

# Tobacco smoking patterns in Samoa in 2010: Implications for interventions

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## ABSTRACT

**INTRODUCTION** Tobacco use in Samoa has been described over time by age, sex and education, but little work exists on other sociodemographic factors associated with tobacco use. We describe current smoking and daily tobacco use in adults from Samoa, with a focus on sex and age stratified analyses of the influence of occupation, education, census region, household asset ownership and alcohol use in order to help develop potential targeted interventions.

**METHODS** In 2010, a nationwide survey of 3745 adults aged 25–65 years from 33 villages was completed in Samoa. Current smoking status, daily tobacco use, as well as current alcohol use, and a variety of sociodemographic factors were assessed by interview. Bivariate and multivariable models, and sex and age group stratified analyses, were performed to determine different patterns of correlates.

**RESULTS** More than half of all men (51.3%) and 21.8% of women were current tobacco smokers. Men and women smoked on average 10.9 and 8.7 cigarettes/day, respectively. Twenty per cent of men consumed  $\geq 20$  cigarettes/day. In men, being married, a subsistence-farmer/laborer, an alcohol user, and having low household assets, were independently associated with being a tobacco smoker (all  $p < 0.01$ ). Among women, not completing secondary education, being 25–34 years, residing in urban Apia, and being an alcohol user, were independently associated with being a tobacco smoker (all  $p < 0.01$ ).

**CONCLUSIONS** Tobacco use in Samoa remains high and correlates of smoking suggest that interventions for cessation need to be developed within the contexts of sex, age, education, and household socioeconomic status.

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## INTRODUCTION

Tobacco smoking is associated with higher risks of non-communicable diseases (NCDs)<sup>1,2</sup> and is responsible annually for >6 million deaths globally<sup>3</sup>. Over the last forty years, smoking prevalence shifted, becoming concentrated in low- and middle-income countries (LMICs)<sup>4</sup> as the tobacco industry employed a variety of tactics to exacerbate tobacco smoking in

LMICs, such as targeted marketing and combatting effective tobacco control measures<sup>5</sup>.

Smoking is a leading NCD risk factor in the Pacific<sup>6–8</sup>, with particularly high levels among men, ranging from 30–50% in this region. In other LMICs, tobacco use is higher among men than women, most often through smoking manufactured cigarettes, and higher in those with lower socioeconomic status

and educational attainment, and among manual laborers<sup>9-13</sup>.

Samoa is one LMIC where smoking is identified as an essential area for focused health promotion activities<sup>14</sup>. Smoking prevalence in Samoa among older and younger adults declined significantly from the late 1970s to 2013<sup>15</sup>. From 1978–2013, the percentage of men who smoked cigarettes daily decreased from 76% to 36%, and among women from 27% to 15%. From 1991–2013, current tobacco smoking decreased from 64% to 40% in men, and 21% to 17% in women<sup>15</sup>. The Samoa 2014 Demographic and Health Survey (DHS) reported that 47.2% of men and 17.0% of women 25–54 years of age used tobacco<sup>16</sup>. In 2015, as part of a nationally representative screening survey of 2234 adults aged ≥18 years, conducted before WHO-sponsored village-level intervention programs, 45% of men and 15% of women reported smoking tobacco in the last 12 months<sup>17</sup>.

To date, most tobacco research among Samoan adults focused very little on societal and individual correlates of smoking<sup>18,19</sup>, with a few exceptions. In a 2005 study among Samoans in American Samoa, Hawaii and California, smoking was associated with being male, younger, married, and less educated<sup>20</sup>. In the temporal trends study in Samoa among men, non-smokers had higher education than smokers, 0.5–0.8 years, but among women there were few differences by education, except in 2013 when smokers had 0.6 years more education than non-smokers<sup>15</sup>. Temporal trends of lower cigarette smoking were accelerated with more education in men, but impeded with more education among women<sup>15</sup>. Among men aged 15–49 years, the 2014 Samoa DHS described lower tobacco use in the highest wealth quintile, those with more than secondary education, and residents of Northwest 'Upolu; in women in the same age group, there were few sociodemographic differences except for lower use among rural residents, especially those from Savai'i<sup>16</sup>. A 2009 study of 1056 adults aged ≥40 years residing in 11 villages in rural Savai'i found a smoking prevalence of 52.6% for men and 16.2% for women, with an apparent decrease with older cross-sectional age only in women<sup>21</sup>. A recent qualitative study identified specific cultural patterns to smoking in Samoa, including insights into the early initiation

of smoking at young ages and the deeply rooted social contexts of smoking<sup>22</sup>.

Given these prior findings, current smoking among adults warrants aggressive measures to combat its financial and health burdens. Identifying specific sociodemographic correlates of smoking is necessary to target tobacco control efforts to subgroups, and even to tailor interventions based on specific individual characteristics<sup>12</sup>. Designing and adapting tobacco interventions for specific groups of Samoan adults may reduce NCDs and be cost effective for under-resourced health systems<sup>23</sup>. Younger adults aged <40 years, in particular, would benefit from targeted interventions as smoking cessation by the age of 40 years reduces all-cause mortality by 90% compared to those who continue to smoke<sup>24</sup>. Reducing adult smoking may also help reduce adolescent smoking, considering that 44.7% of young Samoan adolescents use tobacco and 32.2% smoked cigarettes, both the highest levels among 68 LMICs<sup>25</sup>.

Given these gaps in the existing literature, the purpose of this study is to present prevalence of smoking and number of cigarettes/day and their sociodemographic correlates from a large nationwide survey of adults aged 25–65 years, in 2010 in Samoa. We focus on sex and age stratified multivariable analyses to provide detailed information on correlates of tobacco smoking necessary for designing more targeted interventions.

## METHODS

### Research design and participants

This is a cross-sectional study of health survey data from a genome-wide association study (GWAS) conducted from February to July 2010 in Samoa. Details on the design and methods for the GWAS have already been reported<sup>26</sup>.

There were 3745 participants who: a) self-reported having four Samoan grandparents; b) were aged 25–65 years; c) were non-pregnant; d) had no severe physical or cognitive impairments; and e) completed the interview in the Samoan language. Participants resided in 33 villages from all four census regions ranging from the most rural to the one urban or town region: Savai'i (rural), Rest of 'Upolu (mainly rural), Northwest 'Upolu, and Apia urban area. The sample was representative of

the wider Samoan population in terms of marital status, educational attainment, and access to basic household amenities, but had a greater proportion of women, residents from the more rural Rest of 'Upolu and Savai'i regions, and older participants compared to 2011 census data<sup>26,27</sup>.

The study was approved by the Health Research Committee of the Samoa Ministry of Health and the Brown University Institutional Review Board. Written informed consent was given before participation in the study.

### Assessing outcome of interest

Current smoking was assessed using the question: 'Do you currently smoke cigarettes, cigars or pipes?'. We considered stratification of outcome into current smokers, those who quit smoking, and those who had never smoked, but we chose a binary outcome of current smokers versus those not currently smoking, due to a negligible proportion of those who quit smoking (1.6%). As such, we classified former smokers as 'not currently smoking' along with those who had never smoked. The reported total number of manufactured cigarettes, hand-rolled cigarettes, and cigars, smoked per day among smokers was measured continuously and also classified as:  $\leq 5$ ; 6–10; 11–19; or  $\geq 20$  cigarettes or cigars per day. Information on number of tobacco products per day was provided by 93% of men ( $n=686$ ) and 92.3% of women ( $n=409$ ), who were current smokers.

### Correlates

Several sociodemographic characteristics were explored as potential correlates of tobacco use. In addition to age and sex, education was classified into three categories: less than secondary education completed (including no schooling, some primary school, primary school completed or some secondary); secondary education completed (including those with some non-degree, post-secondary schooling); and university completed or greater. The three categories used to classify occupation were: 1) unemployed, retired, or student; 2) subsistence farmers and fisherman, and semi-skilled and skilled wage laborers, and clerks; and 3) administrative managers, professionals, and political leaders. Among men in the first occupation group, for example, 93% were unemployed, and in the second group, approximately

72% were subsistence farmers and fishermen. Among women in the first group, about 96% were unemployed.

Census region was included as described above given substantial rural to urban differences across Samoa. A household assets inventory of 10 items (architectural house style, cooking facilities, refrigerator, freezer, portable stereo, videocassette recorder, motor vehicle, washing machine, indoor plumbing, couch) as a sensitive measure of family economic resources in modernizing societies was used, previously used to study the adult Samoan population<sup>28,29</sup>. Higher scores represent higher income and/or wealth levels. Following exploratory data analyses, we dichotomized this index into the lowest tertile versus the two top tertiles in order to assess the link between low income and wealth position and smoking. Current alcohol use was identified if participants indicated they had consumed alcohol at least once in the past twelve months.

### Statistical analyses

Sex-stratified analyses were used throughout. Bivariate analyses provided descriptions of current cigarette smoking in association with the categorical covariates. ANOVA and Spearman's correlations were estimated to determine associations of number of cigarettes/day and sociodemographic characteristics. Logistic regressions identified significant associations of covariates with current smoking and produced final models with variables that were significantly associated ( $p < 0.05$ ). Covariates included in the final model were those significantly associated with smoking in initial analyses and initial multivariate models. Lastly, because age in a transitioning society may influence exposure to tobacco, levels of education, and health literacy, we performed age- and sex-stratified logistic regressions to identify significant associations with current smoking. We classified age as  $\leq 40$  years or  $> 40$  years old, in the age-stratified analyses. Analyses were performed using the statistical software packages Stata 15 and SAS 9.4.

## RESULTS

More than half of men (51.3%) and more than one-fifth of women (21.8%) reported current tobacco smoking; approximately one-third of adults smoked

(Table 1). The vast majority of current smokers used manufactured cigarettes (94.5%); only 6% used hand-rolled cigarettes, 3% used cigars, and <1% used pipes.

Bivariate results showed that among men, cigarette smoking was significantly associated with being single, unemployed, or a subsistence-farmer/laborer, having a low level of household assets, and current alcohol use (Table 2). Among women smoking was associated with younger age, being single, residing in the less rural census regions of 'Upolu Island, and consuming alcohol.

Adjusted odds ratios among men showed that subsistence workers, laborers or clerks had significant 44% higher odds of smoking compared

to men working as professionals or administrators (Table 3). Men who consumed alcohol had more than three times the odds of being a current smoker. Compared to men with middle or high household assets, those with low assets had significant 36% higher odds of current smoking.

Adjusted odds ratios among women (Table 4) indicated that those not completing secondary education had twice the odds of smoking compared to those who had a tertiary education. Compared to women aged 25–34 years, women aged 55–64 years had nearly half the odds of being current smokers. Compared to women in the Apia urban area, residents in the Northwest 'Upolu region had lower

Table 1. Cigarette smoking study sample characteristics in Samoa, 2010

Characteristics	Total % (95% CI)	Men N=1137 % (95% CI)	Women N=2038 % (95% CI)
Current cigarette smokers	33.91 (32.35–25.49)	51.33 (48.73–53.91)	21.76 (20.02–23.60)
Cigarettes/day*, mean (SD)	10.1 (7.8)	10.9 (8.2)	8.7 (6.7)
<b>Age (years)</b>			
25–34	24.32 (22.92–25.77)	25.05 (22.88–27.36)	23.80 (22.00–25.70)
35–44	25.78 (24.36–27.27)	23.31 (21.20–25.57)	27.53 (25.63–29.51)
45–54	27.51 (26.05–29.02)	27.49 (25.24–29.86)	27.53 (25.63–29.51)
55–65	22.39 (21.03–23.81)	24.15 (22.00–26.43)	21.15 (19.43–22.98)
>40	49.90 (48.24–51.56)	51.64 (49.05–50.95)	48.68 (46.51–50.84)
<b>Education</b>			
<Secondary completed	24.21 (22.81–25.67)	28.17 (25.89–30.56)	21.42 (19.69–23.26)
Secondary completed	68.35 (66.77–69.88)	63.35 (60.81–65.81)	71.87 (69.87–73.78)
University or greater	7.44 (6.61–8.37)	8.48 (7.14–10.04)	6.71 (5.70–7.89)
<b>Material lifestyle score</b>			
Low	28.41 (26.92–29.94)	28.11 (25.82–30.51)	28.62 (26.69–30.64)
Middle/High	71.59 (70.06–73.08)	71.89 (69.49–74.18)	71.38 (69.36–73.31)
Married	82.74 (81.43–83.96)	77.49 (75.25–79.58)	86.42 (84.86–87.84)
<b>Employment</b>			
Unemployed/student/retired	59.17 (57.49–60.82)	22.01 (19.90–24.28)	85.32 (83.68–86.82)
Subsistence worker/laborer	25.04 (23.60–26.54)	58.58 (55.96–61.15)	1.43 (0.99–2.06)
Managerial/professional	15.79 (14.60–17.07)	19.41 (17.40–21.58)	13.25 (11.82–14.83)
<b>Census region</b>			
Apia urban area	20.00 (18.70–21.36)	20.11 (18.12–22.27)	19.92 (18.24–21.71)
Northwest of 'Upolu	31.37 (29.84–32.93)	32.71 (30.33–35.18)	30.42 (28.46–32.46)
Rest of 'Upolu	26.50 (25.06–28.00)	26.37 (24.16–28.72)	26.59 (24.72–28.56)
Savai'i	22.13 (20.78–23.54)	20.81 (18.78–22.99)	23.06 (21.28–24.95)
Current alcohol use	14.76 (13.63–15.98)	32.96 (30.57–35.44)	2.11 (1.57–2.83)

\*Mean cigarettes & cigars per day among current smokers.

Table 2. Sociodemographic and health behaviors, by sex, associated with current cigarette smoking in Samoan adults, 2010

Characteristics	Men % (95% CI)	p	Women % (95% CI)	p
<b>Age (years)</b>		0.14		<0.01
25–34	56.42 (51.23–61.48)		22.47 (18.98–26.41)	
35–44	50.45 (45.09–55.80)		25.31 (21.88–29.08)	
45–54	50.25 (45.32–55.18)		23.75 (20.40–27.45)	
55–65	48.13 (42.90–53.39)		13.72 (10.78–17.31)	
<b>Education</b>		0.28		0.84
No Secondary	54.73 (49.83–59.54)		22.12 (18.46–26.27)	
Secondary	50.28 (47.02–53.53)		21.92 (19.87–24.13)	
Tertiary	48.76 (39.98–57.62)		19.85 (13.98–27.41)	
<b>Married</b>		<0.01		<0.01
Yes	49.28 (46.33–52.23)		20.46 (18.63–22.41)	
No	57.63 (52.15–62.93)		30.07 (24.95–35.75)	
<b>Employment</b>		<0.01		0.23
Unemployed/student/retired	51.97 (46.35–57.55)		20.73 (18.85–22.74)	
Subsistence worker/laborer	53.84 (50.38–57.25)		28.57 (14.97–47.60)	
Managerial/professional	43.28 (37.47–49.29)		24.62 (19.76–30.22)	
<b>Census region</b>		0.13		<0.01
Apia urban area	45.33 (39.67–51.11)		27.83 (23.69–32.40)	
Northwest of 'Upolu	52.47 (47.92–56.98)		21.32 (18.27–24.73)	
Rest of 'Upolu	54.09 (49.04–59.05)		25.65 (22.14–29.49)	
Savai'i	51.84 (46.17–57.46)		12.58 (9.87–15.90)	
<b>Household assets score</b>		<0.01		0.56
Low	57.54 (52.62–62.31)		22.17 (20.10–24.39)	
Middle/High	48.77 (45.70–51.85)		21.84 (17.84–24.49)	
<b>Current alcohol use</b>		<0.01		<0.01
Yes	68.64 (64.31–72.67)		79.07 (64.42–88.74)	
No	42.81 (39.71–45.97)		20.52 (18.80–22.35)	

Table 3. Adjusted odds ratios (AOR) for correlates of current smoking among Samoan men, 2010

Characteristics	AOR (95% CI)
<b>Household assets score</b>	
Low	1.36 (1.06–1.75)
Middle/High (Ref.)	1.00
<b>Employment</b>	
Unemployed/student/retired	1.21 (0.856–1.72)
Subsistence worker/laborer	1.56 (1.16–2.09)
Managerial/professional (Ref.)	1.00
<b>Current alcohol use</b>	
Yes	3.19 (2.50–4.07)
No (Ref.)	1.00

odds of smoking, while residents of Savai'i had less than half the odds of being a current smoker. Women who were current alcohol users had more than ten times the odds of being a current smoker compared to non-drinkers, though this adjusted association had a wide confidence interval driven by the low percentage of women (2.11%; n=43) reporting alcohol consumption in the past 12 months.

Adjusted odds ratios from age-stratified logistic regression models for men are provided in Table 5. Among men aged ≤40 years, being married was associated with lower odds of smoking while those who had consumed alcohol in the past 12 months had more than three times the odds of smoking.

**Table 4. Adjusted odds ratios (AOR) for correlates of current smoking among Samoan women, 2010**

Characteristics	AOR (95% CI)
<b>Age (years)</b>	
25–34 (Ref.)	1.00
35–44	1.18 (0.871–1.59)
45–54	1.09 (0.804–1.48)
55–65	0.542 (0.372–0.789)
<b>Education</b>	
No Secondary	2.10 (1.22–3.62)
Secondary	1.60 (0.975–2.62)
Tertiary (Ref.)	1.00
<b>Census region</b>	
Apia urban area (Ref.)	1.00
Northwest of 'Upolu	0.719 (0.531–0.973)
Rest of 'Upolu	0.942 (0.697–1.27)
Savai'i	0.406 (0.283–0.581)
<b>Current alcohol use</b>	
Yes	13.2 (6.13–28.3)
No (Ref.)	1.00

**Table 5. Age stratified adjusted odds ratios (AOR) for correlates of current smoking among Samoan men, 2010**

Characteristics	Aged ≤40 years AOR (95% CI)	Aged >40 years AOR (95% CI)
<b>Current alcohol use</b>		
Yes	3.16 (2.24–4.47)	2.83 (2.03–3.96)
No (Ref.)	1.00	1.00
<b>Married</b>		
Yes	0.639 (0.454–0.898)	
No (Ref.)	1.00	
<b>Employment</b>		
Unemployed/student/ retired	1.62 (0.956–2.76)	
Subsistence worker/ laborer	1.82 (1.20–2.77)	
Managerial/professional (Ref.)	1.00	
<b>Census region</b>		
Apia urban area (Ref.)	1.00	
Northwest of 'Upolu	1.78 (1.12–2.83)	
Rest of 'Upolu	1.61 (0.982–2.63)	
Savai'i	1.82 (1.20–2.77)	

**Table 6. Age stratified adjusted odds ratios (AOR) for correlates of current smoking among Samoan women, 2010**

Characteristics	Aged ≤40 years AOR (95% CI)	Aged >40 years AOR (95% CI)
<b>Current alcohol use</b>		
Yes	11.7 (5.05–27.0)	34.7 (4.31–278)
No (Ref.)	1.00	1.00
<b>Education</b>		
No Secondary	2.66 (1.32–5.34)	
Secondary	1.63 (0.911–2.90)	
Tertiary (Ref.)	1.00	
<b>Census region</b>		
Apia urban area (Ref.)	1.00	
Northwest of 'Upolu	0.668 (0.446–1.00)	
Rest of 'Upolu	0.924 (0.614–1.39)	
Savai'i	0.287 (0.171–0.481)	

Residents of Northwest 'Upolu had higher odds of smoking than those in the Apia urban area. Among men aged >40 years, only alcohol consumption was associated with higher odds of smoking.

Among women aged ≤40 years, those not completing secondary education had nearly 2.7 times the odds of smoking compared to those with a tertiary education (Table 6). Younger women who reported alcohol consumption had more than ten times the odds of smoking, though the confidence interval was very wide due to the low prevalence of women who were current smokers and alcohol consumers. This low prevalence also influenced our results for women aged >40 years, as current alcohol users were far more likely to smoke than those who did not consume alcohol, but with a drastically wider confidence interval.

Among men who smoked, the mean number of cigarettes/cigars per day was 10.9 (SD=8.2) with a median of 10 and a range 0.5–60 per day. Among women who smoked, the mean daily consumption was 8.7 (SD=6.7) with a median of 6 and a range 0.5–40 per day (Table 1). Men smoked significantly more cigarettes daily than women ( $p < 0.0001$ ). There was a significant gender difference ( $\chi^2 = 25.5$ ;  $p < 0.0001$ ) in the percentages of total cigarettes/day in the categories: ≤5, 6–10, 11–19, or ≥20/day; for men they were 27.7%, 39.9%, 12.4% and 20.0%,

compared to women with 41.8%, 35.0%, 10.3%, and 13.0%, respectively. One-fifth of men who smoked consumed  $\geq 20$  cigarettes/day.

In multivariable models among men who smoked, age ( $p=0.0003$ ) and household assets ( $p<0.001$ ) were positively associated with number of daily cigarettes consumed, as well as occupation ( $p<0.01$ ) and census region ( $p<0.01$ ). Subsistence workers and laborers consumed more cigarettes daily, mean 11.8, than professionals or administrators, mean 10.7, and the unemployed or retired, mean 9.4. Cigarettes/day increased across the four census regions from rural Savai'i to urban Apia (8.6, 11.0, 10.7 and 12.1).

In multivariable models among men aged  $\leq 40$  years, those in the upper two tertiles of household assets smoked 2.8 cigarettes/day more than the lowest tertile (9.9 vs 7.1;  $p=0.005$ ) and the unemployed smoked fewer per day than managers/professionals or subsistence workers and laborers (6.7, 8.9, 9.8;  $p=0.013$ ). Among older men, only household assets were significantly and positively associated with daily cigarette consumption (11.0 vs 13.5;  $p<0.02$ ). Education was marginally associated with daily consumption in older men; those completing university smoked per day more than those completing secondary or primary school (14.2, 10.3, 12.2, respectively;  $p=0.053$ ).

Among women, multivariable models of daily cigarette smoking showed only marginal associations with increasing age ( $p=0.06$ ) and census region ( $p=0.09$ ), with lower consumption among women from rural Savai'i. Multivariable models stratified by age among women found no significant associations.

## DISCUSSION

The prevalence of smoking in 2010 in Samoa among men was 51.3% (95% CI: 48.7–53.9), and for women it was 21.8% (20.0–23.6), for the age group 25–65 years; these were higher than those (39.5% for men and 16.8% for women) reported for 2013 from the STEPS survey<sup>19</sup> and used in the publication on temporal trends in tobacco use in Samoa<sup>15</sup>. The 2010 prevalences of current tobacco smoking for men and women are also somewhat higher than levels reported in the Samoa 2014 Demographic and Health Survey (DHS) report (tables 3.12.1 & 3.12.2)<sup>16</sup>, 47.2% among men aged 25–54 years and 17.0% among women aged

25–49 years; while among adults, screened in 2015, these were 45% for men and 15% for women<sup>17</sup>. The slightly lower levels we found in 2010, compared to those from several studies from 2013–15, may be part of the temporal decrease in current smoking levels in Samoa<sup>15</sup>, as well as due to methodological differences. New national level surveys are needed to look at the trajectory of these positive trends into the third decade of the 21st century, considering that, regardless of several recent studies in the last decade, 45–50% of men and 15–20% of women smoke tobacco.

We found among tobacco smokers that 20% of men and 13% of women consume  $\geq 20$  cigarettes or cigars daily. Estimating daily tobacco use among all participants, including non-smokers, 9.5% of men and 2.6% of women smoked  $\geq 20$  cigarettes or cigars daily in 2010, which compares well with 2013 estimates in the temporal trends report<sup>15</sup>. The 2014 DHS reported that approximately 67% of all men and 40% of women smoked  $\geq 10$  cigarettes daily<sup>16</sup>. The similarities of the results from 2010 shown here and for later years from various sources<sup>15–18</sup> provide confidence in the findings. Prevalence of adult tobacco smoking and daily smoking in Samoa appears to have decreased, notably in men, within the second decade of the 21st century, suggesting both the need for more research on factors associated with this decline to sustain these likely temporal changes into the third decade of this century, and on developing targeted tobacco interventions at the structural and individual levels.

Having shown that tobacco smoking levels in 2010 are similar, but somewhat higher, than those of later studies, we focused on the age and sex specific socioeconomic and behavioral correlates of smoking in Samoa in order to provide evidence for intervention development. Our multivariable results stratified by age and sex identified risk factors in different sub-groups not seen in aggregate calculations of smoking prevalence for participants of all ages in these regions, such as the 2014 DHS report<sup>16</sup>. Although the 2014 Samoa DHS reports plausible patterns such as lower tobacco use in men among the wealthiest, those with the highest education, and residents of Northwest 'Upolu, and lower use in rural women, it is impossible to disentangle associations with educational attainment, wealth and age on tobacco use.

Our findings, especially among men of all ages, follow similar trends across LMICs that link lower economic position, socioeconomic status and agricultural and physical labor to increased prevalence of cigarette smoking<sup>9-13</sup>. Among women, smoking was higher in those aged <55 years, residents of the capital Apia census region, and those with lower education levels. Further research on the context of initiation, continuation and cessation of tobacco use in younger urban Samoan women is urgently needed to follow up on recent qualitative insights from that sub-group<sup>22</sup>. Education was associated with current smoking only among younger women and in the inverse direction. These findings in women differ from the temporal trend analysis, which found education was not associated with current smoking until 2013 when there was a positive association<sup>15</sup>. Our 2010 results in younger women did show independent associations of smoking with both urban residence and alcohol use. Further research on the expanding economic roles and potential NCD risks of women is needed to clarify the nature of these associations for intervention development. Global patterns of targeted tobacco advertising to lower social status communities and young urban people have been shown elsewhere<sup>5</sup>, and, despite Samoa's tobacco 2013 law regulating tobacco advertising, more research is needed on its community and individual impacts.

Findings from age- and sex-stratified models demonstrate some key differences in correlates across age and gender that may be important for the design of tobacco interventions. While no factor was associated with smoking among older adults besides current alcohol consumption, the variety of correlates identified among younger men and women provides some interesting considerations. Men aged ≤40 years who were subsistence farmers, fisherman, laborers or clerks, had higher odds of smoking, consistent with results in other LMICs<sup>10-13</sup>, while married men in this age group had lower odds of smoking. This indicates the need to target younger single men in manual labor and clerical positions in future smoking-based programs in Samoa, including assessment, prevention, and interventions focused on cessation. This age and sex group generally uses less primary care than other adults, so implementation

research is needed on community level tobacco use interventions<sup>16,23</sup>.

Indicators of social position and socioeconomic status, i.e. household assets and occupation, were associated with daily consumption of tobacco products in men. This could be attributable to higher incomes associated with work and household income and wealth, some of which is used for cigarette purchases. The Samoa household income and expenditures report, from 2013–14, found that, nationally, 0.3% of all household expenses were for tobacco, ranging from 0.2% in Apia to 0.4% in rural Savai'i<sup>30</sup>. These expenditure estimates for the purchase of cigarettes in Samoa are of considerable interest given evidence across many LMICs that household expenditures for tobacco were associated with lower education and health care expenditures<sup>31</sup>. These opportunity costs of tobacco in combination with the likely substantive financial burden of health care costs for individuals and for households with cigarette smokers, are concerning.

The findings that almost one-fourth of women of reproductive age (25–44 years) smoked cigarettes, and those with low education levels had more than twice the adjusted odds of smoking, is alarming given the well-documented associations with later adult health outcomes as well as maternal smoking and child health. In the context of the existing high levels of adult adiposity and cardiometabolic risks among women<sup>26</sup>, there is an urgent need to develop societal and public health programs to prevent cigarette smoking, by avoiding initiation and helping cessation among women. Pregnancy was one reason for smoking cessation cited by women in Apia<sup>21</sup>. For example, research is needed to determine the efficacy of screening for tobacco use and behavioral interventions within standard prenatal care. The recent report on individual-level MHealth intervention for smoking cessation being developed and tested in Samoa is noteworthy<sup>32</sup>. There may be opportunities for information, education and communication (IEC) campaigns sponsored by employers, religious organizations and local villages to encourage smoking cessation and prevent initiation among young people. More broadly, research on smoking cessation and primary prevention of tobacco use is urgently needed in Samoa, as there is very little systematic evidence.

After adjusting for all other variables, regional differences in smoking correlates among younger men and women are notable. Men aged  $\leq 40$  years in the Savai'i and Northwest 'Upolu regions had higher smoking percentages compared to those in the Apia urban area. Women aged  $\leq 40$  years in the Savai'i region had lower smoking levels compared to those in the Apia urban area, and women in the Northwest of 'Upolu area had an odds ratio that was marginally insignificant. These regional findings for women are consistent with previous research, but the findings for men are in conflict with previous reports that smoking prevalence was also lower in Savai'i compared to other regions<sup>16,18,21</sup>.

Among men who currently used tobacco, we found that those in rural Savai'i smoked fewer, and those in urban Apia smoked more cigarettes/cigars per day, in multivariable models. But results from age-stratified models of daily tobacco consumption in men found no census region or rural-to-urban effect; rather, in young men, indicators of social position and income such as household assets and occupation were associated with tobacco consumption. This suggests that the census region socioecological influences on smoking prevalence and daily consumption need more detailed examination for the purpose of developing public health interventions.

Across all models, consuming alcohol in the prior 12 months was associated with current smoking regardless of age, in both men and women. As LMICs like Samoa continue to develop, patterns of co-occurrence of smoking and drinking may begin to match those in developed countries, where the association of smoking and drinking is well-established<sup>33,34</sup>. The co-occurrence of these risk behaviors represents opportunities for structural interventions targeted at both behaviors simultaneously.

Structural level tobacco interventions currently in operation in Samoa including smoking bans in offices, advertising bans in the media, and raising the excise taxes on retail prices, need to be continued and expanded<sup>35</sup>. Given the high proportion of our sample and the Samoan adult population who were unemployed, e.g. among women or subsistence workers among men, workplace smoking prohibitions need to be complemented by broader community interventions. Such interventions should

be informed by the sociocultural context of smoking, as has been recently described<sup>22</sup>. The government of Samoa has been enacting laws since the early 21st century to address tobacco use, including the Tobacco Control Acts of 2008, 2013 and 2019<sup>36,37</sup>, after having joined and ratified the Framework Convention on Tobacco Control (FCTC) a few years earlier. Finally, it is worth noting that Samoa has increased the excise tax on retail prices of all tobacco products. As of 2015, total taxes account for 51.6% of the cost of tobacco purchases, and an estimated WST 28.6 million or US\$ 10.9 million in tobacco taxation may be available for increasing public health and clinical efforts to reduce the health consequences of cigarette smoking<sup>38</sup>.

### Limitations

This study has a few limitations. First, we used cross-sectional data, limiting interpretations about causality. Second, social desirability bias may have caused under-reporting of smoking and drinking behaviors, though our findings related to prevalence are roughly in line with prior research<sup>14-17</sup>. Third, unmeasured confounders like stress and social interaction patterns of smoking were unmeasured making it impossible to interpret more proximate determinants, which are important for tailoring intervention designs in tandem with qualitative work<sup>17,32</sup>. Fourth, our research data were collected in 2010, which creates the potential that correlates of smoking may have shifted over the last decade. Although our estimates of current smoking prevalence are somewhat higher than those of studies 3–4 years later, the correlates identified are plausible and similar to other work, and will be useful in developing interventions. We are following up a sub-sample of 500 adults from 2010 and will report on changes in prevalence.

### CONCLUSIONS

Our findings point to the need for continued structural and sub-group interventions targeted at reducing smoking prevalence and intensity among Samoans, especially those aged  $\leq 40$  years, which may reduce their likelihood of developing serious cardiometabolic and lung disease later in life. Interventions designed for different age, sex and socioeconomic status groups within the Samoan context are important<sup>22,32</sup>. Implementation research will be needed to determine

intervention content, customization and evaluation across sub-groups. In addition, work on biological susceptibility to tobacco may be needed. Recently, the number of cigarettes/day was associated in Native Hawaiians with a single-nucleotide polymorphism variant that is very rare globally but of >17% occurrence in Native Hawaiians<sup>39</sup>. As Samoa continues to grapple with unacceptable high smoking levels, particularly among men, and women of reproductive age, efforts to reduce the prevalence of smoking and understand what interventions work is necessary to protect the health of Samoans moving into the future.

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#### CONFLICTS OF INTEREST

The authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest and none was reported.

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#### AUTHORS' CONTRIBUTIONS

STM conceived and led the study. ACA performed the majority of the statistical analysis and with STM wrote the initial draft of the manuscript. With guidance from STM, NLH led the fieldwork data collection in 2010 and contributed to writing the manuscript. MSR facilitated the 2010 fieldwork in Samoa, and with TN, contributed to the discussion of the interpretation and public health implications of the findings. All authors read and approved the final manuscript.

#### PROVENANCE AND PEER REVIEW

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