2012. Demographic and health surveys: a profile. Int. J. Epidemiol. 41 (6), 1602–1613. https://doi.org/10.1093/ije/dys184.

Dubray, J., Schwartz, R., Chaiton, M., O'Connor, S., Cohen, J.E., 2015. The effect of MPOWER on smoking prevalence. Tob. Control. 24 (6), 540–542. https://doi.org/10.1136/tobaccocontrol-2014-051834.

Fu, M., Martínez-Sánchez, J.M., Clèries, R., Villalbí, J.R., Daynard, R.A., Connolly, G.N., Fernández, E., 2014. Opposite trends in the consumption of manufactured and roll-your-own cigarettes in Spain (1991-2020). BMJ Open 4 (12), e006552. https://doi.org/10.1136/bmjopen-2014-006552.

Hosseinpoor, A.R., Parker, L.A., Tursan d'Espaignet, E., Chatterji, S., 2011. Social determinants of smoking in low- and middle-income countries: results from the World Health Survey. PLoS One 6 (5), e20331. https://doi.org/10.1371/journal.pone.0020331.

Hu, S.S., Neff, L., Agaku, I.T., Cox, S., Day, H.R., Holder-Hayes, E., King, B.A., 2016. Tobacco product use among adults—United States, 2013–2014. MMWR Morb. Mortal. Wkly Rep. 65, 685–691. https://doi.org/10.15585/mmwr.mm6527a1.

Lavrakas, P.J., 2008. Encyclopedia of Survey Research Methods. Sage Publications. https://doi.org/10.4135/9781412963947.

Leckie, G., Charlton, C.M.J., 2013. runmlwin: a program to run the MLwiN multilevel modeling software from within Stata. J. Stat. Softw. 52, 1–40.

Liu, S.T., Nemeth, J.M., Klein, E.G., Ferketich, A.K., Kwan, M.P., Wewers, M.E., 2015. Risk perceptions of smokeless tobacco among adolescent and adult users and nonusers. J. Health Commun. 20 (5), 599–606. https://doi.org/10.1080/10810730.2015.1012237.

Lovato, C., Watts, A., Stead, L., 2011. Impact of tobacco advertising and promotion on increasing adolescent smoking behaviours. Cochrane Database Syst. Rev. 10, CD003439.

McClave-Regan, A.K., Berkowitz, J., 2011. Smokers who are also using smokeless tobacco products in the US: a national assessment of characteristics, behaviours and beliefs of 'dual users'. Tob. Control. 20 (3), 239–242. https://doi.org/10.1136/tc.2010.039115.

Merlo, J., Chaix, B., Ohlsson, H., Beckman, A., Johnell, K., Hjerpe, P., Råstam, L., Larsen, K., 2006. A brief conceptual tutorial of multilevel analysis in social epidemiology: using measures of clustering in multilevel logistic regression to investigate contextual phenomena. J. Epidemiol. Community Health 60 (4), 290–297. https://doi.org/10.1136/jech.2004.029454.

National Center for Chronic Disease, P., Health Promotion Office on, S., & Health, 2014. Reports of the surgeon General. In: The Health Consequences of Smoking—50 Years of Progress: A Report of the Surgeon General. Centers for Disease Control and Prevention (US).

Ng, M., Freeman, M.K., Fleming, T.D., Robinson, M., Dwyer-Lindgren, L., Thomson, B., Wollum, A., Sanman, E., Wulf, S., Lopez, A.D., Murray, C.J.L., Gakidou, E., 2014. Smoking Prevalence and Cigarette Consumption in 187 Countries, 1980-2012. JAMA 311 (2), 183–192. https://doi.org/10.1001/jama.2013.284692.

Ngo, A., Cheng, K.W., Chaloupka, F.J., Shang, C., 2017. The effect of MPOWER scores on cigarette smoking prevalence and consumption. Prev. Med. 105, S10–S14. https://doi.org/10.1016/j.ypmed.2017.05.006.

Paccagnella, O., 2011. Sample size and accuracy of estimates in multilevel models: New simulation results. Methodol. Eur. J. Res. Methods Behav. Soc. Sci. 7 (3), 111–120. https://doi.org/10.1027/1614-2241/a000029.

Palipudi, K.M., Gupta, P.C., Sinha, D.N., Andes, L.J., Asma, S., McAfee, T., 2012. Social determinants of health and tobacco use in thirteen low and middle income countries: evidence from Global Adult Tobacco Survey. PLoS One 7 (3), e33466. https://doi.org/10.1371/journal.pone.0033466.

Rutstein, S.O., Johnson, K., 2004. The DHS Wealth Index (DHS Comparative Reports No. 6). http://dhsprogram.com/pubs/pdf/CR6/CR6.pdf.

Siddiqi, K., Vidyasagaran, A.L., Readshaw, A., Croucher, R., 2017. A policy perspective on the global use of smokeless tobacco. Curr. Addict. Rep. 4 (4), 503–510. https://doi.org/10.1007/s40429-017-0166-7.

Sinha, D.N., Suliankatchi, R.A., Amarchand, R., Krishnan, A., 2016. Prevalence and sociodemographic determinants of any tobacco use and dual use in six countries of

the WHO south-east Asia region: findings from the demographic and health surveys. Nicotine Tob. Res. 18 (5), 750–756. https://doi.org/10.1093/ntr/ntv286.

Southeast Asia Initiative on Tobacco Tax of the Southeast Asian Tobacco Control Alliance, 2016. ASEAN tobacco tax report card: regional comparisons and trends. In: Southeast Asia Tobacco Control Alliance (SEATCA), 5 ed. https://seatca.org/dmdocuments/ASEANtaxReport2016.pdf

Sreeramareddy, C.T., Pradhan, P.M., Mir, I.A., Sin, S., 2014. Smoking and smokeless tobacco use in nine South and Southeast Asian countries: prevalence estimates and social determinants from Demographic and Health Surveys. Popul. Health Metrics 12, 22. https://doi.org/10.1186/s12963-014-0022-0.

Thomas, S., Fayter, D., Misso, K., Ogilvie, D., Petticrew, M., Sowden, A., Whitehead, M., Worthy, G., 2008. Population tobacco control interventions and their effects on social inequalities in smoking: systematic review. Tob. Control. 17 (4), 230–237. https://doi.org/10.1136/tc.2007.023911.

White, M., Adams, J., Heywood, P., 2009. How and why do interventions that increase health overall widen inequalities within populations?. In: Health, Inequality and Society. Policy Press, Bristol, pp. 64–81. https://doi.org/10.1332/policypress/9781847423207.003.0005.

World Bank, 2019. PPP Reported by the World Bank. Retrieved Sep, 2019 from. https://data.worldbank.org/indicator/NY.GDP.MKTP.PP.CD.

World Health Organization, 2017. WHO Report on the Global Tobacco Epidemic, 2017: Monitoring Tobacco Use and Prevention Policies. World Health Organization. https://apps.who.int/iris/handle/10665/255874.

World Health Organization, 2019a. WHO Report on the Global Tobacco Epidemic, 2019: Offer Help to Quit Tobacco Use. World Health Organization. https://apps.who.int/iris/handle/10665/255874.

World Health Organization, 2019b. Tobacco Free Initiative (TFI). Retrieved Sep, 2019 from. https://www.who.int/tobacco/mpower/en/.

Zaatari, G.S., Bazzi, A., 2019. Impact of the WHO FCTC on non-cigarette tobacco products. Tob. Control. 28 (Suppl. 2), s104–s112. https://doi.org/10.1136/tobaccocontrol-2018-054346.

Zaman, M.M., Bhuiyan, M.R., Huq, S.M., Rahman, M.M., Sinha, D.N., Fernando, T., 2014. Dual use of tobacco among Bangladeshi men. Indian J. Cancer 51 (Suppl. 1), S46–S49. https://doi.org/10.4103/0019-509x.147481.