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Electronic Nicotine Delivery Systems (ENDS) Use and Pregnancy I: ENDS Use Behavior During Pregnancy

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Abstract

Purpose of Review: This review examines Electronic Nicotine Delivery Systems (ENDS) use behavior during pregnancy, including the prevalence of and transitions in use during pregnancy.

Recent Findings: Twenty-two papers addressed the prevalence of and/or transitions in ENDS use during pregnancy. Findings show a complex landscape of ENDS use. A minority (0.4%−7.0%) of pregnant persons use ENDS; most commonly this occurs in the form of dual use (ENDS and combustible cigarettes (CC); 75%). Many pregnant persons report using ENDS because they perceive them to be a lower-risk alternative and/or potential cessation aide for CC smoking. However, while a subset of those who use ENDS do quit all tobacco product use during pregnancy, only a small proportion switch from exclusive CC smoking to exclusive ENDS use.

Summary: ENDS are a somewhat new addition to the tobacco product landscape. The perception of ENDS as a lower-risk alternative may contribute to ENDS use in pregnancy. There is insufficient evidence to support the notion that ENDS facilities the cessation of tobacco product use during pregnancy.

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Keywords

ENDS; e-cigarette; vaping; smoking; pregnancy; tobacco regulatory science

1. INTRODUCTION

1.1 Overview of ENDS

The commercial landscape of tobacco products (TPs) has changed remarkably in recent years with one of the biggest changes being the introduction of Electronic Nicotine Delivery Systems (ENDS). ENDS have only been present in the United States (US) marketplace since 2007, with a substantial expansion of ENDS products available in the US since then [1]. The prevalence of ENDS use has substantially increased over the past several years, including among adults of reproductive age [2], despite decreases in the use of combustible cigarettes (CC) over the same time period [3–5].

The term ENDS refers to a category of TPs which use electronic devices to heat a liquid in order to create an aerosol, which is inhaled. This category most notably includes e-cigarettes which are known by a wide range of names including vapes, vape pens, mods, pod mods and Juul. These products vary on two important characteristics. First, the liquid which is aerosolized can differ in terms of its nicotine content, flavor, and/or the other components that form the base of the liquid (e.g., propylene glycol, vegetable glycerin). Second, the electronic device which aerosolizes the liquid can differ on a range of variables, including whether it comes pre-filled with a certain liquid or can be filled with your liquid of choice, whether it has adjustable settings (e.g., higher or lower power settings), and its shape and size.

It is important to note that although the term ‘electronic nicotine delivery system’ (ENDS) implies the presence of nicotine, a product does not need to contain nicotine in order to be considered an ENDS product. The ENDS marketplace includes products that range from containing no nicotine to very high levels of nicotine (e.g., 5% e-liquids), while the average percent nicotine content by weight of tobacco in CC is below 2% [6]. Additionally, there are thousands of different flavor options and devices ranging from small closed-system disposable e-cigarettes that resemble traditional CCs all the way to large rechargeable and adjustable devices [7–9]. So while in this review we consider this broad category of products, it is important to remember that product characteristics such as nicotine level, flavor, or device characteristics may have a substantial impact on the product’s appeal, addictive potential, or potential for conferring risk or efficacy as a harm reduction aid for those who use the products, including pregnant persons.

1.2 Focus of the Review

Use of TPs, such as combustible cigarette (CC) smoking, during pregnancy has been shown to increase the risks for adverse perinatal outcomes [10]. Whether ENDS use during pregnancy is associated with increased risk of adverse perinatal outcomes is an important topic which we have reviewed elsewhere [11]. However, it is important to characterize ENDS use during pregnancy in order to fully understand the contribution that ENDS may

have to the TP landscape during pregnancy. The purpose of this review is to synthesize information on the prevalence of ENDS use during pregnancy, transitions in ENDS use during pregnancy, and, where available, to include information on which types of products are used, how they are used (e.g. exclusively or as dual use with CC smoking; frequency of use), and consider what factors may contribute to pregnant persons' motivation for using ENDS.

1.3 Pregnancy as a Time of Change in TP Use Behavior

For many, pregnancy is a key time to make favorable and lasting behavioral changes to CC smoking and other TP use. Pregnant persons who use TPs may try to abstain, cut down, or switch to products that they perceive will reduce the risk of adverse perinatal outcomes [12]. However, approximately half of people who use CC continue to smoke during pregnancy and breastfeeding; women who do quit smoking CC during pregnancy have high relapse rates following birth [13–16]. Despite a similar level of interest in quitting [10], women, in general, have greater difficulty achieving CC smoking cessation than men [17–24], and these challenges with quitting are still present during pregnancy. Cessation and relapse prevention interventions are still insufficient for some individuals, despite decades of research.

Perceptions of ENDS as a low-risk behavior or as a harm-reduction aid may contribute to ENDS use during pregnancy. Pregnant persons tend to believe that ENDS are less harmful than CCs during pregnancy [25–27]. Additionally, both pregnant persons and non-pregnant women commonly endorse the belief that ENDS would aid in quitting CCs [28, 29]. Whether ENDS are an effective harm reduction strategy depends not only on whether they are safe during pregnancy, but also whether they effectively reduce CC smoking.

In non-pregnant samples, ENDS are often considered in the context of their impact on CC smoking. For example, ENDS has been proposed to present a promising harm reduction alternative to CC smoking for the general population of those using CCs [30], although evidence for the efficacy of ENDS as smoking cessation aids remains somewhat limited [31–36] and a recent Cochrane review found no RCT studies of ENDS for CC cessation during pregnancy [37]. Further, in individuals who had not previously smoked CCs, ENDS may facilitate initiation of CC smoking [38, 39]. Similarly, in individuals who previously smoked CCs and quit, ENDS may facilitate relapse to CC smoking [40, 41]. While consideration of how ENDS influences CC smoking is an important topic, primarily focusing on that relationship may create the impression that ENDS are harmless unto themselves. For the purpose of this review, we will focus specifically on ENDS use and transitions in ENDS use during pregnancy and perinatal time periods. This review will report on other TP use and motivations that relate to cessation of other TP use, but only in as much as it is relevant to understand the findings on ENDS use behavior, which is the focus of this review. Therefore, this review does not attempt to summarize the broader literature on whether ENDS is effective as a CC cessation aid as that topic is beyond the scope of this review.

1.4 Scope and Methods of Review

The goal of this review is to synthesize findings in pregnant persons from population-based or cohort-based samples related to ENDS use behavior and transitions in ENDS use behavior during pregnancy.

This narrative literature review utilized the following methods to identify manuscripts: As was done in [11], searches were limited to 'Human' (i.e., preclinical research not included), and written in the English language. Searches in PubMed database initially focused on two population-based datasets with information on ENDS and pregnancy: namely the Population Assessment of Tobacco and Health (PATH, [42]) and the Pregnancy Risk Assessment Monitoring System (PRAMS, [43]). Searches used search terms related to ENDS (e.g., "electronic nicotine delivery systems" or "ENDS" or "electronic cigarettes" or "e-cigarette" or "vaping") and pregnancy (e.g., "pregnant" or "pregnancy" or "prenatal" or "antenatal" or "perinatal") plus the study names (i.e., "Pregnancy Risk Assessment Monitoring System" or "PRAMS" or "Population Assessment of Tobacco and Health" or "PATH"). More general searches in PubMed, PsychInfo, and Google Scholar to capture other datasets were then performed using the terms related to ENDS and pregnancy detailed above. The references of the identified papers were then reviewed to determine whether any of the cited papers met inclusion criteria for this review.

Papers met criteria for inclusion if they were population-based or cohort studies (cross-sectional or longitudinal) which characterized ENDS use during pregnancy, for example by providing prevalence of use within the sample or transitions in use during pregnancy. Information extracted from each paper (see Table 1) included 1) characteristics of the sample (N, inclusion criteria, years of data collection), 2) time points during pregnancy or the perinatal period captured in the TP use data; 3) the definition/s of ENDS and other TP use groups: which groups were compared, and how group membership was defined; and 4) a summary of findings related to ENDS use prevalence, transitions, or other characteristics of use (e.g., product characteristics, frequency). Where potentially relevant to ENDS use, other topics such as motivations for use or risk perceptions were also included.

2. RESULTS

Twenty-two papers characterized ENDS use during pregnancy (Table 1).

The prevalence of ENDS use amongst non-pregnant females is 6.2% [13] and among females of reproductive age who use combustible TP is approximately 22% [44]. However, pregnancy often prompts abstinence from TPs [44], including from ENDS [13]. A recent analysis of 4 waves of PATH data (Wave 1, 2013–2014; Wave 2, 2014–2015; Wave 3, 2015–2016; Wave 4, 2016–2018), found that the ENDS cessation rate among pregnant women was approximately 76% [45]. A cross-sectional study found that ENDS use declined significantly from early (0.4%) to late (0.0%) pregnancy [46]. Despite these encouraging findings, estimates of the prevalence of ENDS use during pregnancy vary across studies reviewed here (e.g., 0.4% [47]; 0.6% [48]; 5.0% [49]; 7.0% [50]). Additionally, an earlier review reported a wider range of prevalence during pregnancy (0.6 – 15%) [25].

A substantial portion of pregnant ENDS users concomitantly use CCs [51–54]. A large telephone survey of racially/ethnically diverse, low-income pregnant women in the U.S. found that although 4% of participants endorsed current ENDS use, 75% of these ENDS users also currently smoked CCs [54]. Moreover, data from the National Health Interview Survey revealed low rates of ENDS use among pregnant women overall (3.6%), but rates of ENDS use among pregnant people who smoke CC were significantly higher (39%) [52].

A commonly endorsed reason for using ENDS during pregnancy is to aid with CC smoking cessation [28, 50, 51, 55–59]. Among surveyed pregnant individuals who reported current ENDS use, 71% (n=31) endorsed ever using ENDS to try to quit smoking CCs [28]. Similarly, two additional cross-sectional analyses found that, among those who dual use, the primary reason for using ENDS during pregnancy was to help with CC smoking cessation [56, 58]. Finally, a 2014 survey of pregnant women revealed that a majority of participants who ever used ENDS perceived ENDS as safer than CCs (74%) and predominately endorsed using ENDS to help them quit smoking (72%) [59]. Those with current ENDS use are more likely to perceive a greater benefit for using ENDS to help with smoking cessation versus those who do not currently use ENDS [28].

Despite the belief that ENDS may be an effective smoking cessation tool, there is little evidence to substantiate this notion among pregnant persons. In a CC cessation study of pregnant women, a majority of those who endorsed dual use reported using ENDS in an attempt to quit smoking; however, the association between ENDS use and short-term smoking cessation outcomes were non-significant [57]. Further, several studies have examined associations between current ENDS use and CC quit attempts [56, 58, 59], and findings have been mixed. Specifically, although data from a clinical trial of Nicotine Replacement Therapy (NRT) for smoking cessation during pregnancy revealed that using ENDS may be positively associated with an increased number of CC quit attempts [58], other studies did not observe this relationship [56, 59]. A prospective CC cessation trial among pregnant persons in the US (n=428 pregnant) found that although the top reason cited for ENDS use was to help quit smoking CC, the odds of quitting CC were non-significantly lower among ENDS use vs. non-ENDS use groups (OR= 0.70 (0.30, 1.64)) and ENDS use did not reduce the number of CCs smoked per day [57]. However, it must be noted that ENDS use was not randomly assigned and only 36 (8.4%) participants reported baseline ENDS use [57]; plus this study relied on self-reported smoking status, which is sensitive to social desirability bias [60].

There is some evidence that pregnancy status may facilitate a switch from dual use to ENDS only use (i.e., quitting CC smoking but maintaining ENDS use [44]). However, this transitional pattern of ENDS use appears to be limited to a small portion of pregnant persons. An examination of the 2016–2017 PRAMS Arkansan respondents who reported dual use (n=100) found that, although nearly half (44%) of individuals who reported pre-pregnancy dual use reported a decrease in the number of CCs they smoked during pregnancy, very few (5%) switched to exclusive ENDS use [61]. Similarly, Wang et al. (2020) examined the full PRAMS sample (n=31,973) and found that as little as 6.8% of women who reported dual use in the three-months before pregnancy reported switching to ENDS only during late pregnancy, while a further 48.9% switched to no TP use by late

pregnancy [47]. These findings are consistent with the patterns of ENDS use observed among those who reported dual use prior to pregnancy (i.e., pre-pregnancy dual use) and who participated in Waves 1–3 of the PATH study (n=3,767). Specifically, Kurti and colleagues (2020) noted that 4.1% of respondents who reported pre-pregnancy dual use (and 1.2% of CC only use) transitioned to exclusive ENDS use during pregnancy [44]. Further, pre-pregnancy dual use was associated with decreased odds of complete TP cessation during pregnancy. Finally, a cross-sectional analysis of pregnant persons in Wave 1 of PATH revealed that 2.3% of individuals who formerly smoked CC switched to using ENDS [49].

Some pregnant persons report switching from using only CC to dual use during pregnancy [47]. However, the 2016 PRAMS data indicate that this transitional pattern may be similarly limited to a modest subsample of pregnant persons who use TPs. Specifically, Wang et al. (2020) [47] observed that only 1% of individuals who reported CC only pre-pregnancy switched to dual use, while nearly half (44%) continued to exclusively smoke CCs. Despite the limited number of pregnant persons who report switching from exclusive CC smoking to dual use, there is some evidence that this transition may reduce the heaviness of CC smoking in some [61]. For instance, an analysis of the Phase 8 (2016–2017) Arkansas PRAMS data revealed that a majority (85%) of those who report previous CC only use at pre-pregnancy and initiated ENDS use during pregnancy (i.e., switched to dual use) reported a decrease in the number of CCs they smoked; however, none completely stopped smoking CCs by late pregnancy (Cardenas et al., 2020). In contrast, a cross-sectional study of pregnant persons who report current TP use found that, although there was no significant difference in average CC/day among CC only versus dual use groups, the dual use group were more likely to smoke a pack/day or more (11% versus 5%) and had higher dependence scores than the CC only group [56].

Although many of the reviewed studies that characterize ENDS use during pregnancy do not include fine-grained detail on ENDS use, a handful of studies do address the frequency and/or heaviness of use [49, 53, 56, 58, 59, 62–65]. Two survey studies of pregnant persons found that less than 1% of overall participants in each sample (including those who use ENDS and those who do not use ENDS) reported using ENDS daily [53, 59]. Moreover, analyses of PATH data found that among pregnant persons who currently use ENDS, the average number of days of ENDS use in the past 30 days was 13.1 [49]. Notably, evidence indicates that the frequency of ENDS use differs widely. A cross-sectional survey of pregnant individuals who use TP found while a majority of dual use was evenly divided between using ENDS less than 10 days/month (29%) or 10–15 days/month (29%), a large proportion (41%) reported daily ENDS use during pregnancy [56]; similar to other PRAMS analyses [62, 63]. First, a 2015–2016 PRAMS dataset found that 43% of pregnant persons who use ENDS reported using ENDS less than once a week and 30.5% reported more than once/day use during the last three months of pregnancy [62]. Additionally, a more recent analysis of PRAMS found that among those who report only ENDS use, about half used ENDS frequently and the other half only used ENDS occasionally during late pregnancy. Further, a diverse pattern of use emerged with dual use [63]: some smoked CCs heavily (with occasional (36%) or frequent (15.2%) ENDS use, others smoked CCs lightly with occasional (29.3%) or frequent (19.4%) ENDS use. Finally, an online survey of pregnant persons found no differences in the frequency of ENDS use between ENDS-only and dual

use [64]. Overall, these findings confirm that those who use ENDS during pregnancy are not a homogenous group in terms of the frequency or heaviness of ENDS use.

To date, few studies have examined what types of ENDS product characteristics (e.g., nicotine, flavor, device characteristics) are used during pregnancy or how those product characteristics may impact ENDS use during pregnancy [50, 55, 56, 66]. The vast array of available ENDS flavors appears to be a strong motivator for pregnant persons to use ENDS [50, 55, 56, 66]. Analysis of the Texas and Oklahoma PRAMS found that while nearly a quarter (24.5%) of those who used ENDS endorsed using the products due to the availability of flavors in the >3 months before pregnancy; this proportion nearly doubled (42.3%) for the same reason around the time of pregnancy [50]. Similarly, two cross-sectional surveys found that a significant portion of current ENDS users reported using ENDS during pregnancy because they enjoyed the flavor [56], and felt that ENDS tasted better than traditional CC [59]. Additionally, results from a CC smoking cessation trial of pregnant individuals found that approximately 36% of participants endorsed using ENDS because they “taste good and do not smell” [57]. Finally, findings from a small (n=12) focus group of pregnant or “recently postpartum” women observed that participants frequently highlighted the variety of available ENDS flavors [55]. Pregnant persons who reported dual use, reported using fruit (64%), mint/menthol (35%), and candy (27%) flavored ENDS [56]. The majority (69%) of those who use ENDS reported using fruit-flavored ENDS during the perinatal period, with sweet-flavored ENDS being the most preferred flavor category [66]. Amongst pregnant persons, perceptions of ENDS-related health risks do not appear to differ by flavor [66]. Few studies have explored the nicotine level of ENDS used during pregnancy [50, 56]. This is concerning, given that data from PRAMS reveal that a large portion of respondents (41.4%) report using ENDS around the time of pregnancy due to the ability to obtain products without nicotine [50]. Despite the intention to use products with no nicotine, McCubbin and colleagues (2020) found that 8.2% of pregnant persons who use ENDS reported using ENDS products that do not contain nicotine, which is equivalent to the rate of use of higher nicotine level ENDS (8.2% used 19–25mg; an additional 4.9% used >25mg nicotine products). However the most common nicotine level used by pregnant persons was in the lower range (54% used 1–6 mg)[56]. Lastly, there is a significant absence of data examining ENDS device characteristics among pregnant persons. One small study which asked respondents about which ENDS devices were used during pregnancy, 50% (n=7) reported using devices with prefilled cartridges, but only 36% (n=5) could recall the brand they used (4 Blu, 1 Greensmoke) [58]. Overall, there are a dearth of data on ENDS product characteristics used during pregnancy.

Taken together, these data suggest that while a substantial proportion of individuals stop all TP use during pregnancy, like with CC smoking, not all individuals who use ENDS are able to abstain from use during pregnancy. A notable subset of individuals do not transition, and rather continue using whatever TP products they used prior to pregnancy. A minority of pregnant persons use ENDS and even fewer transition from dual or CC use at pre-pregnancy to ENDS-only use within pregnancy. There are very little data on the ENDS product characteristics used during pregnancy, and even less information on how product characteristics may relate to maintenance, or transitions in ENDS use.

3. CONCLUSIONS

3.1 Overview and Discussion of Key Findings on ENDS Use and Transitions in ENDS Use

Most pregnant persons do not use any TP during pregnancy, and many who use TP at the start of pregnancy successfully quit all TP during pregnancy; however, a substantial portion continue using TPs. A minority of pregnant persons use ENDS; yet the rates of CC use are higher amongst those who use ENDS. Despite several surveys finding that CC cessation is a motivator for using ENDS during pregnancy, most pregnant people do not transition away from dual or CC use to ENDS only use. There are some indications that dual use may increase, rather than decrease, exposure.

Accurate identification of the prevalence rates of ENDS only or dual use in pregnancy are of high value to the field. Unfortunately, there remains a dearth of more fine-grained information regarding ENDS use. Given the breadth and continuously emerging landscape of products, it is a challenge to measure patterns of ENDS use and characteristics of ENDS products used. Although standardized measures of ENDS frequency/heaviness of use and dependence have been proposed (e.g., [67, 68]) (e.g., equivalent to cigarettes per day, time to first morning cigarette for CC), many of the large survey studies reviewed herein did not include such measures. Part of the challenge to developing standardized measures that meaningfully capture exposure is the sheer range of ENDS products – including devices, nicotine levels in e-liquids, and flavors- which impact the nicotine and toxicants delivered by a given product [7]. Another challenge is the variability in ways individuals use their products: while most of those who smoke CC are able to quantify their smoking via the number of full or partial cigarettes, ENDS use may occur more slowly throughout the day or in short bouts, complicating the reportability of the quantity of product use. As such, the quality and precision of the data on ENDS use are continuing to improve but lag behind the information available on CC smoking.

Findings from several studies indicate that a substantial proportion of pregnant people who use TPs may perceive ENDS as a safer alternative to CC [28, 51, 64, 69], with an estimated 64% of pregnant people indicating ENDS as safer than CC [64]. Critically, any ENDS use (ENDS-only or dual use) was a significant predictor (versus no use) of viewing e-cigarettes as safer than cigarettes in general, and also during pregnancy [64]. Overall, the perception of ENDS as a safer alternative to CC smoking may motivate some women to initiate or maintain ENDS-use during pregnancy.

3.2 Implications for Clinical Recommendations and Tobacco Regulatory Science

3.2.1 Clinical Implications—Findings indicated that ENDS use among pregnant persons was heavily linked with CC smoking in several ways: the prevalence of CC smoking was higher amongst those who used ENDS, and ENDS were commonly reported to be used as a means of quitting or cutting down on CC smoking, or to provide a lower-risk TP alternative to CC smoking. The potential risks or harm reduction effects of ENDS in pregnancy were beyond the scope of this review; though we have reviewed them elsewhere [11]. These rationales and motivations for ENDS use are important for clinicians to consider. Pregnant persons reported that they were less frequently asked about ENDS use by their

clinician, than about CC smoking. If clinicians were to ask about this more frequently, that would provide an opening for a discussion about the relative safety (or risk) of ENDS use in pregnancy compared to no TP use or CC smoking, and the relative efficacy of ENDS as a cessation device, relative to FDA-approved smoking cessation methods. Clinicians may be hesitant to discuss these topics as the literature is still limited and clear guidelines are lacking. However, keeping pregnant persons informed of the state of the evidence could improve their decision-making surrounding ENDS use in pregnancy. This discussion could provide an opportunity for a clinician to recommend evidence-based methods like a quit line or counseling.

3.2.2 Tobacco Regulatory Implications—Tobacco regulation has the potential to make major impacts on the TP landscape, including the ENDS marketplace. The US Congress passed the 'Tobacco Control Act' in 2009 (Family Smoking Prevention and Tobacco Control Act §§ 901–910, Pub. L. No.111–31, 123 Stat. 1776 (June 22, 2009)) [70], which gave the US Food and Drug Administration (FDA) the ability to regulate TPs. In 2016 this authority was deemed to also apply to ENDS products ([Pub. L. No., 81 FR 28973 (August 8, 2016)). Taken together, the timing of this ongoing emergence of a new class of popular TPs (i.e., ENDS) and the ability for the FDA to make evidence-based regulatory decisions about these products provides a historical opportunity to shape public health.

Understanding how and why ENDS products are used during pregnancy could inform regulatory decision-making. For example, a commonly reported reasons for using ENDS was that they perceived as being less harmful than CC smoking during pregnancy. Public education campaigns and warning labels on the products could impact these perceptions and, by extension, change behavior. Another commonly reported reason was that they were used as a means of cutting down or quitting CC smoking. Tobacco regulators could ensure that ENDS companies are not advertising their products as a cessation tool or a harm reduction aid unless they have an evidence base to support these claims. One challenge for regulators is the dearth of information on the specific types of ENDS products used during pregnancy. While this problem largely arises due to the design of the studies and type of information that is collected, another contribution to this problem is the lack of knowledge amongst the people using ENDS, where they may be unable to reliably report details including the type of devices and level of nicotine they have used. Clearer, more standardized labeling of the products could be required and could improve consumer knowledge- which would make it easier for surveys to collect detailed information. If the FDA were to maintain publicly available and easily searchable databases of approved ENDS products and their product characteristics, researchers could use this resource to inform their study designs and survey questions.

3.3 Next Steps and Future Directions

It would be valuable for future studies to collect more refined information on ENDS use behavior in terms of frequency/heaviness of ENDS use, and ENDS product characteristics (e.g., flavors, nicotine levels, and devices) used during pregnancy. Relatedly, there is a need to continue conducting research, with comprehensive assessments, as new ENDS products emerge.

In addition to focusing on CC smoking cessation endpoints, clinical trials and other longitudinal studies assessing TP cessation attempts during pregnancy should collect and report detailed information on ENDS use, transitions in ENDS use (e.g., initiation or cessation of ENDS during pregnancy), if ENDS was used as a means for cutting down or quitting CC smoking and if they were perceived as being helpful in achieving those goals.

Given the potential public health impact to pregnant persons and their baby, it is of high importance that the field continues to collect timely and detailed information on ENDS use during pregnancy. This information can inform public knowledge, clinical guidelines, and tobacco regulatory decision-making.

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TABLE 1.

ENDS USE & TRANSITIONS IN ENDS USE DURING PREGNANCY

Citation, Dataset, and Sample	Pregnancy Groups and/or Timepoints	ENDS and other TP Use Groups and/or Timepoints	Summary of Findings Relevant to ENDS and/or Pregnancy: prevalence reported as %; odds ratios (OR) or adjusted OR (aOR) or relative risk (RR) always followed by [95% Confidence Intervals (CI)]
SECTION A. TRANSITIONS IN ENDS USE ACROSS PREGNANCY			
Cardenas et al 2020 [61] Dataset: PRAMS; Phase 8 of the Arkansas PRAMS (2016–2017) Sample: Arkansan women who had a live singleton birth during the Phase 8 cycle time frame and had complete information on TP use and SGA (N=1,594) Location: United States (Arkansas)	Examined use/change in use for tobacco products during: **1** Pre-pregnancy: 3mo before pregnancy **2** Late pregnancy: Last 3mo of pregnancy	TP Use Groups based on Pre-pregnancy and/or Late pregnancy timepoints: **1** CC Only (n=372): **2** ENDS Only (n=18) **3** Dual Uses (n=100) **4** Other TP Only (n=42): other=hookah, tobacco chew, snuff, snus, dip, cigars, cigarillos, or little filtered cigars **5** No TP Use (n=1,062) Considered to be ENDS user if reported ENDS use “one day a week or less” or “more than once a day”.	Among Those With Dual Use At Pre and/or Late Pregnancy: **1** 13% did not use ENDS at pre-pregnancy **2** 54% stopped using ENDS at pre-pregnancy or late pregnancy. Among Those With Dual Use at Pre-pregnancy: **1** 44.8% reduced the number of CCs they smoked; **2** 5% stopped smoking CCS (but continued using ENDS); **3** 24.1% stopped all TP use. Among subjects who started using ENDS during pregnancy: 85.4% decreased the number of CCs they smoked; but none completely stopped CC smoking by late pregnancy. No participants switched from CC only at pre-pregnancy to ENDS only use at late pregnancy.
Chiang et al 2019 [57] Dataset: Quit4baby Trial, within individuals enrolled in Text4baby text service (2015–2016) Sample: Pregnant women; age 14 or older; smoked at least 1 puff of a cigarette in the 2-weeks prior to enrollment, completed a follow-up and were still pregnant at follow-up (N=428); enrolled in text service for pregnant women “Text4Baby”. Location: United States (national sample)	All participants were currently pregnant at the time of enrollment. Sample limited to women who completed a 1-month follow up assessment, and were still currently pregnant at follow-up.	Primary focus of the trial was to measure CC cessation in those randomized to continue Text4baby standard text messages vs. a Text4baby plus Quit4baby text message system. Separate prior paper reporting on main RCT results reported limited efficacy of the intervention for CC smoking (Abroms et al. 2017)). Focus of this secondary analysis paper is to consider ENDS use as the main exposure variable of interest. Analyses run with and without Quit4baby treatment group allocation in the model: did not affect ENDS use transitions. ENDS Use transition groups based on reports of any ENDS use in past 7 days, measured at baseline (T1) and at 1-month follow-up assessment (T2). CC quit status at T2 defined as no use in past 7 days at T2 (i.e., 7 day point prevalence abstinence).	Prevalence ENDS Use: 8.4% T1, 7.0% T2. Stopped ENDS: Among those using ENDS at T1, 55.56% did not use ENDS at T2. Started ENDS: Among those not using ENDS at T1, 3.57% at T2. CC Quit Rate per ENDS Trajectory Group: Continued using ENDS: 12.50% (2/16) Stopped using ENDS: 25.0% (5/20) Started using ENDS: 7.14% (1/14). Continued Not Using ENDS: 26.4% (99/375) Top reason cited for ENDS use was to help quit smoking CC. But odds quitting CC were non-significantly lower among ENDS use vs. non-ENDS use groups (OR= 0.70 (0.30, 1.64)).
Kapaya et al 2019 [50] Dataset: PRAMS; Oklahoma and Texas PRAMS datasets (2015) Sample: Population-based (stratified, random) sample of women with a recent live birth (surveyed 2–6 months post-	Retrospective self-report of ENDS use during following time frames: **1** **Before pregnancy**: >3 months before pregnancy	Any ENDS Use during specific time periods: **1** >3 months before pregnancy (n=459; 10.4%) **2** Around the time of pregnancy (n=285; 7.0%)	Among those who used ENDS during last 3 months of pregnancy, 38.4% used ENDS containing nicotine, 35.2% used ENDS that did not contain nicotine, and 26.4% reported not knowing if the ENDS they used contained nicotine. ENDS Use within Past CC vs. No Past CC: Higher rates ENDS in Past CC vs. No Past CC at >3 mo before pregnancy (29.8% vs 6.0%) and around the time of pregnancy (25.1% vs 2.9%). Among Past CC who ever used ENDS, prevalence of Dual

Citation, Dataset, and Sample	Pregnancy Groups and/or Timepoints	ENDS and other TP Use Groups and/or Timepoints	Summary of Findings Relevant to ENDS and/or Pregnancy: prevalence reported as %; odds ratios (OR) or adjusted OR (aOR) or relative risk (RR) always followed by [95% Confidence Intervals (CI)]
delivery); identified by birth certificate records (N=3,277) Location: United States (Oklahoma and Texas)	**2** **Around the time of pregnancy**: any time during the 3 months before pregnancy, the last 3 months of pregnancy, or 2–6 months after delivery	**3** During 3 months before pregnancy (n=223; 5.8%) **4** During last 3 months of pregnancy (n=70; 1.4%) **5** 2–6 months after delivery (n=96; 2.1%) **6** None (n=2,533; 82.6%) Also assessed ENDS use within those who smoked CC within past 2 years (Past CC) vs. those who did not smoke CC within past 2 years (No Past CC).	use was 38.0% at >3mo before pregnancy, 7.7% during last 3 mo pregnancy, 11.8% at 2–6mo after delivery; ENDS only use highest in 2–6 months after delivery (3.8%); no TP use highest during the last 3 months of pregnancy(61.9%). Top reported reasons for ENDS use among women using ENDS >3mo & those who used ENDS around the time of pregnancy: 1) curiosity (78.6%, 54.0%), 2) perception ENDS help with quitting or reducing CC (27.4%, 45.2%); 3) perception ENDS less harmful than CC (24.6%, 45.2%); 4) availability of flavors (24.5%, 42.3%); 5) ability to get ENDS without nicotine (16.9%, 41.4%).
Kim 2020 [45] Dataset: PATH; Waves 1–4 (2013–2017) Sample: Adult women (age 18+) with complete data from any 2 consecutive Waves (T1 and T2); who were pregnant at T2, but NOT pregnant at T1 (N=864) Location: United States (nationally representative sample)	Examined TP use in participants at 2 timepoints during pregnancy (T1 and T2): **1** Pre-Pregnancy: Wave prior to current pregnancy (T1) **2** Pregnancy: Wave of current pregnancy (T2). Data was not time-locked with specific gestational period, but information on gestational trimester was collected.	TP use definition: Ever used (product category) regularly, and currently using it every day or some days. Compared factors differing between those who quit all TP (n=162) vs. persistent ENDS users (n=29) or persistent CC users (n=159) at T2.	Rates of ENDS use decreased from pre-pregnancy (6.1%) to pregnancy (2.8%). ENDS cessation rate (T1 vs. T2) = 76.2% Complete TP abstainers vs. persistent ENDS users did not differ in pregnancy trimester at time of T2 survey [persistent ENDS users 25.9% first, 42.0% second, 32.1% third trimester]. Persistent ENDS users (vs. complete TP quitters): more likely to be White, have non-private or no medical insurance.
Kurti et al 2017 [49] Dataset: PATH Wave 1 (2013–2014) Sample: Women (aged ≥18) who reported being pregnant at the time of survey completion (N=388) Location: United States (nationally representative sample)	Analyses included currently pregnant persons. Survey was not time-locked with specific gestational age. Average gestational age at time of data collection was 21 weeks.	ENDS and CC use classified as Current, Former, or Never Users. Current ENDS use=using some days or every day (either established (EST) or experimental (EXP) use); Former ENDS use= previously using some days or every day (EST or EXP) and no current use; Never use = no lifetime use. CC use categories: same definitions as ENDS but required 100+ CC in lifetime to count as a current or former CC smoker.	Prevalence of Current ENDS use: Among current CC smokers: 28.5%. Among former CC smokers: 2.3%. Among never CC smokers:0% Among Current ENDS users, mean # of days of ENDS use in the past 30 days=13.1. Odds of Current ENDS use significantly higher among current vs former CC smokers (aOR=28.02 (9.95–78.92)); and among those who did vs. did not use illicit drugs in the past year (aOR=3.84 (1.49–9.90).
Kurti et al 2018 [13] Dataset: PATH; Waves 1–2 (2013–2015) Sample: Adult women (18–44) who had complete data for Waves 1–2 and were NOT pregnant at Wave 1 (N=7,814) Location: United States (nationally representative sample)	Pregnancy groups defined by self-reported 'currently pregnant' (y/n) at T2 (*none* pregnant at T1): **1** Pregnant (n=332) **2** Not Pregnant (n=7,482)	Tobacco product use: Current established (EST) or experimental (EXP) use of CCs, ENDS, hookah, and any cigar (traditional cigars, filtered cigars, and cigarillos). T1 ENDS Use Pregnant: 5.2% (2.8% EST, 2.4% EXP) Not Pregnant: 6.2% (2.7% EST, 3.5% EXP) No information on ENDS characteristics. Definition of Quit tobacco product at T2: Current user at T1, former user of same product category at T2.	Quit Rates for ENDS at T2: Pregnant: 81.3% (71.2% of EST, 100.0% of EXP). Not Pregnant: 45.0% (32.8% of EST, 55.1% of EXP). Pregnancy was the strongest predictor of quitting ENDS (aOR=20.99(2.6, 170.3)). Results suggest this relationship may vary by ENDS use status (EST vs. EXP). Absence of pregnant EXP users at T2 (n=0) prevented the authors from calculating ORs.

Citation, Dataset, and Sample	Pregnancy Groups and/or Timepoints	ENDS and other TP Use Groups and/or Timepoints	Summary of Findings Relevant to ENDS and/or Pregnancy: prevalence reported as %; odds ratios (OR) or adjusted OR (aOR) or relative risk (RR) always followed by [95% Confidence Intervals (CI)]
	Average gestational age of the sample at T2 was 20.7 weeks.		
Kurti et al 2020 [44] Dataset: Population Assessment of Tobacco and Health (PATH); Waves 1–3 (2013–2016) Sample: Adult women (18–49) who completed 2 consecutive waves of data (T1, T2); were not pregnant at T1; and used combustible TP at T1 (N=3,767) Location: United States (nationally representative sample)	Pregnancy groups defined by self-reported 'currently pregnant' (y/n) at T2 (*none* were pregnant at T1): **1** Pregnant (n=197; 4.5%) **2** Not Pregnant (n=3,570; 95.5%) Pregnant at T2 was considered as predictor variable in analysis of tobacco transitions. Average gestational age of the pregnant sample at T2 was 21.7 weeks.	TP Use Transition Groups, Defined by T2 (*all* had Combustible TP Use at T1, none were pregnant at T1): **1** T1 Combustible TP (cTP) Use → T2 cTP Use ("Harm Maintaining"*). Continued use of cTP (CC, hookah, pipes, cigars); with or without ENDS. n=3,156; 2.8% pregnant at T2) **2** T1 cTP Use→ T2 ENDS Only ("Harm-Reducing"*) n=87; 1.2% of whom were pregnant at T2) **3** T1 cTP Use→ T2 No TP Use ("Harm-Eliminating"*) n=524; 14.5% of whom were pregnant at T2) *Harm labels from TP Use groups assigned in paper based on presumed risk; no adverse health outcomes measured in these groups. ENDS use at T1 considered as prediction variable, but not considered in definition of transition groups. ENDS Use defined as using regularly ("current established") or at least some days ("experimental").	ENDS use Prevalence at T1 Overall (total sample) = 22.4% T1 cTP Use → T2 cTP Use = 23.4% T1 cTP Use→ T2 ENDS Only = 37.9% T1 cTP Use→ T2 No TP Use = 14.6% Predictors of TP Use Transition Groups →T2 No Combustible TP Use ("Harm-Eliminating") Pregnancy at T2 increased odds (aOR=5.97 (3.92–9.10)) **ENDS use at T1 decreased odds (aOR=0.56 (0.42–0.76)) → T2 ENDS Only ("Harm-Reducing") Pregnancy at T2: not a significant predictor. **ENDS use at T1 increased odds (aOR=1.92 (1.04–3.55)) **ENDS use at T1 predictor results includes pregnant and non-pregnant women in sample.
Schilling et al 2020 [46] Dataset: STudy on E-cigarettes and Pregnancy (STEP) Sample: Pregnant women, aged 17+, who registered for birth at a clinic (Asklepios Klinik Barmbek) between April 4th, 2018, and January 11th, 2019, provided informed consent and complete CC & ENDS data (N=540) Location: Germany (Hamburg)	All participants completed the survey only once after giving birth; survey included questions about CC or ENDS use during three prior time periods: 1) Pre-Pregnancy: year before pregnancy; 2) Early Pregnancy: First 3mo of pregnancy; 3) Late Pregnancy: Remainder of pregnancy (month 4 to birth)	Before pregnancy: CC only (n=108; 20%), ENDS only (n=7; 1.3%), Dual users (n=35; 6.5%) Early pregnancy: CC only (n=47; 8.7%), ENDS only (n=2; 0.4%), Dual users (n=0) Late pregnancy: CC only (n=15; 2.8%), ENDS only (n=0), Dual users (n=0) Use definition: Any use of CC and/or ENDS during the time period.	Transitions from Pre to Early Pregnancy: 97.1% of Dual Users stopped using ENDS 57.1% of Dual Users stopped smoking CCs 0% of CC smokers switched to ENDS Individuals with low or medium (vs high) education attainment more likely to be dual users.
Stroud et al 2019 [66] Dataset: Data drawn from larger study of smoking during pregnancy and fetal development (study not named) Sample: Adult pregnant women (ages 18–40) no current/prior involvement with	Timeframe captured by the ENDS use surveys covered 3mo pre-conception, through pregnancy, and 1mo post-partum. 4 interview sessions held at 2nd & 3rd trimesters and 1mo post-partum. TP use data collected at each interview. ENDS flavor preference & perception surveys completed at one	Prevalence ENDS use (full sample N=100): Any use in lifetime: 45% Any use in peripartum period: 16% • 3mo before pregnancy: 9% • During pregnancy: 9% • 1 mo post-partum: 3%	Those reporting any *lifetime* use ENDS more likely (than never users) to smoke CC during pregnancy. Among the 16% endorsing any ENDS use in peripartum period: 63% used ENDS more than one-time Flavors: 69% fruit, 19% candy, 19% mind, 13% tobacco, 6% spice, 6% coffee; 25% multiple flavors. Pregnant persons endorsed greater preference and intention to use sweet flavors (fruit, candy) vs. tobacco flavors. -Perceived risk of ENDS use on general, pregnancy, and fetal health was

Citation, Dataset, and Sample	Pregnancy Groups and/or Timepoints	ENDS and other TP Use Groups and/or Timepoints	Summary of Findings Relevant to ENDS and/or Pregnancy: prevalence reported as %; odds ratios (OR) or adjusted OR (aOR) or relative risk (RR) always followed by [95% Confidence Intervals (CI)]
child protective services, and no history of serious gestational medical conditions; recruited from obstetric clinics, health centers and the surrounding community. (N=100; 50% reported CC smoking at least once during pregnancy (oversampled for CC smoking during pregnancy)) Location: United States (Southern New England)	interview session in 3rd trimester. Gestational age at enrollment: mean= 21 weeks (SD=1). Interview sessions took place at 21±1, 27±1, and 33±1 weeks gestation and at 31±1 days postpartum.		high (but lower than perceived risk from CC smoking), and did not significantly differ by flavor.
Wang et al 2020 [47] Dataset: PRAMS; 2016 Sample: Adult women who gave birth to singletons and provided complete information on CC and ENDS use (N=31,973) Location: United States (nationally representative sample)	Examined nicotine exposure in at 2 timepoints during pregnancy: **1** Pre-pregnancy: 3mo before pregnancy Late-pregnancy: last 3mo of pregnancy	Pre-pregnancy TP Use (N=31,793): **1** ENDS only (n=267; 1%) **2** CC only (n=5,029; 14%) **3** Dual users (n=976; 3%) **4** No TP (n=25,521; 82%) Late-pregnancy TP Use (N=31,793): **1** ENDS only (n=126; 0.4%) **2** CC only (n=2,632; 7%) **3** Dual users (n=265; 0.6%) **4** No TP (n=28,770; 92%)	Transition Groups: Pre → Late Pregnancy: *Pre-pregnancy No TP (n=25,521)* No TP → No TP use (n=25,501; 99.9%) No TP → CC only (n=17; 0.1%) No TP → ENDS only (n=3; 0%) No TP → Dual (n=0; 0%) *Pre-pregnancy ENDS only (n=267)* ENDS only → No TP (n=215; 81.7%) ENDS only → CC only (n=3; 0.7%) ENDS only → ENDS only (n=49; 17.6%) ENDS only → Dual (n=0; 0%) *Pre-pregnancy CC only (n=5,029)* CC only → No TP (n=2,622; 55.1%) CC only → CC only (n=2,342; 43.6%) CC only → ENDS only (n=18; 0.3%) CC only → Dual (n=47; 1.0%) *Pre-pregnancy Dual Users (n=976)* Dual → No TP (n=432; 48.9%) Dual → CC only (n=270; 25.9%) Dual → ENDS only (n=56; 6.8%) Dual → Dual (n=218; 18.4%) Characteristics of Transition Groups: *CC only → ENDS only or Dual (vs. CC only → No TP use):* younger, less educated, non-Hispanic white, unmarried *CC only → ENDS only or Dual (vs. CC only → CC only):* younger, less educated, unmarried *Dual → No TP use (vs. Dual → Dual):* more educated, nulliparous, received adequate prenatal care Dual → ENDS only (vs. Dual → Dual or CC only): received adequate prenatal care
SECTION B. DESCRIPTION OF ENDS USE			
Ashford et al 2016 [51] Dataset: Cross-sectional dataset recruited from clinics in Kentucky. Sample: Adult women (18–45) who currently use TP	Categorized sample by pregnancy status: **1** Pregnant (n=101) **2** Non-pregnant (n=99)	Categorized participants by ENDS use status: **1** Current ENDS Use (n=49; 25%) **2** Former ENDS Use (n=77; 40%)	88% of current ENDS use group also reported current CC use; 46.9% of current ENDS use group were currently pregnant. Pregnant (vs. non-pregnant) persons 51% less likely to be more frequent ENDS users (p=0.03). Most common reasons for ENDS use: 1) To help quit CC smoking, 2) ENDS are cheaper than CC, 3) Can use ENDS

Citation, Dataset, and Sample	Pregnancy Groups and/or Timepoints	ENDS and other TP Use Groups and/or Timepoints	Summary of Findings Relevant to ENDS and/or Pregnancy: prevalence reported as %; odds ratios (OR) or adjusted OR (aOR) or relative risk (RR) always followed by [95% Confidence Intervals (CI)]
or used TP within the past 12 months; English-speaking; pregnant (recruited from prenatal clinic) or non-pregnant (recruited from women's clinic) (N=194) Location: United States (Kentucky)	No restrictions on timing within pregnancy or information on gestational age.	**3** Never ENDS Use (n=68; 35%) To be eligible for study, participants needed to have used some form of TP within past 12 months. Questions on reasons for using ENDS only given to those who ever used ENDS. Perceived risk ENDS questions asked of full sample.	where CC are prohibited, 4) ENDS are less harmful than CC. Perception of ENDS as 'serious' (10.9%), 'moderate' (30.6%); 'minor' (38.3%); 'no' (20.2%) health risk. In multivariate model, not-pregnant, younger age, White/Non-Hispanic race/ethnicity were associated with ENDS use; education, CC use status and perceived harm were not significantly related to ENDS use in the model.
Bhandari et al 2018 [28] Dataset: Cross-sectional survey (2015) Sample: Adult (>18 years old) pregnant women recruited from a women's clinic; excluded women who had not heard of ENDS from the analysis (N=18) or incomplete data. (N=409, final analyses N=382) Location: United States (Arkansas)	All subjects were pregnant or post-partum at the time of survey completion: third trimester (55%); second trimester (26.3%); first trimester (11.0%); postpartum (7.2%). ENDS use status groups did not differ in average gestational age (i.e., trimester).	Participants were categorized into groups based on ENDS use status, then separately categorized based on ENDS and/or CC use status: ENDS use status during pregnancy: **1** Current ENDS Use (n=44; 11.9%) **2** Former ENDS Use (n=71; 19.1%) **3** Never ENDS Use (n=256; 69.0%) ENDS and/or CC use status during pregnancy: **1** ENDS and/or CC Use (n=230; 62.7%) **2** Neither ENDS nor CC (n=137; 37.3%)	Group Differences in ENDS Perceptions *Beneficial in quitting smoking:* Current ENDS Use > Never ENDS *Perceived risk of ENDS*: Never ENDS > Current ENDS Use Never ENDS > Former ENDS Use 71% of current ENDS use group endorsed ever using ENDS to try to quit smoking CC. 74.6% of sample had adequate (i.e., score of ≥4) knowledge related to the facts and safety of ENDS, and this did not differ across ENDS use status. Fewer participants reported being asked by their healthcare provider about their use of ENDS than their use of CC during pregnancy. This pattern was true regardless of ENDS and/or CC status of the participant.
Dobbs et al 2020 [69] Dataset: Online survey; May-Dec 2017 Sample: Convenience sample of gestational women (currently pregnant, had been pregnant in past or planned to be pregnant in future); Ages 18–45; Recruited through social media (e.g., Facebook, Reddit). (N=218) Location: United States	Participants were categorized based on pregnancy status: **1** Currently Pregnant (n=51) **2** Previously (but not currently) Pregnant (n=103) **3** Future Pregnant (n=64): Women who had never been pregnant, but planned to be pregnant in the future No restrictions on timing within pregnancy or timeframe of plan for future pregnancy.	Ever use of CCs and ENDS: any self-reported use in a subject's lifetime (y/n). Current use of CCs and ENDS: smoking or vaping "every day or some days" (y/n).	37.7% of participants had ever tried ENDS; 19% of the Ever ENDS use group had used ENDS in the past 30 days. Prevalence reporting Current ENDS Use significantly higher in the group who planned to be pregnant in the future (17.2%) compared to currently pregnant (5.9%), pregnant in the past (4.9%) groups. Prevalence of lifetime ENDS use did not significantly differ by pregnancy status. The full sample perceived risk of ENDS lower than risk of CC during pregnancy for a broad range of postnatal health outcomes. Ratings of perceived risk of ENDS or CC use during pregnancy were higher among the planned to be pregnant vs. currently pregnant group. Reported healthcare providers less likely to ask about use or talk about risks (general or during pregnancy) of ENDS than to ask/talk about CC use and risks.
Fallin et al 2016 [55] Dataset: Focus group interviews Sample: Pregnant or recently postpartum women who reported using CCs and/or	Currently pregnant (n=8) Recently Postpartum (n=4)	Sample included persons who smoked CCs and/or used ENDS in the 3 months prior to pregnancy or during pregnancy.	4 focus group themes emerged: **1** Attraction to ENDS as a harm reduction strategy (i.e., for smoking cessation and/or CC replacement)

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ENDS in the 3 months before their pregnancy or during their pregnancy (N=12). Location: United States (Kentucky)			**2** Uncertainty regarding the health effects of ENDS **3** Ambivalence regarding novel product characteristics of ENDS **4** Behaviors reflected dual use and often complete relapse to CCs
Hawkins et al 2020 [62] Dataset: PRAMS restricted to state with ≥60% response rate. (2015–2016) Sample: Women who gave birth to singletons; with complete information relevant to analysis (N=33, 964) Location: United States (29 states and New York City)	All women in the sample were pregnant at the time of survey completion. Data on ENDS use and CC smoking relates to use during the last 3 months of pregnancy.	Categorized into (Non-Exclusive) Categories Based on Use in Last 3 Mo Pregnancy: Any ENDS Use (n=408; 1.2%) ENDS Only Use (n=170; 0.5%) Any CC Use (n=2,615; 7.7%) CC Only Use (n=2,378; 7.0%) Dual Use (n=272; 0.8%)	Among ENDS use group: 43.2% used ENDS ≤1 day/week 10.4% used ENDS 2–6 days/week 16.0% used ENDS once/day, 30.5% used ENDS more than once/day ENDS use group more likely to be White or Other/Mixed Race/Ethnicity, have less years of education, and use CCs during pregnancy. 9.7% of those who smoke CCs and 0.5% of those who do not smoke CCs used ENDS prenatally.
Liu et al 2019 [52] Dataset: National Health Interview Survey (NHIS); 2014–2017 Sample: Pregnant and non-pregnant adult women of reproductive age (18–44) enrolled in the NHIS (N=27,920) Location: United States (nationally representative sample)	Currently pregnant (n=1,071) Non-pregnant (n=26,849) No restrictions on timing within pregnancy or information on gestational age.	Ever use of CCs and ENDS: any self-reported use in a subject's lifetime (y/n). Current use of CCs and ENDS: smoking or vaping "every day or some days" (y/n).	Overall ENDS use: Prevalence of current ENDS use did not significantly differ between pregnant (3.6%) and non-pregnant women (3.3%). ENDS use by CC smoking status: *Among pregnant persons*: Prevalence of current ENDS use was higher among those who currently (38.9%) vs. formerly (1.3%) and never (0.3%) smoked CCs. *Among non-pregnant women*: Prevalence of current ENDS use was higher among those who currently (13.5%) vs. formerly (8.8%) and never (0.7%) smoked CCs.
Mark et al 2015 [59] Dataset: Cross-sectional survey; June-July 2014 Sample: All English-speaking women presenting to a university-based outpatient clinic for prenatal care June 2014-July 2014 (N=326 approached for inclusion; N=316 completed the survey) Location: United States (Maryland)	All participants were pregnant at the time of survey completion. No restrictions on timing in pregnancy. Average gestational age at survey completion was 28 weeks.	Participants were categorized into 2 groups based on 'ever use' of ENDS: **1** ENDS Ever Use (n=42; 13%): any prior or current (past 30 day) use of ENDS **2** ENDS Never Use (n=274; 87%) Also asked about other TP use: current CC smoker defined as any CC smoking in past 30 days. Asked to complete full survey on ENDS perceptions and motivations of use, even if in the Never ENDS Use group.	0.6% (n=2) of ENDS Ever Users reported current daily ENDS daily. ENDS Ever (vs. Never ENDS) Use Groups: • More likely to be a current CC smoker (43% vs. 14%) • More likely to have tried pharmacological agent to quit CC, rated seriousness about quitting CC higher, but did not differ in likelihood or number of prior CC quit attempts • More likely to believe ENDS less harmful to self and baby, and cheaper, than CC • Groups did not differ in knowledge of harm of CC use during pregnancy • Slightly older, more likely to be White Among Ever Use Group, perceived benefits of ENDS: Not as bad for my health (74%), may help quit smoking (73%), make

Citation, Dataset, and Sample	Pregnancy Groups and/or Timepoints	ENDS and other TP Use Groups and/or Timepoints	Summary of Findings Relevant to ENDS and/or Pregnancy: prevalence reported as %; odds ratios (OR) or adjusted OR (aOR) or relative risk (RR) always followed by [95% Confidence Intervals (CI)]
			easier to cut down on number CC (72%), use in places CC banned (55%), taste better (54%)
McCubbin et al 2020 [56] Dataset: Cross-sectional data from a larger multi-center study of pregnant women (2016–2019) Sample: Adult pregnant women (ages 18–44) in their first or second trimester, had used ENDS and/or CC in past 30 days, receiving prenatal care in one of three obstetric clinics in central Kentucky. (N=188; final analyses N=176) Location: United States (Kentucky)	All persons in the sample were currently pregnant and in either their first or second trimester.	Subjects were categorized based on any past 30-day use of CC and/or ENDS : **1** CC Only (n=110) **2** Dual Use (n=66) ENDS Only use group was excluded from analyses and descriptions of ENDS use patterns due to insufficient sample size (n=12) Dual Use (vs. CC only) Groups: Less likely smoke CC daily (70% vs 90%) Higher CC dependency (PSCDI) (11.8 vs 10.6) No significant difference in average CC/day or baseline demographics	Among Dual Users (n=66)during pregnancy: Daily ENDS use: 41% <10 days/month ENDS use: 29% 10–15 days/month ENDS use: 29% 16–20 days/month ENDS use: 3% # times/day ENDS used: median 8 (interquartile range=3–15) Dual Users (vs. CC-Only) were less likely to perceive ENDS as harmful to general health (45% vs. 63%) and fetal health (41% vs. 60%) and more likely to rated ENDS use during pregnancy as acceptable; however, did not differ in the number of previous quit attempts. Most commonly reported: Reasons for using ENDS were help quit smoking CCs (83%), less expensive (49%), less harmful to self (46%), like taste/ flavors (42%). ENDS flavors used were fruit (64%),mint/menthol (35%), candy or other sweets (27%). Nicotine levels (in mg) of the e-liquid used in most recent ENDS were 1–6mg (54%), 7–12mg (16.4%), 19–25mg (8.2%), >25mg (4.9%). Only 8.2% reported using nicotine-free (0mg) e-liquids.
Obisesan et al 2020 [53] Dataset: Behavioral Risk Factor Surveillance System Survey (BRFSS; 2016–2018) Sample: Adult women (18–49); who were currently pregnant and already enrolled in BRFSS (N=7,434) Location: United States (nationally representative sample)	All subjects were pregnant at the time of survey completion. No restrictions on timing within pregnancy or information on gestational age.	Categorized based on ENDS Use **1** Ever ENDS Use (even once in lifetime)? **a.** Current ENDS Use (n=164; 2.2%) *Daily* (n=45; 0.6%) *Occasional* (n=115; 1.5%); some days **b.** Former ENDS Use (n=1,561; 21%) **2** Never ENDS Use (n=5,709; 76.8%) Additionally, categorized based on CC use: Ever CC smoke >100 CC in lifetime? Current CC Smoke (n=520; 7%) Former CC Smoke (n=1,383; 18.6%) Never CC Smoke (n=5,531; 74.4%)	A majority of Current ENDS use group was young (69.2% <30 years), White (63.3%), single (57.6%), and employed (61.7%). 46.3% of Current ENDS use group also reported Current CC use (i.e., 1.1% of the total study sample were dual users). 30.1% of Current ENDS use group had never smoked CCs. Pregnant Current ENDS use group (vs. never ENDS use group) had a higher prevalence of: Other tobacco use (3.6% vs. 0.5%) Marijuana use (46.8% vs. 3.1%) Heavy alcohol use (12.0% vs. 1.3%) Binge-drinking (24.1% vs. 2.6%) Other high-risk behaviors, such as illicit drug use (22.6% vs. 6.0%)
Oncken et al 2017 [58] Dataset: Part of a double-blind, placebo-controlled randomized clinical trial of NRT (nicotine inhaler) plus behavioral counseling	All participants in the sample were pregnant; pregnant persons who were at greater than 26 weeks of gestation were excluded.	All participants reported current CC use. Overall sample was divided into 2 groups based on any lifetime ENDS use: **1** ENDS Ever use (n=55; 53%)	ENDS Use During Pregnancy 14% of participants used ENDS during pregnancy (10% used ENDS in the first trimester). Mean (SD) days of ENDS use =7.5 (10.3) and frequency ENDS use/day= 6.4 (7.5) N (%) who recall ENDS brand used= 5 (36%), used prefilled cartridges=7 (50%), reporting using to quit CC = 8(57%) or

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for smoking cessation in pregnancy; enrollment 2012–2016. Sample: Pregnant women <26 wks gestation, who smoked ≥ 5 CCs a day, and were unable to quit CC smoking; primarily recruited from two hospitals in Hartford CT and Springfield MA, plus private practice; who received the ENDS use questionnaires (N=103). Location: United States (Connecticut and Massachusetts)		**2** ENDS Never use (n=48; 47%)	reduce CC use = 5 (36%). Persons who used ENDS during pregnancy more likely to have a history of substance abuse and a greater number of previous smoking quit attempts. Ever (vs. Never) ENDS use groups: **1** Smoked more CC/day prior to pregnancy **2** Had a greater number of previous CC smoking quit attempts **3** Were more likely to be Hispanic or non-Hispanic White 15% of Ever ENDS Use group used ENDS as part of a past CC quit attempt.
Rollins et al 2020 [54] Dataset: Telephone survey (2015–2018) Sample: Pregnant women; Ages 16–45; recruited from an urban, low-income clinic, and flyers at local obstetric offices and community centers (N=1,476; final analysis N=1,365) Location: United States (Rhode Island)	All participants were pregnant at the time of the survey completion. No restrictions on timing within pregnancy. Gestational age at the time of survey completion was mean= 13.7 (SD=9.2) weeks TP use categories based on current use (during pregnancy). TP use questions asked about use at pre-conception (3mo pre-pregnancy) and during pregnancy.	Categorized participants into three groups by current TP use status: **1** ENDS Use (n=54; 4%); included in this group if used ENDS regardless of whether they also used CC or other TP. **2** CC (but No ENDS) Use (n=372; 27%); use CC but not ENDS; not excluded for other TP use **3** No TP or NRT use (n=939; 69%) Participants who did not use ENDS or CC, but who used other TP or NRT were excluded from analysis (n= 111)	74.1% of subjects who used ENDS also smoked CCs (i.e., Dual use), while 25.9% reported only ENDS use. Among persons who smoked CC, those who also used ENDS smoked more CC per day (8.86 CC/day) than those who only used CC (6.18 CC/day). ENDS use vs. CC only group: more likely to be White/ Non-Hispanic (OR=2.48 (1.34–4.60)); have a higher level of education (OR=1.95 (1.02–3.72)) and household income (OR=2.84 (1.49–5.39)); and report depressive symptoms (OR=2.06 (1.00–4.22)). ENDS use vs. No TP/NRT group: more likely to be White/Non-Hispanic (OR=4.25 (4.20–7.89)); report depressive symptoms (OR=4.28 (2.13–8.62)); and have a history of severe mental illness (OR=5.34 (2.3012.40)).
Wagner et al 2017 [64] Dataset: Online survey using Amazon Mechanical Turk (MTurk); July–Aug 2015 Sample: Pregnant women; Ages 18–45; on MTURK (N=445) Location: United States	All participants were currently pregnant at the time of survey completion. No restrictions on gestational age at participation. Gestational age at time of survey completion was mean=17.3 (SD=9.8) weeks in the sample overall. Gestational age significantly differed between the TP use group categories: CC only (21 (10.1)), ENDS only (13.8 (8.4)), Dual (13.8 (8.9)), No TP use (17.6 (9.9)).	Categorized participants into 4 groups based on self-reported ENDS + CC use before and during pregnancy: **1** No TP Use (n=353; 79.3%) **2** CC only (n=25; 5.6%) **3** ENDS only (n=29; 6.5%) **4** Dual use (n=38; 8.84%)	74.6% of ENDS only use group reported having switched to ENDS once learning they were pregnant. ENDS only and Dual use groups were younger than CC only group, but did not differ by race, income, rurality. Frequency of ENDS use during pregnancy did not significantly differ between exclusive ENDS use and dual use groups. 64.27% of all participants viewed ENDS as safer than CC in general, only 35.28% viewed ENDS as safer than CC for pregnant women. ENDS use (ENDS only or Dual) more likely than No TP Use group to report ENDS safer than CC in general and during pregnancy.

Abbreviations and Terms: TOBACCO-RELATED: TP=tobacco product (includes CC and ENDS and other tobacco products); ENDS=Electronic Nicotine Delivery Systems (note: ENDS refers to a category which includes e-cigarettes; although nicotine is in the name, we are using this term generally and products assessed in each study CANNOT be presumed to include nicotine just because they are referred to as ENDS); CC=Combustible cigarette; Dual Use= ENDS and CC use; EST, established user; EXP, experimental user; NRT= nicotine replacement therapy (e.g., nicotine patch or inhaler). STATISTICS: OR= Odds Ratio; aOR= Adjusted Odds Ratio; RR = Risk Ratio; M=mean, SD=Standard Deviation; CI=Confidence Interval. OTHER: BMI=-Body Mass Index; PRAMS= Pregnancy Risk Assessment Monitoring System; W=Wave, T=Timepoint.