



## Short Communication

## Leveraging technology to address the problem of cigarette smoking among women of reproductive age



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## A B S T R A C T

Women of reproductive age and particularly pregnant women underutilize evidence-based smoking cessation services such as counseling and quit lines. Mobile health (mHealth) may constitute an unexplored and innovative avenue for providing smoking cessation support to a population that is otherwise difficult to reach with evidence-based interventions. Female respondents aged 18–44 years ( $N = 10,023$ ) were drawn from the first wave of the Population Assessment of Tobacco and Health (PATH) study (2013–2014). We examined prevalence of use of various digital forms of communication (e.g., social media, text messaging, smartphone ownership) among non-pregnant women of reproductive age, pregnant women, and among smokers versus non-smokers within these groups. Multiple logistic regression modeling was conducted to identify correlates of using each digital form adjusting for smoking status, pregnancy, and demographic characteristics. Over two thirds of women overall and within subgroups of non-pregnant and pregnant smokers reported using social media, owning a cell phone, owning a smartphone, downloading apps, and sending/receiving text messages. Current smokers and those with lower educational attainment generally had lower odds of using each digital form relative to non-smokers and those with higher educational attainment, the exception being that smokers had higher odds of using social media relative to non-smokers. The high prevalence of using various digital forms among both non-pregnant smokers of reproductive age and pregnant smokers suggests that leveraging technology to expand access to prevention, education, and treatment resources may reduce smoking-attributable adverse health effects among reproductive-aged women and their offspring.

## 1. Introduction

Studying use of cigarettes and alternative tobacco products among women of reproductive age is critical, as smoking confers health risks that are unique to women (e.g., osteoporosis, early menopause, cervical cancer) (Roth and Taylor, 2001), and cigarette smoking during pregnancy increases risk for pregnancy complications, preterm birth, childhood behavioral problems, and chronic health conditions in adulthood (England et al., 2015; Dietz et al., 2010). The current clinical practice guidelines recommend a range of cessation approaches including assessment of smoking status, provider counseling, and referral to a cessation-specific counselor or quit line (Fiore et al., 2015). However, reproductive-aged women and particularly pregnant women underutilize evidence-based cessation services (Borland and Segan, 2006). Barriers to engagement include fear of being judged, poor access to healthcare facilities, and negative attitudes towards support provided by healthcare professionals (Ussher et al., 2006). Given the difficulty providing evidence-based interventions to reproductive-aged women,

the emerging field of mobile health (mHealth) may be an unexplored avenue to better support smoking cessation among this population.

There are many examples of text programs and smartphone apps targeting the general population of smokers, but few target reproductive-aged women. One recent report identified just five text programs and two apps designed specifically for pregnant women (Griffiths et al., 2016), despite pregnant women preferring text over in-person cessation support (Naughton et al., 2013). Apps may be superior to text message support, as they can take advantage of multi-touch surface and other functionalities of smart digital devices (Tombor et al., 2016). Using other modalities (e.g., blogs, social media) to provide cessation support deserves consideration as well. Importantly, the utility of leveraging any digital platform to reduce smoking depends on the extent to which reproductive-aged women have access to the specific digital form in question (Fisher and Clayton, 2012). Although PEW Research Center has published data on prevalence of cell phone and smartphone ownership among U.S. adults (PEW Research Center: Internet and technology, n.d.), this report does not include other digital

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forms nor does it address questions about use as a function of pregnancy or smoking status. Such information may guide the development and dissemination of prevention, education, and treatment resources to reduce smoking among women of reproductive age. Thus, the present study examines prevalence and correlates of using various digital forms among a U.S. national sample of reproductive-aged women.

## 2. Methods

### 2.1. Data source

Data were obtained from the Public Use File (PUF) of the first wave of the PATH study, a household-based, nationally representative, longitudinal cohort study of 45,971 youth and adults in the U.S. non-institutionalized population. Data were collected from September 12, 2013 through December 15, 2014 using address-based, area-probability sampling. Weighting procedures adjusted for varying selection probabilities and differential non-response rates, while appropriately accounting for the complex study design. The overall weighted response rate was 74.0%.

### 2.2. Data analysis

We obtained data on respondents' demographic characteristics including age, race/ethnicity, education, U.S. census region, and poverty status. Current cigarette smoking was defined using PATH pre-defined variables where current smokers included respondents who reported (a) smoking  $\geq 100$  lifetime cigarettes and smoking some days or daily now, or (b) smoking  $< 100$  lifetime cigarettes and smoking some days or daily now.

Prevalence of using various digital forms was examined among all women aged 18–44 years ( $N = 10,023$ ) and among non-pregnant ( $N = 9637$ , weighted % = 96.5, 95% CI = 96.0, 97.0; smokers  $n = 3695$ , weighted % = 21.4, 95% CI = 20.4, 22.5; non-smokers  $n = 5922$ , weighted % = 78.6, 95% CI = 77.5, 79.6) and pregnant women ( $N = 386$ , weighted % = 3.5, 95% CI = 3.0, 4.0; smokers  $n = 98$ , weighted % = 13.7, 95% CI = 10.4, 17.0; non-smokers  $n = 287$ , weighted % = 86.3, 95% CI = 83.0, 89.6).

The specific items pertaining to use of digital forms included the following questions: “Do you have a Facebook, Google Plus, MySpace, Twitter or other social media networking account;” “Do you have a cell phone for personal use;” “Is your cell phone a smart phone;” “Do you send or receive text messages on your cell phone;” “Ever downloaded an app (or application) using your cell phone.”

### 2.3. Statistical analyses

Frequencies and percentages were generated across all respondents and were weighted to account for the complex sampling scheme, sampling probability, and differential non-response. Variance estimation was conducted as a variant of balanced repeated replication (Fay's method) using a predetermined value  $\epsilon = 0.3$  (Judkins, 1990; McCarthy, 1969). For each digital form above, we examined prevalence (95% CI) overall and separately among subgroups defined by pregnancy and smoking status.

We supplemented our examinations of prevalence with logistic regressions assessing the extent to which smoking status, pregnancy, and demographic variables were related to use of each digital form, thus five separate regressions were conducted. Women reporting not owning a cell phone did not receive subsequent questions about owning a smartphone, downloading an app, or text messaging, and were coded as “No” for these variables. The same predictor variables were retained in all five regressions to ensure comparability of results across models. While interaction terms between smoking and pregnancy status, as well as smoking and poverty status, were included to determine whether smokers' access to each digital form differed among pregnant versus non-pregnant women, or those living above versus below the poverty line, none of these terms were statistically significant. Thus, they were dropped from all models, with the results reported here reflecting the analyses without interaction effects. Odds ratios (ORs) represent the odds of using each digital form adjusting for all other variables in the final model.

All analyses were conducted using SAS 9.4 software (SAS Institute, Cary, NC) and statistical significance was defined as  $p < .05$  (2-tailed). Missing data on any variable resulted in case-wise deletion of that respondent.

## 3. Results

### 3.1. Sample characteristics

Overall, the majority of women were between 25 and 44 years, White, had a minimum educational attainment of some college, resided in the South, and were at or above the poverty level. A higher proportion of smokers, both non-pregnant and pregnant, were socio-economically disadvantaged (i.e.,  $<$  high school/GED, below poverty level) relative to non-smokers (Supplementary Table 1).

### 3.2. Prevalence using digital forms

The vast majority ( $> 80.0\%$ ) of women responded affirmatively to using each digital form, and this pattern was replicated within

**Table 1**

Use of various digital forms among females age 18–44 who completed Wave 1 of the Population Assessment of Tobacco and Health (PATH) Study, United States, 2013–2014.

Characteristics	Smokers			Non-smokers	
	Overall ( $n = 10,023$ )	Non-pregnant women ( $n = 3695$ )	Pregnant women ( $n = 98$ )	Non-pregnant women ( $n = 5922$ )	Pregnant women ( $n = 287$ )
	Weighted (95% CI)	Weighted (95% CI)	Weighted (95% CI)	Weighted (95% CI)	Weighted (95% CI)
Has Facebook, Google Plus, MySpace, Twitter, etc.	88.4 (87.4–89.4)	90.3 (89.0–91.6)	87.2 (79.1–95.3)	88.1 (86.8–89.3)	85.4 (78.7–92.1)
Has cell phone for personal use	95.0 (94.4–95.6)	92.9 (91.9–93.8)	90.8 (83.9–97.7)	95.7 (95–96.5)	93.0 (87.9–98.2)
Cell phone is a smart phone <sup>a</sup>	81.4 (80.2–82.5)	75.4 (73.8–76.9)	69.6 (60.2–79)	83.0 (81.6–84.4)	83.6 (77.2–90.0)
Ever downloaded an app using a cell phone <sup>a</sup>	90.0 (89.2–90.8)	88.4 (87.1–89.7)	87.0 (78.1–95.9)	90.5 (89.4–91.5)	87.4 (81.0–93.8)
Sends/receives text messages on a cell phone <sup>a</sup>	93.0 (92.3–93.7)	90.9 (89.8–92.0)	89.4 (82.2–96.5)	93.6 (92.8–94.5)	93.0 (87.9–98.2)

<sup>a</sup> Based on overall percent. People reporting not having a cell phone are coded as “no”.

**Table 2**  
Multiple logistic regressions assessing associations of demographic characteristics, pregnancy, and smoking status with using digital forms among females age 18–44 yrs. who completed Wave 1 of the Population Assessment of Tobacco and Health (PATH) Study, United States, 2013–2014.

	Has Facebook, Google Plus, MySpace, Twitter, etc.			Has cell phone for personal use			Cell phone is a smart phone <sup>d</sup>			Ever downloaded an app using a cell phone <sup>d</sup>			Sends/receives text messages on a cell phone <sup>d</sup>		
	AOR	95% CI	p	AOR	95% CI	p	AOR	95% CI	p	AOR	95% CI	p	AOR	95% CI	p
Age															
18–24 years	3.16	2.47	4.04	1.36	1.02	1.83	0.08	2.93	2.39	3.59	< 0.001	3.17	2.42	4.16	< 0.001
25–34 years	1.61	1.25	2.07	1.09	0.77	1.55		1.65	1.35	2.01		1.69	1.25	2.28	
35–44 years	Ref.			Ref.			< 0.01	Ref.			0.53	Ref.			< 0.001
Race <sup>a</sup>															
White	Ref.			Ref.				Ref.				Ref.			
Black	0.56	0.43	0.73	0.94	0.61	1.43		1.13	0.90	1.43		0.63	0.43	0.94	
Other	0.71	0.45	1.12	0.47	0.26	0.87		0.93	0.61	1.41		0.35	0.23	0.52	
Hispanic	0.48	0.37	0.62	0.53	0.37	0.74		1.13	0.89	1.45		0.48	0.35	0.65	
Education <sup>b</sup>							< 0.001				< 0.001				< 0.001
< HS/GED	Ref.			Ref.				Ref.				Ref.			
HS graduate	1.40	0.97	2.01	1.82	1.19	2.78		1.46	1.10	1.93		2.25	1.60	3.18	
Some college	2.46	1.68	3.59	4.18	2.54	6.89		2.65	1.99	3.53		4.95	3.54	6.93	
Bachelor's+	3.32	2.13	5.18	5.81	2.84	11.86		3.71	2.60	5.31		8.43	4.99	14.24	
Poverty <sup>c</sup>							0.21				< 0.001				< 0.001
Below	1.18	0.91	1.53	0.72	0.49	1.06		0.51	0.42	0.63		0.57	0.44	0.76	
At or above	Ref.			Ref.				Ref.				Ref.			
Pregnant							0.17				0.79				0.86
Yes	0.68	0.39	1.18	0.64	0.30	1.36		1.08	0.62	1.87		0.93	0.42	2.05	
No	Ref.			Ref.				Ref.				Ref.			
Smoke cigarettes							0.01				0.06				< 0.01
Yes	1.32	1.08	1.60	0.64	0.49	0.84		0.85	0.071	1.01		1.86	1.26	2.76	
No	Ref.	2.47	4.04	Ref.				Ref.				Ref.			

<sup>a</sup> The four racial/ethnicity categories (White, Black, Other, Hispanic) are mutually exclusive; persons identifying as Hispanic are categorized as such, regardless of race, “other” includes non-Hispanic persons of two or more races and persons belonging to racial groups other than non-Hispanic White or non-Hispanic black.

<sup>b</sup> HS = high school; some college refers to some college/associates degree; Bachelor's + refers to bachelors/advanced degree.

<sup>c</sup> Based on reported family income and poverty thresholds published by the U.S. Department of Health and Human Services.

<sup>d</sup> Based on overall percent. People reporting not having a cell phone are coded as “no”.

subgroups defined by pregnancy and smoking status (Table 1).

Comparing smokers to non-smokers, smokers generally reported lower access to each digital form relative to non-smokers, although CIs for all estimates overlapped among pregnant smokers versus pregnant non-smokers. The one item for which prevalence was higher among both non-pregnant and pregnant smokers versus their non-smoking counterparts was using social media, whereby 90.3% of non-pregnant smokers and 87.2% of pregnant smokers responded affirmatively (versus 88.1% of non-pregnant non-smokers and 85.4% of pregnant non-smokers). The item for which prevalence was lowest overall, and among subgroups based on pregnancy and smoking status, was smartphone ownership. However, even here over two-thirds of the women in each subgroup owned a smartphone.

### 3.3. Correlates of using digital forms

Table 2 shows results of the regression analyses examining correlates of using each digital form.

#### 3.3.1. Social media

Significant correlates of using social media included being a smoker versus a non-smoker, being 18–24 or 25–34 versus 35–44 years, being White versus Black or Hispanic, and having attained a Bachelor's or higher versus completing high school or some college.

#### 3.3.2. Cell phone ownership

Significant correlates of cell phone ownership included being a non-smoker versus a smoker, being White versus Hispanic or Other, and having completed high school, some college, or a Bachelor's degree versus < high school/GED.

#### 3.3.3. Smartphone ownership

Significant correlates of smartphone ownership included being a non-smoker versus a smoker, being 18–24 or 25–34 versus 35–44 years, completing high school, some college, or a Bachelor's degree versus < high school/GED, and being at or above the poverty level versus below it.

#### 3.3.4. Downloading an app

Significant correlates of downloading an app included being 18–24 or 25–34 versus 35–44 years, being White versus Black, Hispanic, or Other, completing high school, some college, or a Bachelor's degree versus < high school/GED, and being at or above the poverty level versus below it.

#### 3.3.5. Text messaging

Significant correlates of sending/receiving texts included being a non-smoker versus a smoker, being 18–24 or 25–34 versus 35–44 years, being White versus Hispanic or Other, completing high school, some college, or a Bachelor's degree versus < high school/GED, and being at or above the poverty level versus below it.

## 4. Discussion

We examined prevalence and correlates of using various digital forms among a U.S. national sample of reproductive-aged women, and will comment on four points. First, a majority of women overall and within subgroups of non-pregnant and pregnant smokers endorsed using each digital form examined. Indeed, the item for which prevalence was lowest was smartphone ownership, where a majority of both non-pregnant (75.4%) and pregnant smokers (69.6%) nonetheless owned a smartphone for personal use. Our findings indicating a lower prevalence of mobile phone ownership among smokers versus non-smokers is consistent with data published by PEW Research Center indicating a lower prevalence of cell phone and smartphone ownership among more socioeconomically disadvantaged groups. (PEW Research

Center: Internet and technology, n.d.) Importantly, while the present report used PATH data collected between 2013 and 2014, PEW data indicate a dramatic increase in smartphone ownership in the U.S. between 2013 (51.0%) and 2018 (77.0%) that is accounted for largely by growing access to smartphones among disadvantaged groups. The high and increasing prevalence of using various digital forms among non-pregnant and pregnant smokers supports the feasibility of leveraging technology to expand access to evidence-based smoking prevention, education, and treatment resources targeting this population as part of comprehensive tobacco control.

Second, while overall prevalence of using each digital form was high, notable sociodemographic disparities were discernible. For example, prevalence was generally lower among current smokers and those with lower educational attainment versus non-smokers and those with higher educational attainment, the exception being greater use of social media by smokers. Thus, those developing technology-based cessation programs must plan for engaging smokers who remain in the minority without access to various digital platforms. One way to limit response effort and engage these individuals in tobacco control efforts may involve directing them to locations in their community that offer free computer and Internet access (e.g., libraries, community centers) (McInnes et al., 2013), or to programs that distribute free mobile phones to low-income persons (Komando, n.d.). Alternatively, recent decreases in the price of mobile phones (Bagchi et al., 2008) and pay-as-you-go mobile plans (Le Dantec and Edwards, n.d.) may permit researchers, clinicians, or health departments to provide mobile phones and support payment plans for any smokers seeking remote cessation support who do not own a mobile phone.

Third, the lack of interactions between pregnancy and smoking status indicate that both non-pregnant and pregnant smokers can be targeted in efforts leveraging digital platforms to reduce smoking, however certain platforms may expand access more than others. For example, ~90.0% of both non-pregnant and pregnant smokers endorsed owning mobile phones and sending/receiving texts, thus efforts to reduce smoking involving text-based support may reach more women than efforts leveraging other modalities. However, maximizing reach must be balanced with considerations about efficacy. For example, researchers should be aware that text-based interventions may be less effective among women in general relative to men (Scott-Sheldon et al., 2016), and have yielded mixed results among pregnant women specifically (Naughton et al., 2012; Pollak et al., 2013). It will also be important to consider the content of smoking cessation programs targeting non-pregnant versus pregnant smokers, as the latter may be more motivated by pregnancy-specific content than reproductive-aged women without plans to become pregnant.

Last, there are several limitations. First, the relatively small sample of pregnant women presumably reduced the reliability of prevalence estimates and contributed to the wide confidence intervals observed. Second, use of tobacco products other than cigarettes were not examined, thus future research should examine differences in demographics and access to digital forms among women using other tobacco products. Third, although the high prevalence of using various digital forms supports the feasibility of targeting reproductive-aged women in technology-based smoking cessation efforts, women were not queried about their interest in such efforts, thus no conclusions can be drawn surrounding acceptability. Finally, wave one of the PATH study was conducted between 2013 and 2014 and prevalence of mobile phone ownership has increased since then (McCarthy, 1969), thus prevalence estimates may underestimate current prevalence of using the digital forms examined in this report.

These limitations notwithstanding, the present study provides novel information on prevalence and correlates of using various digital forms among a U.S. national sample of reproductive-aged women. Although more research is needed to determine how to most effectively leverage digital platforms to reduce smoking and improve health among reproductive-aged women, the present results indicating high prevalence

of using various digital forms among this population certainly suggest that efforts to deliver evidence-based smoking prevention, education, and treatment resources using digital platforms are worthwhile, and would likely reach substantial numbers of reproductive-aged women.

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## Declaration of interests

None declared.

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