PRICES, USE RESTRICTIONS, AND ELECTRONIC CIGARETTE USE – EVIDENCE FROM ITC US OF THE 4CV1 (2016) SURVEY

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ABSTRACT

Aims: To determine if there are associations between changes in the explicit (i.e., price) and implicit (i.e., use restrictions in public places) costs of cigarettes and nicotine vaping products (NVPs) and their use patterns in the United States.

Methods: Data came from the Wave 1 (2016) US data of the ITC Four Country Smoking and Vaping Survey (ITC US 4CV1) and Nielsen Scanner Track database. A multiple logistic regression model was applied to estimate the likelihoods of NVP use (vaping at least monthly), cigarette/NVP concurrent use (vaping and smoking at least monthly), and switch from cigarettes to NVPs (had quit smoking < 24 months and currently vape) among ever smokers, conditioning upon cigarette/NVP prices, use restrictions and socio-demographics.

Results: Living in places where vaping is allowed in smoke-free areas was significantly associated with an increase in the likelihood of vaping (Marginal Effect, M.E. = 0.17; $p<0.05$) and the concurrent use of cigarettes and NVPs (M.E. = 0.11; $p<0.05$). Higher NVP prices were associated with decreased likelihood of NVP use, concurrent use, and complete switch ($P>0.05$). Higher cigarette prices were associated with greater likelihood of cigarette and NVP concurrent use ($P>0.05$). Working in places where vaping is banned is associated with lower likelihood of vaping and NVP and cigarette concurrent use ($P>0.05$).

Conclusions: Higher prices for nicotine vaping products (NVPs) and vaping restrictions in public places are associated with less NVP use and less concurrent use of vaping and smoking. Public policies that increase prices for vaping devices and supplies (i.e., regulations, taxes) and restrict where vaping is allowed are likely to suppress vaping.

INTRODUCTION

While cigarettes are the most frequently used tobacco product among adults in the United States, non-cigarette nicotine products are becoming increasingly popular[1]. The prevalence of US adults currently using more than one nicotine product increased from 2.5% in 2003 to 3.4% in 2008[2,3] to 27.6% of adults in 2013 and 2014[4].

Nicotine vaping products (NVPs), a vaping device or vaporizer delivering nicotine in vapor or aerosol form, are relatively new products that started to steadily gain market share in the US after 2010. As of 2016, global sales of NVP reached $11.43 billion dollars and are expected to increase to over $86.43 billion by 2025[5], of which a substantial share of sales are in the US, although they are increasing in other countries as well[4,6,7].

With the introduction of and the growth in use of NVP and other novel nicotine products, concerns have been raised that the marketing of these new products might reverse and/or slow down the steady decline in cigarette consumption that has taken place since the early 1980s[8,9]. In particular, some public health officials have raised concerns that the marketing of NVPs may lead some nonsmoking teens and young adults to take up smoking[9-12] and that use of NVPs could delay efforts to stop smoking cigarettes by promoting dual use[8]. A specific concern is that cigarette smokers use NVPs in those situations where cigarette smoking is restricted to maintain their nicotine addiction; this concurrent use behavior (complementarity) could potentially blunt the impact of anti-smoking regulations and prolong the use of conventional cigarettes[10,12]. Alternatively, if NVPs are an effective substitute for conventional cigarettes (substitution), this could lead to a more rapid decline in cigarette use[13-17]. These behaviors of complementarity and substitution between smoking and NVP use in response to prices and smoke-free regulations are not mutually exclusive. Complementarity and substitution may occur both within and across populations, depending on the particular situations subjects face and the characteristics of a particular population subgroup.

In this paper, we investigate the associations between prices, use restrictions in public places and use patterns of cigarettes and NVPs (i.e. NVP use, concurrent use, and complete switch to NVPs). We use data from the 2016 wave of the ITC Four Country Smoking and Vaping Survey (ITC 4CV1) to estimate the likelihood of NVP use regardless of current or previous use of other nicotine products, cigarette and NVP concurrent use, and completely switching from cigarette to NVP use under varying conditions of cigarette prices and smoking/vaping restrictions in public places..

METHODS

Data

The data used in this study came from two sources: Wave 1 (2016) of US data from the ITC Four Country Smoking and Vaping Survey (ITC US 4CV1) and the 2016 Nielsen Scanner Track database. The 2016 ITC US 4CV1 provides detailed information on individuals' status of NVP use and cigarette smoking, smoking/vaping restrictions in public places, demographics and socioeconomics, and geographic location. Market-level NVP and cigarette prices were constructed using data from the 2016 Nielsen Scanner Track database.

The ITC 4CV1 Survey was designed to understand the relationships between use of NVPs and tobacco use. The survey over-sampled current smokers, former smokers, and NVP users. It comprised the cohorts of (1) re-contacted smokers and former smokers who participated in the last wave of the ITC Four Country Project, regardless of NVP use, (2) newly recruited current smokers and recent former smokers (quit smoking in the past 24 months) from country-specific panels, regardless of NVP use, and (3) newly recruited current NVP users (use at least weekly) from country-specific panels. Response rates by country for new recruits ranged from 15.2% to 49.6% with cooperation rates above 90%. Retention rates from the 4C cohort ranged from 35.7% to 44.2%.[18] Our study used the ITC 4CV1 for the US only. The Nielsen Scanner Track database contains quarterly total dollar sales and sales volume of NVPs and cigarettes for each of 52 Nielsen markets in the US, which allows construction of the market-level price measures for NVPs and cigarettes. The data were gathered directly from participating retailers including food (such as Kroger, Food Lion, Publix, Safeway, Albertsons, and WinnDixie), drug (such as CVS, Walgreens, and RiteAid), and mass-merchandise stores (K-mart and Target) in 52 US markets; and convenience stores (such as 7 Eleven, Shell, Circle K, BP, and Exxon) in a subset of 25 markets. A Nielsen market consists of groups of counties centered on a major city, sometimes covering areas in two or multiple states.

Because a Nielsen market consists of a number of counties surrounding a major city, we were able to link the 2016 ITC US 4CV1 data with the market-level cigarette and NVP prices based on respondents' county residency to identify the cigarette and NVP prices that each respondent faces. The final analytical samples were restricted to non-missing values of dependent variables (NVP use, concurrent use, switch), independent variables (NVP price, cigarette price, smoking/vaping restrictions in public places), and demographic and socioeconomic variables. Figure A.1 (Appendix) presents a flowchart explaining how the final sample was derived. The sample size of the 2016 ITC US 4 CV1 survey is 2812. The survey was first merged with the Nielsen NVP price data using respondents' federal information processing standard publication (FIPS) county code, reaching the sample size of 2250. We excluded respondents with missing observations in demographic characteristics and self-reported vaping restrictions in public places, leading to the final sample size N = 2078. In addition, due to missing price data on NVP cartridge, the sample size of the analytical sample for NVP cartridge becomes 2043. Likewise, since 44% of the respondents did not report their vaping restrictions at work due to not working outside of the home, the sample size decreased to 1157 for the analytical samples for NVP disposable prices and NVP starter kit prices and 1138 for the NVP cartridge prices analytical sample.

Measures

Current NVP use and cigarette smoking

The 2016 ITC US 4CV1 Survey contained information on the status of NVP/cigarette use measured by, "How often, if at all, do you CURRENTLY use e-cigarettes/ vaping devices (i.e., vape)?" and "How often, if at all, do you CURRENTLY smoke ordinary cigarettes (either factory-made/packet or roll-your-own)?" Daily smokers, weekly smokers, and at least monthly smokers were defined as current cigarette smokers. Similarly, daily vapers, weekly vapers, and at least monthly vapers were defined as current NVP users (vapers).

Concurrent users and recent quitters

Concurrent users were defined as those who were both current vapers who vaped at least monthly, and current cigarette smokers who smoked at least monthly.

Recent quitters were defined as those who had smoked 100+ lifetime cigarettes and reported they had quit smoking in the last 24 months.

Complete switch to NVP

Complete switchers were defined as those who had smoked 100+ cigarettes in their lifetimes, quit smoking in the last 24 months, and were current NVP users.

Vaping allowed in smoke-free public areas

A binary variable was defined from the answer to the question: "In the last 30 days, have you seen anybody vaping indoors where smoking regular cigarettes is banned?" Those who answered "Yes, but only once," "Yes, a few times," or "Yes, frequently" are defined as 1 or living in a place where vaping is not regulated in their smoke-free venues; and 0 otherwise.

Vaping banned in workplace

A binary variable was defined from the question, "Which of the following best describes the vaping policy where you work?" Those who were currently employed outside the home answered the question. Those who answered "Vaping is not allowed in any indoor area" were coded as 1 or those whose workplace regulates vaping indoors; and 0 otherwise.

Market-level product-specific NVP prices and the weighted average NVP prices

Product-specific NVP prices were constructed by dividing total dollar sales by total sales volume for each specific type of NVP in a given market and year. Product-specific NVP prices included prices for NVP disposables and NVP starter kits. The weighted average NVP price in a market was defined as the weighted average price of all different NVPs available in the market, taking into account the market share for each specific type.

Market-level cigarette prices

In order to create the volume representative variable for cigarette price, the volumes were converted into number of cigarette sticks sold in a market, by taking into account the number of packs contained in each unique product as well as the number of cigarettes contained in each cigarette pack type. Market-level cigarette prices were constructed by dividing total dollar sales by total number of cigarette sticks sold in a given market.

Demographics and socioeconomic status

Age was measured as a continuous variable. Ethnicity was a dichotomous variable. Ethnicity was 1 if the respondents reported being Caucasian, and 0 otherwise.

Statistical Models

We estimated a multiple logistic regression model of the likelihood of NVP use, cigarette and NVP concurrent use, and completely switching from cigarettes to NVP, respectively, conditioning upon cigarette price, NVP price, vaping allowed in smoke-free public places, and socio-demographics.

In addition, in order to explore the impact of vaping regulations in the workplace, we estimated a logit model of the likelihood of NVP use, concurrent use, and completely switching from cigarettes to NVPs, respectively, among respondents who currently work outside of the home, conditioning upon cigarette price, NVP price, vaping restrictions in the workplace, and socio-demographics. NVP and cigarette prices, vaping indoor regulations, and socio-demographics such as age and ethnicity are covariates found in the literature to be associated with vaping.

All analyses were weighted to account for the complex sampling design using the wave 1 cross-sectional inflation weight for the main sample – kWTS100v. The significance level (α) was set at the 5% level. The weight is designed so that individuals in each group are representative of the corresponding population at the time of data collection[19]. All analyses were weighted using the Stata command 'svyset [pweight = kWTS100v]' and were conducted using STATA Version 13.

RESULTS

Table 1 presents weighted summary statistics for the final analytical sample of ever smokers. On average, 72% of the sample were current cigarette smokers, 28% of ever-smokers were current NVP users, 20% of ever-smokers are concurrent users, and 2.7% of ever-smokers are complete switchers. The average prices of NVP cartridges, NVP disposables, and NVP starter kits at the market level were $3.31, $8.10, and $9.76 respectively. The weighted average NVP price was $5.48. On average, 25% of respondents reported seeing people vaping in smoke-free public places. Approximately 66% of

respondents working outside of the home reported that vaping is banned in the workplace. The average age of the individuals in the sample was 45.40 and 76% were Caucasian.

Table 2 represents the estimates of the likelihood of NVP use, concurrent use, and complete switch, separately estimated depending on different NVP price measures (NVP disposable price, NVP starter kit price, and NVP weighted average price), cigarette prices, self-report of having seen vaping in smoke-free public places, and demographics. Columns of NVP/DP, NVP/SK, and NVP/WA indicate separate regression results using price of disposable, starter kit, and weighted average, respectively, for NVP price. The coefficients reported in the table are marginal effects.

The estimates of NVP starter kits price and NVP weighted average price across specifications indicate that higher NVP prices were associated with decreased likelihood of NVP use, concurrent use, and complete switch to NVPs. The marginal effects of NVP starter kits price were -0.00 (price elasticity = -0.05), -0.00 (price elasticity = -0.01), and -0.01 (price elasticity = -3.17, $p< 0.5$) on NVP use, concurrent use, and complete switching, respectively. The marginal effects of weighted average price were -0.01 (price elasticity =-0.16), -0.01 (price elasticity = -0.40), and -0.02 (price elasticity = -5.17) on NVP use, concurrent use, and complete switch, respectively. However, the associations do not reach significance levels across all specifications, except for the specification using NVP starter kit prices for complete switch.

The estimate on cigarette price effect on the likelihood of concurrent use suggests that higher cigarette prices were associated with a greater likelihood of concurrent use, but higher cigarette prices were also associated with a lower likelihood of NVP use and completely switching to NVPs. However, none of these associations reached significance levels.
The results indicate that having seen vaping in smoke-free public places was positively associated with NVP use (M.E. = 0.16; $P<0.05$), concurrent use (M.E. = 0.10; $P<0.05$), and complete switch (M.E. = 0.01; $P>0.05$). The results indicated that having seen vaping in smoke-free public places was associated with a 16 percentage point, 10 percentage point, and 1 percentage point increase in NVP use, concurrent use, and complete switch, respectively. The associations were all statistically significant across specifications, except for the likelihood of complete switch.

The coefficients on respondents' demographic characteristics indicate that being older was associated with lower likelihood of NVP use and concurrent use. A similar, but non-significant association was observed among complete switchers. Caucasians were more likely to use NVPs and be concurrent users compared to their non-Caucasian counterparts, although those associations were not significant either.

Table 3 represents the estimates of the likelihood of NVP use, concurrent use, and complete switch, separately estimated depending on different NVP price measures, cigarette prices, self-reported

vaping restrictions in the workplace, and socio-demographics among respondents who worked outside of the home. Columns of NVP/DP, NVP/SK, and NVP/WA respectively indicate separate regression results using price of disposable, starter kit and weighted average, respectively, for NVP price. The coefficients reported in the table are marginal effects.

Higher NVP starter kit prices and higher NVP weighted average prices were associated with decreased likelihood of NVP use (marginal effect = -0.01, price elasticity = -0.23), concurrent use (marginal effect = -0.00, price elasticity = -0.14) and complete switch (marginal effect = -0.00, price elasticity = -1.73) to NVP use. However, the associations did not reach significance levels across all specifications. There was no clear pattern observed in the associations between cigarette prices and NVP use, concurrent use, or complete switch.

Workplace vaping restriction was associated with less likelihood of NVP use, concurrent use, and complete switch, although the estimates were statistically non-significant from zero. Younger respondents were more likely to use NVPs and be concurrent users than were their older counterparts. The associations were statistically significant across specifications, except for complete switch. Caucasians were more likely to use NVPs and completely switch to NVPs than were other races, but the associations were not statistically significant.

Sensitivity Analysis

We conducted a sensitivity analysis by including daily smokers and weekly smokers as current cigarette smokers. Similarly, daily vapers and weekly vapers were defined as current NVP users. The results are consistent with the results that included monthly smokers and vapers.

DISCUSSION

Our study uncovered some interesting substitution and complementarity relationships between NVP and cigarette use. First, our study found that costs of vaping, both explicit (NVP prices) and implicit costs (vaping restrictions in public places), may play an important role in explaining NVP use and cigarette and NVP concurrent use. Higher NVP prices and vaping restrictions in public places were associated with less NVP use and less concurrent use. Secondly, we did not find that NVPs could potentially act as a substitute for cigarette smoking in response to higher cigarette prices, as there were no consistent patterns observed in the influences of cigarette prices on NVP use or completely switching. Third, we found potential complementarity between cigarette and NVP use. Those who reported that vaping was allowed in the smoke-free areas were significantly more likely to be cigarette and NVP concurrent users. Similarly, those who reported their workplaces restricted vaping inside were less likely to report concurrent use. By tackling the relationships between NVPs and cigarettes and the extent to which NVPs could potentially act as a substitute for or a complement to cigarettes, our study provides significant implications for the design and implementation of policy.

Previous studies have estimated the demand for NVPs and analyzed the impact of prices and smoke-free regulations on NVP demand either using aggregate sales data or individual-level data[20-22]. However, previous studies did not explore whether NVPs could serve as a substitute for or complement to cigarettes by gauging the impact of costs of vaping, NVP prices, and vaping restrictions in public places on changes in use patterns between cigarettes and NVPs. Furthermore, previous studies relied on respondents' self-reported reasons for NVP use, reflecting on either NVPs as a substitute away from cigarettes or concurrent use to conquer smoking restrictions[23,24]. Other studies have investigated the relationships between concurrent use and smoking cessation[17,25]. Our study contributes to the current literature by investigating whether increased cigarette price is associated with increased likelihood of using NVPs to substitute away from cigarettes (i.e., substitution) and whether allowing vaping in smoke-free areas is associated with increased likelihood of NVP and cigarette concurrent use to facilitate nicotine demand anywhere to conquer smoking restrictions (i.e., complementarity).

Our study is subject to some limitations associated with the use of Nielsen Scanner Track data. First, these data are gathered from participating retailers of convenience stores, food, drug, and mass-merchandise stores, and may not reflect the prices from other retailer types such as internet, tobacco shops, and vape shops. In addition, for those using "roll your own (RYO)" cigarettes instead of the manufactured cigarettes, cigarette prices obtained from Nielsen data do not reflect the prices paid by those RYO smokers. Indeed, only about one-third of NVP sales were happening in retail locations such as supermarkets, gas stations, convenience stores, and drug stores, while vape shops and internet account for two-thirds of the sales[26]. Self-reported NVP prices from ITC 4CV1 data indicate that price variations are larger with a wider range, while NVP prices provided by Nielsen Scanner Track have less variation with a narrower price range (the authors' calculation), as these price sources mainly come from conventional retailers. Future studies will benefit from obtaining NVP price information from various purchasing locations, such as internet, vape shops, and tobacco shops, to fully capture NVP prices from all purchasing locations. Second, as a Nielsen market consists of groups of counties centered on a major city, our sample using prices from Nielsen Scanner Track data underrepresents the population in rural areas. Third, our vape-free measures, having seen anyone vaping in smoke-free areas and self-reported vaping restriction in the workplace, may not fully capture all vaping regulations and may contain measurement errors. In addition, this self-reported measure may be endogenous, such that a particular subgroup which is more inclined to vape may be more aware of vaping restrictions, causing endogeneity between these two variables. Fourth, using the cross-sectional data, we cannot make any causal inferences on the relationships between prices, use restrictions, and behaviors of concurrent use and complete switch. Further, using cross-sectional data, we cannot explain whether and to what extent concurrent use will ultimately lead to complete switch[27]. Finally, a smaller sample size of the survey data may provide insufficient power to detect price effects on NVP use, concurrent use, and complete switch. Future

studies may benefit from using large-scale and longitudinal data to explore the impact of prices and use restrictions on changes in use patterns between cigarettes and NVPs and studying whether these use patterns may ultimately lead to abstinence.

Despite these limitations, our results imply that cost of vaping may play an important role in explaining use patterns between cigarettes and NVPs. Policies raising retail NVP prices, such as taxes, have the potential to reduce NVP use and concurrent use of cigarettes and NVPs. State and local governments may consider restricting NVP use in their current smoke-free venues to decrease the potential complementary behaviors between cigarettes and NVPs.

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Table 1: Weighted Summary Statistics

Variables	N	Average or percentage
Current Vapers (%)	2,078	28
Concurrent Users (%)	2,078	20
Complete Switchers (%)	2,078	2.7
Price of NVP Cartridges ($)	2,078	3.31
Price of NVP Disposables ($)	2,078	8.10
Price of NVP Starter Kit ($)	2,078	9.76
Weighted NVP price ($)	2,078	5.47
Current Cigarette Use (%)	2,078	72
Cigarette Price (per stick) ($)	2,078	0.30
Vaping is banned in workplace (%)	1,157	66
See vaping in smokefree public places (%)	2,078	25
Age (years)	2,078	45.40
Caucasian (%)	2,078	76

Table 2: Associations between NVP use and NVP/cigarette prices and 100% seeing vaping in smokefree public places

	NVP Use			Concurrent Use			Complete switch		
	NVP/DP	NVP/SK	NVP/WA	NVP/DP	NVP/SK	NVP/WA	NVP/DP	NVP/SK	NVP/WA
NVP Price	0.03 (0.02)	-0.00 (0.01)	-0.01 (0.02)	0.01 (0.01)	-0.00 (0.01)	-0.01 (0.02)	-0.01 (0.01)	-0.01* (0.00)	-0.02 (0.02)
Cig Price	-0.17 (0.22)	-0.11 (0.23)	-0.08 (0.24)	0.01 (0.18)	0.04 (0.19)	0.11 (0.19)	-0.15 (0.10)	-0.07 (0.10)	-0.06 (0.13)
Vaping allowed in Smokefree areas	0.17** (0.03)	0.17** (0.03)	0.17** (0.03)	0.11** (0.03)	0.11** (0.03)	0.11** (0.03)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)
Age	-0.00** (0.00)	-0.00** (0.00)	-0.00** (0.00)	-0.00** (0.00)	-0.00** (0.00)	-0.00** (0.00)	-0.00 (0.00)	-0.00 (0.00)	-0.00 (0.00)
Caucasian	0.05 (0.04)	0.05 (0.04)	0.05 (0.04)	0.03 (0.03)	0.03 (0.03)	0.03 (0.03)	0.02 (0.02)	0.02 (0.02)	0.02 (0.02)
NVP price Elasticity	0.82 (0.53)	-0.05 (0.33)	-0.16 (0.37)	0.60 (0.55)	-0.01 (0.34)	-0.40 (0.42)	-2.31 (2.60)	-3.17 (1.13)	-5.17 (2.90)
Cross price elasticity	-0.17	-0.11	-0.08	0.01	0.05	0.14	-1.83	-0.85	-0.71
Number of Obs.	2,078	2,078	2,078	2,078	2,078	2,078	2,078	2,078	2,078

Note: Columns of NVP/DP, NVP/SK, and NVP/WA respectively indicate separate regression results using price of disposable, starter kit and weighted average, respectively for NVP price. The coefficients were the marginal effect estimates. Standard errors are in parentheses. NVP price elasticities were calculated using the Stata command: margins, eyex. *p<0.05, **p<0.01.

Table 3: Associations between EC use and EC/cigarette prices and vaping restrictions in workplace

	NVP Use			Concurrent Use			Complete switch		
	NVP/DP	NVP/SK	NVP/WA	NVP/DP	NVP/SK	NVP/WA	NVP/DP	NVP/SK	NVP/WA
NVP Price	0.00 (0.02)	-0.01 (0.01)	-0.02 (0.03)	0.01 (0.02)	-0.00 (0.01)	-0.01 (0.02)	-0.01 (0.01)	-0.00 (0.00)	-0.03 (0.03)
Cig Price	-0.26 (0.33)	-0.19 (0.34)	-0.14 (0.35)	-0.01 (0.28)	0.05 (0.30)	0.06 (0.31)	-0.08 (0.11)	-0.03 (0.11)	0.07 (0.15)
Vaping is banned in workplace	-0.02 (0.04)	-0.02 (0.04)	-0.02 (0.04)	-0.05 (0.04)	-0.05 (0.04)	-0.05 (0.04)	0.00 (0.02)	0.00 (0.02)	0.01 (0.02)
Age	-0.01** (0.00)	-0.00** (0.00)	-0.00** (0.00)	-0.00** (0.00)	-0.00** (0.00)	-0.00** (0.00)	-0.00 (0.00)	-0.00 (0.00)	-0.00 (0.00)
Caucasian	0.07 (0.05)	0.07 (0.05)	0.06 (0.05)	0.00 (0.04)	-0.00 (0.04)	-0.00 (0.04)	0.05 (0.03)	0.05 (0.03)	0.05 (0.03)
NVP price Elasticity	0.08 (0.63)	-0.23 (0.40)	0.06 (0.05)	0.48 (0.67)	-0.14 (0.43)	-0.20 (0.50)	-4.14 (3.46)	-1.73 (0.97)	-7.77 (5.32)
Cross price elasticity	-0.26	-0.20	-0.14	-0.01	0.06	0.08	-0.98	-0.32	0.82
Number of Obs.	1,157	1,157	1,157	1,157	1,157	1,157	1,157	1,157	1,157

Note: The study sample restricts to respondents who work outside of home. Columns of NVP/DP, NVP/SK, and NVP/WA respectively indicate separate regression results using price of disposable NVP, starter kit and weighted average, respectively for NVP price. The coefficients were the marginal effect estimates. Standard errors are in parentheses. NVP price elasticities were calculated using the Stata command: margins, eyex. *p<0.05, **p<0.01.

Appendix

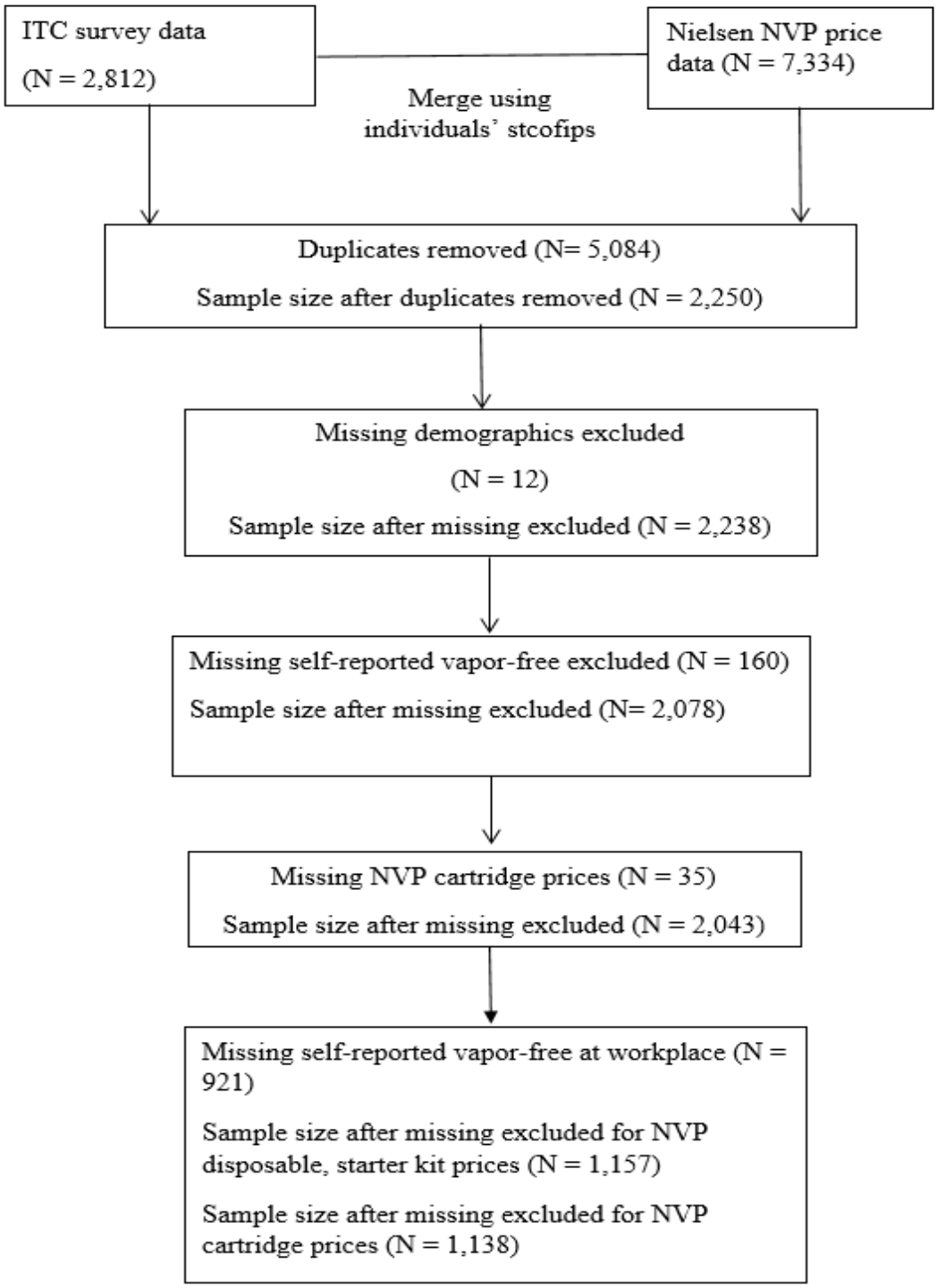

Figure A.1. Flowchart of Sample Size