

The impact of local smoke-free policies on smoking behaviour among adults in Indonesia: a quasi-experimental national study

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ABSTRACT

Aims To investigate to what extent the adoption of local smoke-free policies (SFPs) in Indonesia in 2007–13 was associated with changes in adult smoking behaviour. **Design** A quasi-experimental study. **Setting** Indonesia, 2007 and 2013. **Participants** A total of 1 052 611 > 25-year-old adults. Data were derived from the 2007 and 2013 Indonesian national health survey. **Measurements** For both years, provincial and district SFPs were identified from government documents in 497 districts in 33 provinces. Multi-level logistic regression analysis assessed the association of adoption of provincial and district SFPs between 2007 and 2013 with smoking continuation (among ever-smokers), current smoking and high smoking intensity (among current smokers). We controlled for survey year, SFP in 2007, socio-demographics and district characteristics. **Findings** Provincial SFP exposure was associated with lower odds of smoking continuation [strong SFP versus no SFP: odds ratio (OR) = 0.71, 95% confidence interval (CI) = 0.66–0.76] and smoking intensity (strong SFP: OR = 0.91, 95% CI = 0.86–0.97), but also with higher odds of current smoking (strong SFP versus no SFP: OR = 1.08; 95% CI = 1.04–1.12). District SFP exposure was associated with higher odds of smoking continuation (strong SFP versus no SFP: OR = 1.07, 95% CI = 1.01–1.14) and current smoking (strong SFP versus no SFP: OR = 1.09, 95% CI = 1.05–1.14), but with lower odds of smoking intensity (moderately strong SFP versus no SFP: OR = 0.95, 95% CI = 0.91–0.99). **Conclusions** There may be an association between the adoption of local smoke-free policies in Indonesia and decreased adult smoking intensity. However, the evidence is inconsistent, which may reflect problems with policy implementation and enforcement.

Keywords Indonesia, smoke-free policy, smoking ban, smoking continuation, smoking intensity, smoking prevalence, tobacco.

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INTRODUCTION

During the past decade, the global number of tobacco smokers has increased to 1.1 billion [1]. Two-thirds of smokers reside in low- and middle-income countries (LMICs) and since 2005, the smoking burden in these countries has remained stable or even increased [2]. Smoking is therefore one of the major public health challenges in LMICs [1]. The implementation of effective tobacco control policies to promote smoking cessation will be imperative in reducing the future disease burden caused by smoking in LMICs [2].

Banning smoking from public places is one of the World Health Organization's (WHO) recommended effective tobacco control policies within the MPOWER package [3]. A 2002 systematic review of 26 studies from high-income-countries (HIC) demonstrated that, after implementation of smoke-free work-places, cigarette consumption among smokers decreased by 29% and smoking prevalence by 3.8% [4]. A 2010 systematic review found a 6.4 percentage-points higher smoking cessation rate among smokers exposed to smoke-free policies (SFPs) compared with those not exposed [5]. Implementing SFPs may therefore be an important step for LMICs to reduce smoking.

Evidence from HICs cannot be readily transferred to LMICs, due to differences in, for example, local opportunities for effective implementation and enforcement. Unfortunately, evidence on the impact of SFPs in LMICs remains limited. A few studies from LMICs to date have demonstrated a decrease in second-hand smoke exposure with the implementation of SFPs [6,7]. One study from Turkey assessed the association between SFP implementation and smoking cessation in high school students, but found no effect [8]. To our knowledge, effects on smoking cessation among adult smokers in LMICs have not yet been assessed.

Indonesia is an example of an LMIC in need of effective tobacco control policies. Its male adult smoking prevalence increased from 53.9% in 1995 to 63.3% in 2013, and in 2013 200 000 Indonesians died as a consequence of smoking-attributable diseases [9,10]. Despite the high smoking burden, Indonesia has not signed and ratified the WHO Framework Convention on Tobacco Control (FCTC), and has an active tobacco industry with a strong economic interest in obstructing tobacco control policy adoption [11,12]. Nevertheless, Indonesia has recently adopted some tobacco control policies at the local level [3,12,13], such as SFPs for work-places and other public areas.

Indonesia's de-centralized government structure gives local governments (i.e. in districts and provinces) autonomy in SFP adoption [12,14]. Provinces and districts are in different layers of government and can independently adopt SFPs. The province has less authority than the district, which means that, in practice, provincial policies are not strictly implemented and enforced in all parts of the province [11]. A number of provinces and districts have adopted SFPs during the last decade. As a result, there is a large variation between provinces and districts in whether and when SFPs have been adopted, and how comprehensively these policies ban smoking from a range of public places. We can use this natural experiment to evaluate the effectiveness of SFPs in Indonesia.

The aim of this study was to investigate the impact of local SFPs on adult smoking behaviour in Indonesia. We may expect SFPs to most directly increase smoking cessation, and therefore the main outcome in this paper was smoking continuation among ever smokers. Current smoking in the total population and smoking intensity among current smokers were secondary outcomes. We used nationally representative survey data from 2007 and 2013 of more than 1 million Indonesians in a multi-level analysis. Using a quasi-experimental design, we compared odds of smoking outcomes among respondents of the 2013 health survey living in areas that adopted SFPs between 2007 and 2013, with 2007 respondents and 2013 respondent in areas that did not adopt SFPs.

METHODS

Study population

Individual survey data were obtained from the Indonesian Basic Health Survey (Riset Kesehatan Dasar; RISKESDAS) administered by the Indonesian Ministry of Health in 2007 and 2013. RISKESDAS is a national cross-sectional survey conducted every 6 years in all 33 provinces and in 440 (2007) and 497 (2013) districts. RISKESDAS was ethically approved by the national ethical committee of the National Institution of Health Research and Development (NIHRD), Ministry of Health, Republic of Indonesia (reference number 2007 KS.02.01.2.1.4739 and 2013 LB.02.01/5.2/KE.006/2013). Informed consent was obtained from all respondents.

A sample of households was selected through multi-stage cluster sampling to obtain a sample representative of each district. All individuals from the selected households were asked to complete a face-to-face household interview with a trained interviewer. In 2007, RISKESDAS achieved a response rate of 98.8% at the census block level (17.150 of 17.357), 93.1% at the household level (258 466 of 277 630) and 85.8% at the individual level (972 989 of 1 134 225). In 2013, response rates were 99.9% (11 986 of 12 000), 98.3% (294 595 of 300 000) and 93% (1 027 763 of 1 105 122), respectively. Community leaders (i.e. religious leaders and chiefs) were involved in the recruitment to increase participation. In 2013, households could be replaced, with up to five per 25 households in a block, if an initially selected household was missing due to force major (e.g. natural disaster, conflict) or if the household did not appear to exist due to administrative problems. Only RISKESDAS's participants over the age of 25 years ($n = 491\,979$ in 2007 and $n = 560\,632$ in 2013) were included in our study, as they were most likely to have been an established smoker before the adoption of SFPs.

Measurements

Individual-level measurements

Respondents were asked: 'Did you smoke in the past 30 days?'. Respondents who answered: 'yes, smoked daily' and 'yes, smoked occasionally' were considered current smokers. Current smoking prevalence was defined as the percentage of current smokers among the total study population. Respondents answering 'yes, smoked daily', 'yes, smoked occasionally' and 'no, but smoked in the past' were considered ever-smokers. We defined smoking continuation as the cross-sectional percentage of current smokers among ever-smokers. Smoking intensity was measured among current smokers, with the following question:

'How many cigarettes did you smoke in the last 30 days?'. As cigarette quantity was not normally distributed, the prevalence of high smoking intensity was defined as the percentage current smokers smoking > 10 cigarettes per day on average. This cut-off has been used in previous studies to distinguish light and heavy smokers [15], and corresponds to a standard-sized cigarette pack in Indonesia.

Individual characteristics included gender (male versus female), age (in years) and highest completed education level. Respondents were categorized into 'high' (completed university or senior high school), 'low' (completed primary school or junior high school) and 'no education' (did not attend school or did not complete primary school). We found no missing values in any of the included individual-level variables.

Measurements of provincial and district smoke-free policies

Data on district and provincial SFPs were obtained from a systematic search for policy documents on the official governmental on-line database network (Jaringan Dokumentasi Informasi dan Hukum; JDIH). This database stores governmental documents and is managed by district and provincial authorities. The search was conducted between February and June 2016 and updated in March 2019. For two districts that were included in the RISKESDAS data we were unable to retrieve policy documents, even after directly contacting district authorities. These districts were assumed not to have adopted SFPs by 2013.

We assessed the strength of SFPs in each province and district in 2007 and 2013 separately, based on the policy documents. We calculated SFP scores according to the Tobacco Control Scale's (TCS) subscale for SFPs [16,17]. The subscale ranges from 1 to 22, with higher scores for more comprehensive SFPs (i.e. complete smoking bans without exceptions or smoking rooms) in the work-place, cafes and restaurants, public transport, educational institution, health facilities, government buildings and cultural places. Among districts and provinces that had adopted SFPs by 2013, the median TCS subscale score was 12.

For the variable 'district SFP adopted by 2007', respondents from either survey (2007 or 2013) were classified into 'no policy' when they lived in a district where no policy had been adopted up to 2007, 'moderately strong' when the 2007 TCS score was ≤ 12 (i.e. the median) and 'strong' when the TCS score was > 12 . For the variable 'district SFP adoption 2007–13', all respondents from the 2007 were classified into 'no new policy adoption', as none of them were exposed to policies adopted between 2007 and 2013. Respondents to the 2013 survey were also classified into 'no new policy adoption' if their district had not adopted SFP up to 2013, or if these districts had SFP up

to 2007 but did not amend the policy between 2007 and 2013. Respondents to the 2013 were classified into 'moderately strong new policy adoption' when SFPs were adopted between 2007 and 2013, and the TCS score was ≤ 12 in 2013. They classified as 'strong new policy adoption' when the TCS score had become > 12 between 2007 and 2013. The same approach was taken for provinces as for districts. No provinces or districts changed their policy from moderate to strong.

In 2013 there were 497 districts, including 57 districts that had split from larger districts since 2007. Adoption of SFPs for these 57 districts was determined by comparing the SFP in the newly split district in 2013 with the SFPs in its origin district in 2007.

Other district-level measurements

District-level covariates included the gross domestic product (GDP) per-capita (in US\$), population density (in people/km²), type of residence (urban or rural) and district tobacco production (in tonnes of tobacco leaf produced/inhabitant) in 2007 and 2013. Data on the GDP per capita and population density were obtained from Statistics Indonesia (Badan Pusat Statistik; BPS) [18]. Districts were grouped into urban or rural according to the classification in Indonesia's subnational governing structure that distinguishes municipal (urban) and regency (rural) districts [19]. Tobacco production in each district was obtained from the Indonesian Ministry of Agriculture [20,21]. The median amount produced in districts with any production was 0.27 tonnes per inhabitant. Tobacco production was categorized into 'no production', 'low' (< 0.27 tonnes/inhabitant) and 'high' (≥ 0.27 tonnes/inhabitant).

Statistical analyses

The study sample characteristics were described at the individual and district levels. Maps were created to describe the geographical pattern of the change in age-standardized smoking continuation prevalence between 2007 and 2013. Data were not weighted, as sampling represented the population and the response rate in the survey was high. The relative change in district-level prevalence rates was categorized as: decrease ($< 0\%$), slight increase (0–5.0%), intermediate increase (5.1–10%) and large increase ($> 10\%$). Adoption of SFP between 2007 and 2013 was mapped for districts and provinces. Maps were created using QGIS version 2.18.

Multi-level logistic regression nested individual respondents (level 0), in districts (level 1) and in provinces (level 2). For the main outcome, smoking continuation, four models were assessed. Model 1 included survey year, district SFP adopted by 2007, district policy adoption between

2007 and 2013 and individual characteristics (age, gender and education). Model 2 included survey year, provincial SFP adopted by 2007, provincial policy adoption between 2007 and 2013 and individual characteristics. Model 3 included all covariates of models 1 and 2. Model 4 was built on model 3 and added all district-level covariates (GDP per capita, population density, tobacco production and type of residence). Current smoking and smoking intensity were analysed only with model 4. As a sensitivity analysis, SFP scores and changes therein between 2007 and 2013 were used as continuous variables. In a second sensitivity analysis, we excluded the three provinces that adopted strong SFPs between 2007 and 2013, given that this is a small number of provinces. For all analyses, we used R version 3.4.1 with the lme4 package [22]. The analyses were not pre-registered and the results should be considered exploratory.

RESULTS

Figure 1 presents a map of changes in the smoking continuation prevalence at district level between 2007 and 2013. Based on age-standardized observed changes, smoking continuation prevalence reduced in 122 districts, but there were more districts in which an increase was observed, with a slight increase in 205 districts, an intermediate increase in 123 districts and a large increase in 48 districts. There was no clear geographical pattern of clustering in these changes.

Figure 2a,b presents maps of adoption of SFPs between 2007 and 2013 at the district and provincial level, respectively. Figure 2a shows that adoption of district SFP was concentrated in western Indonesia, specifically on Java

and Sumatra. Before 2007, 10 districts had adopted moderate SFPs. Between 2007 and 2013, 74 districts adopted SFPs, 41 of which were moderately strong and 33 were strong policies. Figure 2b shows that seven provinces adopted SFPs between 2007 and 2013. These were not necessarily in the same areas where district policies were most often adopted. In total, eight of 33 provinces adopted SFPs by 2013 and 84 districts (of 497) in 24 provinces had adopted SFPs by 2013.

Supporting information, Table S1 presents the number of provinces and districts with SFPs in 2007 and 2013 by island. On Java and Sumatra, more districts had adopted SFPs by 2013 than on all other islands combined. Smoking bans were mainly implemented in work-places, and less often in cafes and restaurants. Most work-places had separate smoking areas. Comprehensive SFPs were implemented in most public transportation and public places, such as schools, playgrounds and worship places. Of the 84 districts that implemented SFPs, 12 districts did not allow smoking rooms in work-places and 13 districts prohibited smoking in cafes/restaurants.

Table 1 describes the individuals in the study population. In the total population, the mean age was 44.7 years in 2007 and 45.8 years in 2013; female respondents represented 52% in 2007 and 52.6% in 2013; 43.8% (2007) and 47.8% (2013) had low education levels. Among ever-smokers, the prevalence of smoking continuation was 88.9% in 2007 and 86.2% in 2013, and among current smokers high smoking intensity prevalence was 53.7% in 2007 and 59.2% in 2013. Supporting information, Table S2 describes individuals by the level of district and provincial SFP.

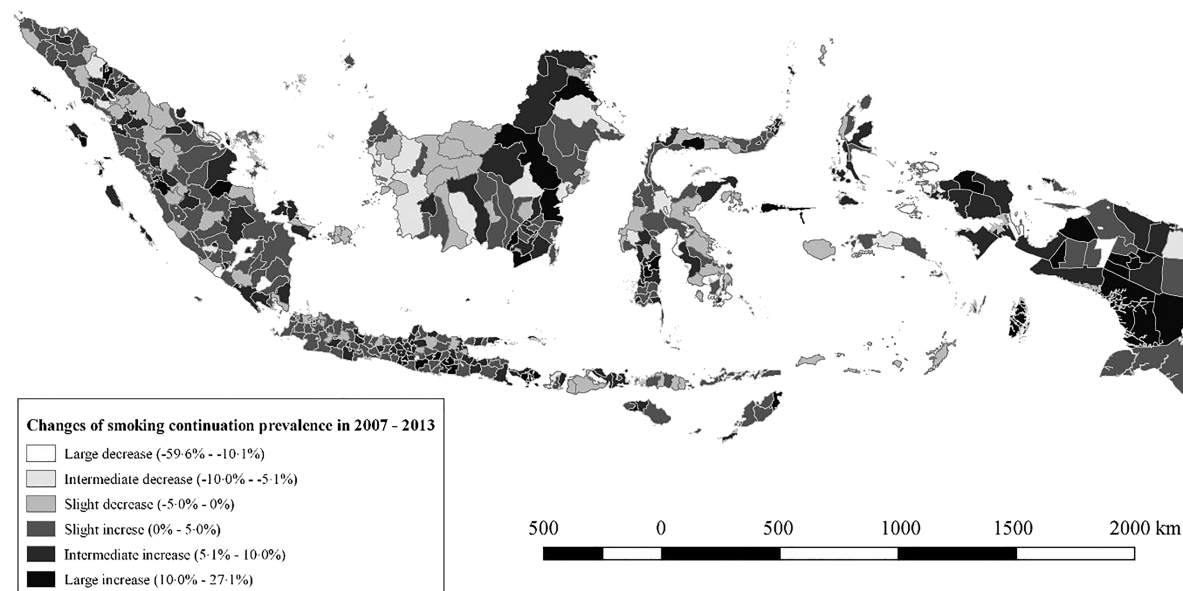


Figure 1 Change in age-standardized smoking continuation prevalence rate at district level between 2007 and 2013

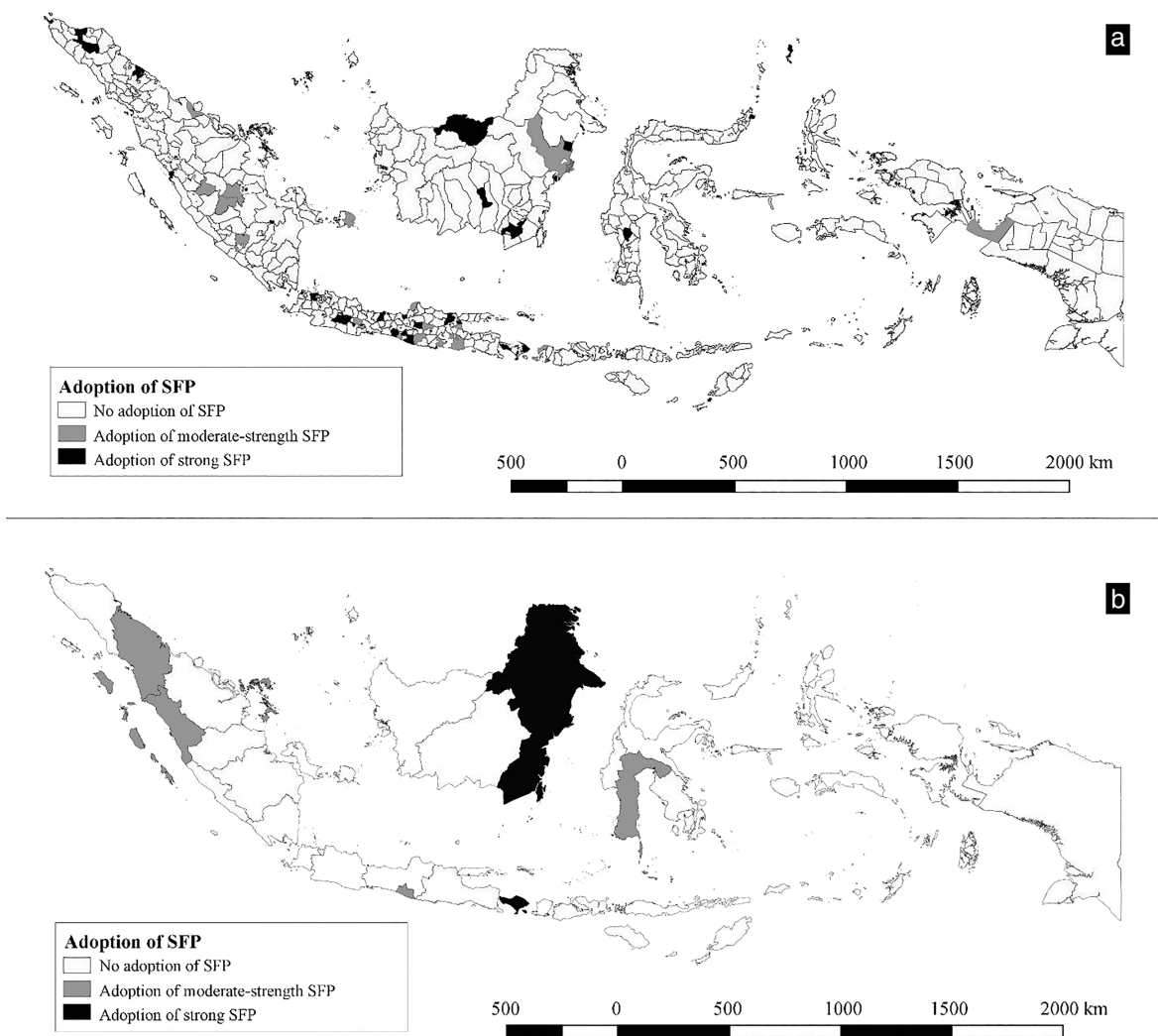


Figure 2 (a) Adoption of district smoke-free policy (SFP) between 2007 and 2013; (b) adoption of provincial SFP between 2007 and 2013

Table 2 describes the 497 districts included into the study. By 2007, 2.3% of districts had adopted a moderately strong SFP. None had adopted strong policies by 2007. Between 2007 and 2013, 8.2% adopted moderately strong new SFPs and 6.6% adopted strong new SFPs. The average population density was 1100 people/km² and GDP per capita was 2100 US\$. There was no tobacco production in 71.7% of districts, while 14.3% had lower-than-median and 14.1% had higher production. The majority of districts was categorized as rural (80.1%).

Table 3 presents results from the multi-level regression models for smoking continuation. Odds of smoking continuation were lower in 2013 than in 2007 in all models. In model 1, the odds of smoking continuation were lower for those exposed to moderately strong district policies adopted by 2007, but the odds were significantly higher for respondents in 2013 living in districts that had adopted moderately new strong policies. In model 2, at the provincial level, the odds of smoking continuation were lower for those living in provinces that had adopted moderately

strong SFPs by 2007 [odds ratio (OR) = 0.67, 95% confidence interval (CI) = 0.41–1.08] and significantly lower for respondents in 2013 living in provinces that had adopted new policies that were moderately strong (OR = 0.85, 95% CI = 0.80–0.90) or strong (OR = 0.71, 95% CI = 0.66–0.77). In model 3, estimates for ORs were similar to models 1 and 2, although confidence intervals widened. After adjusting for district covariates in model 4, all relevant associations maintained the same direction, except for higher odds of smoking continuation for those exposed to moderately strong policies in 2007 at district and provincial levels.

Table 4 presents the fully adjusted models for current smoking and smoking intensity. Between 2007 and 2013, odds of current smoking decreased but odds of smoking intensity increased. At the district level, exposure to moderately strong SFP adopted by 2007 was positively associated with current smoking, but not with smoking intensity. At the provincial level, policies adopted by 2007 were not associated with these two outcomes. Adoption

Table 1 Description of individuals in the sample, in percentages unless otherwise specified.

	Total population	Ever-smokers	Current smokers
2007			
<i>n</i>	491 979	201 094	178 770
Age ^a	44.7 (13.8)	45.6 (14.0)	44.7 (13.5)
Gender			
Female	52.0	9.5	8.9
Male	48.0	90.5	91.1
Education			
High	25.2	25.2	24.8
Low	43.8	44.5	45.2
No education	31.0	30.3	30.1
Current smoking	36.3	–	–
Smoking continuation ^b	–	88.9	–
High smoking intensity ^c	–	–	53.7
2013			
<i>n</i>	560 632	216 507	186 730
Age ^a	45.8 (13.4)	46.2 (13.2)	45.1 (12.6)
Gender			
Female	52.6	5.1	4.5
Male	47.6	94.9	95.5
Education			
High	29.4	29.7	29.1
Low	47.8	49.3	50.1
No education	22.8	21.0	20.7
Current smoking	33.3	–	–
Smoking continuation ^b	–	86.2	–
High smoking intensity ^c	–	–	59.2

^aMean (standard deviation); ^bThe percentage of current smokers among all ever-smokers (i.e. those who did not quit); ^cthe percentage of current smokers who smoke more than 10 cigarettes per day.

of new district policies between 2007 and 2013 was positively associated with odds of current smoking in 2013 and negatively with smoking intensity. Adoption of strong new provincial policies between 2007 and 2013 was associated with reduced odds of smoking intensity in 2013 and increased odds of current smoking.

Supporting information, Table S3 provides results of the sensitivity analysis in which we used continuous policy scores. The results are largely consistent with our main analysis. Exposure among 2013 respondents to an increase of 1 point in the provincial policy score between 2007 and 2013 was associated with lower odds of smoking continuation (OR = 0.85, 95% CI = 0.83–0.88) and smoking intensity (OR = 0.95; 95% CI = 0.93–0.97) and was associated with higher odds of current smoking (OR = 1.03; 95% CI = 1.01–1.05). An increase in

Table 2 Description of districts in the sample (*n* = 497), in percentages unless otherwise specified.

	Description of districts
District smoke-free policy adopted by 2007 (%)	
No policy	97.7
Moderately strong policy	2.3
District smoke-free policy adoption 2007–13 (%)	
No new policy adoption	85.1
Moderately strong new policy	8.2
Strong new policy	6.6
Population density (×1000 people/km ²) ^a	1.1 (2.5)
GDP per capita (×1000 US\$) ^a	2.1 (3.4)
Tobacco production	
No production	71.7
Low	14.3
High	14.1
Type of residence (%)	
Rural	80.1
Urban	19.9

^aMean (standard deviation).

district-level policy was associated with higher odds of smoking continuation (OR = 1.06, 95% CI = 1.02–1.09) and current smoking (OR = 1.06, 95% CI = 1.04–1.08), but not with smoking intensity (OR = 1.02, 95% CI = 0.99–1.04). Supporting information, Table S4 presents results of sensitivity analysis from which the three provinces that had adopted strong policy between 2007 and 2013 were excluded. The association between district SFP adoption and smoking continuation remained similar to the main analysis.

In Tables 3 and 4, we observed that odds of smoking continuation, current smoking and high smoking intensity were significantly higher among males than females, younger than older respondents and less educated than highly educated individuals. Individuals in districts with high tobacco production, lower population density and rural areas were also more likely to continue smoking. Tobacco production was also positively associated with current smoking, but not with smoking intensity.

DISCUSSION

Key findings

Overall, our results were inconsistent across outcomes and levels of government. Exposure to provincial SFP adoption between 2007 and 2013 was associated with lower odds of smoking continuation and smoking intensity, but was positively associated with current smoking. At district level, exposure to new SFP between 2007 and 2013 was associated with reduced odds of smoking intensity and increased odds of smoking continuation and current smoking.

Table 3 Prevalence of smoking continuation and results for multi-level logistic regression analysis with smoking continuation as the dependent variable.

	% Smoking continuation ^d	OR (95% CI)			
		Model 1	Model 2	Model 3	Model 4
Year					
2007	88.9	Ref.	Ref.	Ref.	Ref.
2013	86.2	0.78 (0.76–0.80)	0.82 (0.80–0.84)	0.81 (0.79–0.83)	0.81 (0.79–0.83)
Smoke-free policy					
District SFP adopted by 2007	87.7	Ref.			Ref.
No policy	83.3	0.76 (0.57–1.02)		0.80 (0.57–1.14)	1.11 (0.81–1.51)
Moderately strong policy					
District SFP adoption 2007–13	87.8	Ref.			Ref.
No new policy adoption	84.4	1.06 (1.01–1.13)		1.07 (1.01–1.14)	1.11 (1.02–1.15)
Moderately strong new policy	84.3	1.00 (0.94–1.07)		1.05 (0.98–1.13)	1.07 (1.01–1.14)
Strong new policy					
Provincial SFP adopted by 2007	87.6		Ref.		Ref.
No policy	81.7		0.67 (0.41–1.08)	0.83 (0.46–1.51)	1.14 (0.64–2.02)
Moderately strong policy					
Provincial SFP adoption 2007–13	87.8		Ref.		Ref.
No new policy adoption	86.0		0.85 (0.80–0.90)	0.85 (0.80–0.90)	0.85 (0.80–0.90)
Moderately strong new policy	81.6		0.71 (0.66–0.77)	0.71 (0.66–0.76)	0.71 (0.66–0.76)
Strong new policy					
Individual level					
Age (OR per 10-year increase)	–	0.63 (0.62–0.64)	0.63 (0.62–0.64)	0.63 (0.62–0.64)	0.63 (0.62–0.64)
Gender					
Female	80.1	Ref.	Ref.	Ref.	Ref.
Male	88.1	1.65 (1.60–1.70)	1.65 (1.60–1.71)	1.65 (1.60–1.70)	1.65 (1.60–1.70)
Education					
High	85.8	Ref.	Ref.	Ref.	Ref.
Low	88.8	1.56 (1.52–1.59)	1.56 (1.52–1.59)	1.56 (1.52–1.59)	1.55 (1.51–1.58)
No education	87.0	2.01 (1.95–2.07)	2.01 (1.95–2.07)	2.01 (1.95–2.07)	2.00 (1.94–2.06)
District level					
Population density	–				0.96 (0.95–0.98)
(OR per 1000 people/km ² increase)					
GDP per capita	–				0.99 (0.98–1.01)
(OR per 1000 US\$ increase)					
Tobacco production					

(Continues)

Table 3. (Continued)

	OR (95% CI)			
	Model 1	Model 2	Model 3	Model 4
% Smoking continuation ^d				
No production	87.0			Ref
Low	88.0			1.14 (1.05–1.24)
High	89.1			1.22 (1.11–1.34)
Type of residence				
Rural	88.4			Ref
Urban	83.8			0.87 (0.80–0.94)
District variance (SD)		0.107 (0.327)	0.108 (0.329)	0.079 (0.280)
District intraclass correlation (%)		3.13	3.14	2.31
Province variance (SD)		0.048 (0.219)	0.039 (0.198)	0.038 (0.196)
Province intraclass correlation (%)		1.39	1.15	1.12

^aAny discrepancies between groups differences in the crude smoking continuation prevalence and the odd ratios (OR) presented are due to adjustment for confounders in the regression models. SD = standard deviation; GDP = gross domestic product; SFP = smoke-free policies; CI = confidence interval.

Evaluation of potential limitations

Several limitations need to be considered when interpreting these findings. First, we measured SFP adoption, and did not capture implementation of and compliance with the policies. The association estimates presented in this study may therefore underestimate the potential impact of policies that are well implemented and enforced. Secondly, we were unable to control for the secular smoking trend before 2007. We therefore cannot rule out that trends prior to adoption were already more positive or more negative in the areas where policies were adopted. Thirdly, although we controlled for several district characteristics that potentially relate to smoking trends between 2007 and 2013, we cannot rule out that residual confounding may account for part of the associations found. Any other tobacco control policies implemented locally around the same time as SFPs may act as residual confounders. Although tobacco advertising, promotion and sponsorship (TAPS) bans are also adopted at the local level, these have been less widely implemented and generally later than SFPs. However, we cannot rule out that a small part of the observed associations may be due to local TAPS bans implemented during the study period. Fourthly, as only three provinces adopted strong provincial policies, the statistical power for association with strong provincial policies was limited. Moreover, due to small numbers, provincial-level confounders such as province characteristics could not be taken into account.

Interpretation of the findings

Adoption of provincial SFPs was associated with lower odds of smoking continuation and smoking intensity among current smokers. This finding corresponds with results of previous studies on the impact of SFPs on smoking cessation and smoking intensity [4,5]. This suggests that smokers who were exposed to provincial SFPs in Indonesia were more likely to quit, and those who did not quit smoking may have continued smoking at lower intensity. It is also possible that there may be some selective quitting in which heavier smokers were more likely to quit as a result of SFPs than lighter smokers.

In the analyses at district level, we found evidence for an increase in smoking continuation among individuals exposed to the adoption of district SFPs. This finding contradicts previous systematic reviews concluding that smoking declined after implementation of SFPs [4]. Perhaps this anomalous finding resulted from a selection effect in which policies may have particularly been adopted between 2007 and 2013 in districts with pre-existing increases in smoking rates. Moreover, given that the majority of policy adoptions took place in 2011 and 2012

Table 4 Results for multi-level logistic regression analyses with current smoking and smoking intensity as dependent variables; models adjusted for all variables.

	<i>n</i> ^a	<i>Current smoking</i>		<i>Smoking intensity</i>	
		<i>%</i> ^{b,d}	<i>OR (95% CI)</i>	<i>%</i> ^{c,d}	<i>OR (95% CI)</i>
<i>Year</i>					
2007	491 979	36.3	Ref.	53.7	Ref.
2013	560 632	33.3	0.84 (0.83–0.85)	59.2	1.25 (1.23–1.27)
<i>Smoke-free policy</i>					
<i>District SFP adopted by 2007</i>					
No policy	1 022 760	34.7	Ref.	56.6	Ref.
Moderately strong new policy	29 851	34.5	1.45 (1.05–2.04)	51.4	1.00 (0.70–1.43)
<i>District SFP adoption 2007–13</i>					
No new policy adoption	956 351	35.0	Ref.	56.5	Ref.
Moderately strong new policy	51 216	31.9	1.10 (1.06–1.14)	56.2	0.95 (0.91–0.99)
Strong new policy	45 044	31.4	1.09 (1.05–1.14)	55.6	1.04 (0.99–1.09)
<i>Provincial SFP adopted by 2007</i>					
No policy	1 035 396	34.8	Ref.	56.5	Ref.
Moderately strong policy	17 215	31.7	1.07 (0.53–2.18)	51.0	1.08 (0.38–3.09)
<i>Provincial SFP adoption 2007–13</i>					
No new policy adoption	945 351	35.0	Ref.	55.4	Ref.
Moderately strong new policy	68 670	34.6	0.97 (0.94–1.01)	69.2	0.96 (0.92–1.00)
Strong new policy	38 590	28.1	1.08 (1.04–1.12)	62.2	0.91 (0.86–0.97)
<i>Individual level</i>					
Age (OR per 10-year increase)	1 052 611	–	0.86 (0.85–0.87)	–	0.89 (0.88–0.90)
<i>Gender</i>					
Female	550 662	4.4	Ref.	25.7	Ref.
Male	501 949	68.0	57.74 (56.88–58.61)	58.6	3.83 (3.71–3.95)
<i>Education</i>					
High	288 311	34.2	Ref.	59.2	Ref.
Low	483 716	36.0	1.60 (1.58–1.63)	58.1	1.06 (1.04–1.08)
No education	280 584	33.0	2.22 (2.18–2.25)	50.5	0.99 (0.98–1.01)
<i>District level</i>					
Population density (OR per 1000 people/km ² increase)	–	–	0.97 (0.95–0.99)	–	0.98 (0.96–1.01)
GDP per capita (OR per 1000 US\$ increase)	–	–	0.99 (0.98–1.01)	–	1.00 (0.99–1.02)
<i>Tobacco production</i>					
No production	685 612	34.3	Ref.	59.9	Ref.
Low	184 141	35.6	1.21 (1.12–1.31)	51.4	0.98 (0.90–1.07)
High	182 858	35.5	1.34 (1.23–1.46)	49.2	0.92 (0.84–1.02)
<i>Type of residence</i>					
Rural	836 198	35.4	Ref.	56.5	Ref.
Urban	216 413	32.0	1.00 (0.93–1.06)	56.4	0.95 (0.88–1.02)
<i>District variance (SD)</i>					
District intraclass correlation (%)			0.099 (0.314)		0.109 (0.330)
<i>Province variance (SD)</i>					
Province intraclass correlation (%)			4.70		3.02
<i>Province variance (SD)</i>					
Province intraclass correlation (%)			0.063 (0.250)		0.208 (0.456)
<i>Province variance (SD)</i>					
<i>Province intraclass correlation (%)</i>					
<i>Province variance (SD)</i>					
<i>Province intraclass correlation (%)</i>					

^aTotal number of individuals in each subgroup; ^bprevalence of current smoking, in %, among the total population within each subgroup; ^cprevalence of heavy smoking intensity, in %, among current smokers within each subgroup; ^dany discrepancies between groups differences in the crude smoking continuation prevalence and the odd ratios (ORs) presented are due to adjustment for confounders in the regression models. SD = standard deviation; CI = confidence interval; SFP = smoke-free policies.

[11], there may have been insufficient time for the policies to counteract these unfavourable trends.

Overall, our results were inconsistent across outcomes and levels of government and the impact of SFPs was

modest, at best. In Indonesia, compliance to public policies is generally known to be inadequate. The positive social norm towards smoking may have caused compliance to SFPs to be particularly low [13,23]. Moreover, compliance

may have been diminished by weak enforcement of the law by government officials, perhaps particularly at the district level. If smoking in public places is not effectively reduced, SFPs are unlikely to have substantially affected smoking prevalence and cessation rates.

It is worrisome that smoking prevalence in Indonesia has only slightly decreased during 6 years. Implementation of a more comprehensive package of tobacco control policies, as described in the FCTC, and their strong enforcement are urgently needed to accelerate the decline in smoking. This has proved not to be an easy task, as international efforts have thus far not overcome the economic interests of the tobacco industry that hinder effective tobacco control in Indonesia. Our results demonstrate that not only is policy adoption complicated by tobacco industry presence, but smoking prevalence is also higher in areas with a productive industry. The tobacco industry encourages positive social norms towards smoking among policymakers and the general public, for example through tobacco advertising [24,25] and providing local communities with health care, clean water, environmental initiatives, sport infrastructure and scholarships [26]. Further actions of anti-tobacco advocates at several levels, locally, nationally and internationally, are greatly encouraged to counter tobacco industry influence.

Smoking among Indonesian adults was more prevalent in men and in less-educated respondents. In many Asian countries, smoking by females is disapproved of and female smokers are highly stigmatized [27,28]. This may be reinforced by Indonesia's pregnancy-focused health warning messages on cigarette packs [18]. The official declaration by Indonesian Islamic authorities that smoking is *haram* (forbidden) for pregnant women may also contribute to stigmatization [29]. Smoking is, however, not unequivocally dependent upon declarations of religious leaders, as demonstrated in Malaysia and Egypt, where smoking is *haram* for all Muslims yet male smoking rates are high [30,31]. The difference in smoking prevalence between educational groups in Indonesia may be largely attributed to the high level of illiteracy among poorly educated individuals, resulting in a lack of knowledge on health risks [32] and poor understanding of textual health warning messages and anti-smoking campaigns.

This study provides some evidence for effectiveness of SFPs on smoking cessation and intensity in Indonesia. However, the evidence is inconsistent, given the variation in findings across smoking outcomes and throughout policy levels. As this inconsistency may reflect problems with the policy implementation and enforcement, the current evidence does not directly support a continuation of the approach to SFPs that has been applied in Indonesia between 2007 and 2013. In Indonesia and other LMICs, the implementation of SFPs may need strong enforcement and close monitoring, which is only realistic with the mobilization of

substantial national and local resources. Further studies are needed to assess how efforts to enhance the implementation, enforcement and monitoring of SFPs in Indonesia or other LMICs may improve their effectiveness.

Declaration of interests

None.

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Author contribution

Wahyu Septiono: Conceptualization; formal analysis; methodology; visualization. **Mirte A.G. Kuipers:** Methodology; supervision. **Nawi Ng:** Methodology. **Anton E. Kunst:** Conceptualization; methodology; supervision.

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Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Table S1 Number of provinces and districts with smoke-free policy in 2007 and 2013 according to islands

Table S2 Description of individuals in the sample stratified by the level of district and provincial smoke-free policy, in percentages unless otherwise specified.

Table S3 Sensitivity analysis using continuous scores to express the strength of district and provincial smoke-free policy (SFP).

Table S4 Sensitivity analysis for the main analysis on smoking continuation, from which three provinces which adopted strong provincial smoke-free policy (SFP) were excluded.