
Perceptions and use of electronic cigarettes in pregnancy

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Abstract

Use of electronic cigarettes (e-cigs) is quickly growing in the United States, despite the unknown health implications and unregulated device contents. Although research is emerging around e-cigs in general, there continues to be a lack of scientific evidence regarding the safety and risks of e-cig use on maternal and fetal health, even though adverse health effects of nicotine on maternal and fetal outcomes are documented. This review summarizes existing perceptions of e-cig use in pregnancy, based on the limited number of publications available, and highlights the necessity of conducting additional research in this field of public health. Authors conducted a literature search of scientific peer-reviewed articles published from January 2006 to October 2016, comprising more than a decade of research. Search keywords include ‘tobacco use’, ‘electronic cigarette(s)’ and ‘pregnancy’. Fifty-seven publications were identified, narrowed to fifteen by screening title/abstract for potential relevance, with seven articles chosen for final inclusion. Of these seven studies, most participants not only believed e-cigs pose risks to maternal and child health but also perceived e-cigs as a safer and potentially healthier alternative to traditional cigarettes, and may assist with smoking cessation. Further research is needed to determine health implications and provide clinical guidelines for e-cig use in pregnancy.

Introduction

The United States has had the largest and fastest growing market for electronic cigarettes (e-cigs) [1, 2] since they entered the U.S. market in 2007. From 2009 to 2011, awareness of emerging e-cig products drastically increased from 16% to 58% [3], and ever-use of electronic cigarettes increased from 1.8% (2010) to 13% (2013) [4] in the general population of the United States. More than 300 brands of e-cigs were being manufactured as of 2013, and recent projections estimate e-cigs to become a \$10 billion industry by 2017 [5].

Following this explosive growth, the U.S. Food and Drug Administration extended their authority to regulate cigarettes to all tobacco products, including e-cigs in August 2016 [6]. These new regulations will require the e-cig manufacturers to disclose contents and ingredients. Results of recent studies indicate that the main components of e-cigs are nicotine, propylene glycol and glycerine. Trace amounts of tobacco-specific nitrosamines and diethylene glycol have also been confirmed [7–9]. The health impact of exposure to these components and additional unknown toxins in e-cigs is currently unclear. In addition, e-cigs have potential harm to children. According to Centers for Disease Control and Prevention reports, e-cig exposure calls (ingestion of nicotine liquid, absorption through the skin and inhalation) to poison centers, increased from one in September 2010 to 215 in February 2014 [10].

In the general population, people initiate e-cig use due to perceptions that e-cigs are safer than regular

cigarettes, and the desire to reduce or stop smoking traditional cigarettes [11–13]; however, the belief that e-cigs are harm reduction or novel cessation products has been at the center of recent scientific controversy. While some scientists assert that e-cigs potentially reduce disease burden and mortality, others perceive e-cigs as a product that either encourages nicotine-substance initiation or complicates cessation [14–16].

Despite the controversy, little is known about the impact of e-cig use during pregnancy. Current literature suggests that perceptions of increased safety with e-cig use during pregnancy may promote initiation and increased use during that time [17, 18]. Estimations of tobacco use are reported at 16–19% for women of childbearing age (18–44 years), with approximately 10% of pregnant women reporting conventional tobacco use during the last 3 months of pregnancy [19–21]. With little known among pregnant women and healthcare professionals about the health impact of e-cigs during and after pregnancy, the perception of the products as a potential smoking cessation aid or safer alternative to traditional tobacco cigarettes signifies the topic is an important public health matter.

Women who use nicotine products during pregnancy increase their risk for preterm birth, small for gestational age infant, miscarriage, altered placental attachment and function and impeded fetal lung and brain development [22]. Additionally after birth, these infants are at increased risk for SIDS, altered lung function, lung cancer and behavioral disorders [19, 23, 24]. E-cigs contain varied concentrations of nicotine, which in any form, has the potential to exhibit teratogenic effects on the developing fetus [25].

It is important to understand the perceptions surrounding use of e-cigs in pregnancy despite the unknown risks to maternal and fetal health. The purpose of this systematic review is to summarize published findings from the past 10 years, specific to e-cig perceptions and use in pregnancy, thus highlighting importance of continued research in this area of public health.

Materials and methods

Literature search

Using university-based *InfoKat Discovery* (a tool for searching multiple library resources from one interface), authors compiled literature for this systematic review, with the purpose of summarizing published research about perceptions and use of electronic cigarettes in pregnancy. *InfoKat Discovery* searches database collections including EBSCO, MEDLINE, Academic Search Complete, Web of Science, PubMed, Cochrane Library, PsycINFO, CINAHL and ScienceDirect. The search includes keywords and indexed terms to capture peer-reviewed articles published in English about tobacco use, electronic cigarette(s), and pregnancy from January 2006 to October 2016, representing more than a decade of research on the topic. The search strategy was adjusted to limit results to U.S. studies of e-cigs and pregnancy (Appendix 1).

Forty-eight publications were identified through *InfoKat Discovery*, and nine additional studies were identified through screening references. After removing duplicates, records were screened by title and abstract for relevance. Authors independently reviewed 15 articles in full, and unanimously agreed on inclusion of the 7 final articles, which described perceptions and use of e-cigs in the context of pregnancy. All authors contributed to the literature search, title/abstracts assessments and selection and review of the final articles. Conference and dissertation abstracts were excluded (Fig. 1).

Results

Seven studies, conducted from 2013 to 2016 met inclusion criteria: three cross-sectional studies, three qualitative assessments and one case study. The samples ranged from $N = 1$ to $N = 316$.

Mark, Farquhar, Chisolm, Coleman-Cowger, Terplan [26] conducted a cross-sectional study surveying 316 pregnant women from a prenatal care clinic at the University of Maryland to determine the prevalence of use and evaluate knowledge of e-cigs during pregnancy. Baeza-Loya *et al.* [18]

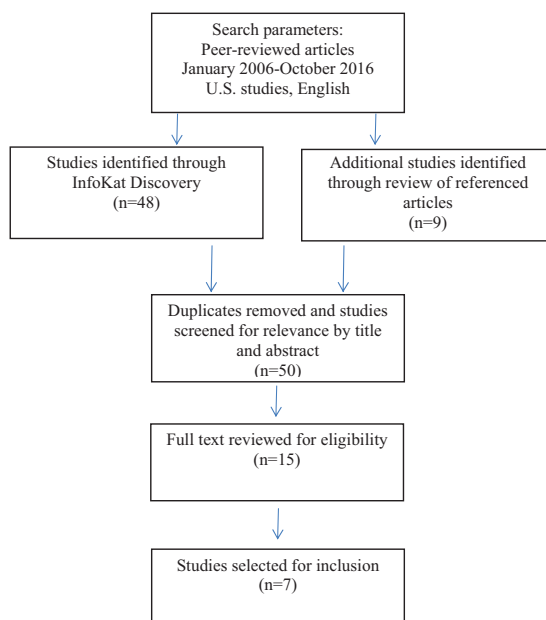


Fig. 1. Flow diagram of identification of studies for inclusion.

conducted a cross-sectional study by administering a modified version of the Global Health Youth Surveys (WHO, <http://www.who.int/tobacco/surveillance/gyts/en/>) to 184 participants (electronically or on paper) with the goal of studying the perceived safety of e-cigs versus tobacco cigarettes. The third cross-sectional study was conducted by Ashford *et al.* [27] and evaluated e-cig use and perceived harm among 194 women of childbearing age (101 of whom were pregnant) in Central and Eastern Kentucky.

Three qualitative assessments met inclusion criteria for this summary. Kahr *et al.* [28] conducted a study using 11 focus groups with 87 total participants in Houston, Texas, to evaluate perceived risks of e-cigs and hookah use in pregnancy. England *et al.* [29] conducted 15 focus groups with a total of 102 women (59 of whom were pregnant) in MT, OK, TN and PA to evaluate use and perceptions of emerging tobacco products among women. The third qualitative descriptive study, conducted by Fallin, Miller, Assef and Ashford [30] in central Kentucky, utilized two focus groups (total of 12

women who were pregnant or in the postpartum period) to evaluate perceptions of e-cigs.

In addition, one final study, a case study, met inclusion criteria for this review. In this case study, one patient, a 22-year-old single white female from the University of Maryland, enrolled in a perinatal substance use treatment program and shared her beliefs about (and experience with) e-cig use in pregnancy [31].

Included articles are summarized in Table I.

Use during pregnancy

Only two reviewed studies evaluated actual use (current or past) of e-cigs in pregnant women [26, 27]. Mark, Farquhar, Chisolm, Coleman-Cowger, Terplan [26] administered a survey to 316 pregnant women from a University of Maryland prenatal clinic. The survey, which aimed to determine the prevalence of use and evaluate knowledge of e-cigs during pregnancy, obtained information from the following three categories: demographic variables, traditional tobacco cigarette knowledge/use and e-cig use and

Table I. Summary of studies examining perceptions and/or beliefs of electronic cigarette use during pregnancy

Authors	n	Type of study	Author's conclusions
Ashford, Wiggins, Butler, Ickes, Rayens, Hahn [27]	194: 101 pregnant women and 99 non-pregnant women 18–45 years old, receiving care from three university-affiliated OB/GYN and Women's Health clinics Lexington, Kentucky	Cross-sectional survey	<ul style="list-style-type: none"> • Most current e-cig users were also current traditional cigarette users (dual users) (88%). • More than two-thirds (69%) of participants believed that e-cigs are a minor or moderate health hazard; 20% did not believe that e-cigs are a health hazard at all. • More than half of both current and former e-cig users decided to use them because they wanted to quit smoking.
Fallin, Miller, Assef, Ashford [30]	12: eight pregnant women and four recently postpartum women Receiving care at a university-affiliated prenatal clinic and reported use of tobacco or electronic cigarettes Two focus groups Lexington, Kentucky	Qualitative assessment, Focus groups	<ul style="list-style-type: none"> • Four overarching themes: <ul style="list-style-type: none"> ◦ E-cigs are attractive as a harm reduction and tobacco cessation strategy. ◦ There is uncertainty about the health effects of e-cigs. ◦ There is ambivalence about the characteristics (flavors, equipment, etc.) of e-cigs. ◦ Use of e-cigs often led to dual use or complete relapse to traditional cigarettes, particularly postpartum.
England, Tong, Koblit, Kish-Doto, Lynch, Southwell [29]	102: 32 pregnant smokers, 27 pregnant quitters and 43 smokers planning a pregnancy 18–40 years old 15 focus groups Billings, Montana Oklahoma City, OK Memphis, TN Philadelphia, PA	Qualitative assessment, Focus groups	<ul style="list-style-type: none"> • Most participants believed that use of any tobacco product is harmful during pregnancy; however some women viewed non-combustible products (particularly ENDS) as less hazardous than smoking traditional cigarettes. • Of the few patients who had used ENDS, they did so with the intention to quit smoking but became dual users instead.
Farquhar, Mark, Terplan, Chisolm [31]	1 Female, age 22 years Caucasian Enrolled in perinatal substance abuse treatment program Baltimore, Maryland	Case Study, Interview	<ul style="list-style-type: none"> • Patient perceives e-cigs as less harmful to both her and her baby than regular cigarettes. • Patient believes e-cigs cause less nicotine to be transferred to baby than traditional cigarettes. • Reasons patient uses e-cigs: <ul style="list-style-type: none"> ◦ Not as bad for health as ◦ Regular cigarettes ◦ E-cigs make it easier to reduce number of cigarettes smoked ◦ E-cigs may help to quit altogether

(Continued)

Table I. *Continued*

Authors	<i>n</i>	Type of study	Author's conclusions
Baeza-Loya, Viswanath, Carter, Molfese, Velasquez, Baldwin, Thompson-Lake, Sharp, Fowler, De La Garza, Salas [18]	184: 68 young adults (age 18–20 years), 55 adults (age 21–30 years) and 61 older adults (age ≥31 years) Males and females Race/ethnicity not provided Texas	Cross-sectional, Survey	<ul style="list-style-type: none"> • Respondents of all ages perceive e-cigs as significantly less harmful than tobacco cigs for pregnant women to use.
Kahr, Padgett, Shope, Griffin, Xie, Gonzalez, Levison, Mastrobattista, Abramovici, Northrup, Stotts, Aagaard, Suter [28]	87 Pregnant women participating in CenteringPregnancy® group prenatal care program. Eleven focus groups at three different prenatal clinics. 26% African American 66% Hispanic 4% Caucasian 4% Other Houston, Texas	Qualitative assessment, Focus Groups	<ul style="list-style-type: none"> • Major themes from focus groups: <ul style="list-style-type: none"> ◦ E-cigs are safer/healthier alternative to traditional cigarettes ◦ E-cigs are not safe in pregnancy for mother or fetus • E-cigs use in pregnancy is not as bad as traditional cigarette use if it is being used as a smoking cessation aid.
Mark, Farquhar, Chisolm, Coleman-Cowger, Terplan [26]	316 Pregnant women receiving care at university-based prenatal clinic Mean age 25.6 82% African American 12% Caucasian 6% Other 3% Hispanic College Park, Maryland	Cross-sectional survey	<ul style="list-style-type: none"> • Most common reasons given for e-cig use by participants who have ever used an e-cig: <ul style="list-style-type: none"> ◦ Perception of less harm than traditional cigarettes to self (7%) ◦ May assist with smoking cessation (73%) ◦ Makes it easier to cut down on number of cigarettes smoked (72%) • Of e-cig ever users, 68% believe e-cigs are less harmful to the baby, and 78% believe they are less harmful to themselves. • Of e-cig never users, only 31% believe e-cigs are less harmful to the baby, and 31% believe they are less harmful to themselves.

motivations for use. The majority (66.1%) of participants affirmed having heard of e-cigs, 13% reported prior or current use of e-cigs, and 0.6% reported current daily e-cig use. When analyzing by age, race, and type of use (ever-users versus never-users), Mark *et al.* [26] found that those who had ever used e-cigs (ever-users) were slightly older and more likely to identify as white when compared to never-users.

Ashford *et al.* [27] administered a survey to 194 current or former female tobacco users (101 whom were pregnant) who were attending an appointment at a University of Kentucky OB/GYN clinic. The purpose of the survey was to evaluate e-cig use and perceived harm. Of the pregnant participants, 23 were current e-cig users and 38 were former e-cig users. In comparing e-cig use between pregnant and non-pregnant participants, the pregnant

participants reported using e-cigs less frequently than the comparison group.

Perceptions

Two common perceptions of e-cig use in pregnancy were identified by this review of literature: (i) e-cigs are a safer and potentially healthier alternative (for mother and baby) compared to traditional cigarettes and (ii) e-cigs may be used as a tool for smoking cessation.

Perception: e-cigs are safer and potentially healthier than traditional cigarettes

Across all seven studies, e-cigs, in general, were perceived by study participants as less harmful than traditional cigarettes. Some differences were noted, however, in the perception of safety for use during the prenatal period. In the survey conducted by Mark *et al.* [26], results indicated that 45% of the pregnant participants believed e-cigs were less harmful than traditional cigarettes to themselves, and 43% believed e-cigs were less harmful to their baby's health. Interestingly, when analysed by e-cig use (ever-use versus never-use), differences emerged. The majority of e-cig ever-users believed that e-cigs were less harmful than traditional cigarettes to themselves and to the baby (78% and 68%, respectively). Conversely, less than half of e-cig never-users reported the belief that e-cigs were less harmful than traditional cigarettes to themselves and to the baby (31% and 31%, respectively). While the majority (61%) of pregnant women surveyed acknowledged e-cigs as addictive, 43% of them reported not knowing that most e-cigs contain nicotine [26].

A qualitative assessment conducted in Houston, Texas, by Kahr *et al.* [28] evaluated perceived risks of e-cigs and hookah use in pregnancy through the use of focus groups in three health clinics in the greater Houston area. Focus group participants were actively enrolled in CenteringPregnancy® (CP) group prenatal care; however, focus groups for the survey were conducted after regularly scheduled CP care appointments. From the interviews, Kahr *et al.* [28] determined that pregnant

participants believed e-cigs, in general, were a safer and healthier alternative to traditional cigarette use. During pregnancy, however, participants did not believe e-cigs were safe; in fact, participants affirmed e-cigs were potentially harmful to the fetus and possibly as bad as traditional cigarettes during pregnancy. Interestingly, a contradicting sub-theme emerged from the focus groups that implied that e-cig use in pregnancy was not as bad as traditional smoking when used as a smoking cessation aid. Although participants exhibited knowledge of how to purchase e-cig devices, they were less knowledgeable about e-cig contents and health implications.

Baeza-Loya *et al.* [18] conducted a cross-sectional study to evaluate the perceived safety of e-cigs versus traditional tobacco cigarettes. Participants who completed the study survey represented both genders, encompassed the age ranges of 'young adult' through 'older adult', and included both smokers and nonsmokers of tobacco and e-cigs. The survey included questions about traditional tobacco cigarettes and e-cigs, specifically asking the participant if he/she thought tobacco cigarettes and e-cigs are harmful for pregnant women to use. While almost 100% of respondents (across all age categories) indicated that traditional tobacco cigarettes were harmful for pregnant women to use, only 50–75% of these participants indicated the perception that e-cigs were harmful for pregnant women to use. These results suggest that although the study participants perceived potential harm in using e-cigs in pregnancy, they still considered e-cigs safer than traditional tobacco cigarettes.

England *et al.* [29] conducted focus groups to evaluate perceptions of emerging tobacco products among pregnant women and women planning for a pregnancy. The focus group discussion guide included topics about tobacco use history as well as familiarity, perceptions and health effects of emerging tobacco products (such as e-cigs, snus, dissolvables) and nicotine replacement therapy (NRT) use during pregnancy and in general. Of the 102 women recruited, 31% were pregnant smokers, 26% were pregnant but classified as [smoking]

quitters, and 42% were smokers planning to become pregnant. Study participants consistently reported that products containing nicotine were harmful during pregnancy, however there was a lack of consistency on which products were viewed as most harmful. While a few women considered NRT or dissolvables to be least harmful during pregnancy, participants most often mentioned ENDS (electronic nicotine delivery systems, or e-cigs [32]) as being least harmful.

Fallin *et al.* [30] analyzed focus group discussions to ascertain the knowledge, attitudes, and perceptions of e-cig use among pregnant ($n = 8$) and postpartum ($n = 4$) women. A guide was developed to assess awareness of e-cig products, use patterns, and risk/benefit health perceptions. Researchers found participants believed e-cigs were less harmful than traditional cigarettes; in fact, one participant described e-cigs as “not as threatening as regular cigarettes” and a “cleaner” option (page 322) [30]. However, participants also revealed a level of uncertainty regarding the health impact of e-cig use, referring to potential side effects and unknown device contents.

Ashford *et al.* [27] conducted a survey of women of childbearing age, including pregnant women, and posed questions to evaluate perceptions of health risks associated with e-cig use. While 69% of the 195 participants viewed e-cigs as a moderate or minor health hazard, 20% viewed the products as posing no health hazard at all. When evaluating reasons participants decided to use e-cigs, ‘less harmful (to others and self)’ was among the top four most frequent reasons cited.

In addition, Farquhar, Mark, Terplan, Chisolm [31] also reported on the common perception that e-cigs are potentially safer than traditional cigarettes. Their case study evaluated a 22-year-old, single white patient enrolled in a perinatal substance use treatment program. The patient described awareness that e-cigs contained nicotine, but reported the belief that e-cig use during pregnancy was less harmful for her and the health of her baby. The patient also communicated her belief that e-cigs caused less nicotine to be transferred to her baby than traditional cigarettes.

Perception: e-cigs are a smoking cessation method

The second common perception about e-cig use in pregnancy is that e-cigs can be used as a smoking cessation method. This perception was noted by participants in six of the reviewed studies (Mark *et al.* [26], Kahr *et al.* [28], Farquhar, Mark, Terplan, Chisolm [31], Ashford *et al.* [27], Fallin, Miller, Assef and Ashford [30] and England *et al.* [29]).

Mark *et al.* [26] reported three quarters of the pregnant respondents viewed e-cigs as a tool for smoking cessation. Interestingly, though there were no differences found between the number of ever-users and never-users who had previously attempted to quit smoking or in the number of prior quit attempts. According to the Ashford *et al.* [27] study, more than 50% of both current and former e-cig ever-users indicated initiating e-cig use as an aid to smoking cessation. In fact, ‘wanted to quit smoking’ was the number one response selected as the reason for deciding to use e-cigs.

Kahr *et al.* [28] reported an overall consensus among pregnant focus group participants that e-cigs may be used as a tool for smoking cessation, and specifically noted this perception among participants who were current smokers. Similarly, Fallin *et al.* [30] determined the appeal of e-cigs as a harm reduction strategy as one of four overarching themes of the focus group discussions, specifically noting participants were drawn to e-cigs as a smoking cessation device. England *et al.* [29] reported similar findings among focus group participants who considered using ENDS to assist them with smoking cessation. Finally, the results of the case study by Farquhar, Mark, Terplan, Chisolm [31] indicated the participant had previously only used e-cigs on two occasions; however, she switched to a rechargeable e-cig device once she learned she was pregnant as a way to help her reduce the number of traditional cigarettes she smoked per day.

Discussion

Our review of the literature indicates that there is a lack of evidence-based research on e-cig use during

pregnancy. Thus, e-cig users, people exposed to e-cig byproducts (such as aerosol), and healthcare providers face uncertainty regarding the potential health implications associated with e-cig use. The most common perceptions for e-cig use during pregnancy, as ascertained from our review of the literature, are as follows: (i) e-cigs are a safer and a potentially healthier alternative (for mother and baby) compared to traditional cigarettes and (ii) e-cigs may be used as a tool for smoking cessation.

Our findings are similar to those of studies on the perceptions of e-cig safety in the general population of the U.S. Several publications have indicated both men and women believe e-cigs are a safer option than traditional tobacco cigarettes overall [33–36]. Choi and Forster [33] assessed the characteristics of awareness, perceptions and use of e-cigs among 2,624 young adults (age 20–28). In their study, 52.8% of participants who indicated awareness of e-cigs believed them to be less harmful than tobacco cigarettes, and 26.3% agreed that e-cigs are less addictive than tobacco cigarettes. Consistent with these findings, Pearson *et al.* [34] reviewed data from two cross-sectional surveys and reported 70.6% of their participants who completed an online survey believed e-cigs were less harmful than traditional cigarettes. In addition, an astounding 84.7% of participants in a large cohort of smokers (Legacy Longitudinal Smoker Cohort) reported the belief that e-cigs are less harmful than traditional cigarettes [34]. A May 2016 publication by Pechacek, Nayak, Gregory, Weaver, Eriksen [35] described a cross sectional survey conducted by researchers at Georgia State University's Tobacco Center of Regulatory Science in 2014, in which 5,717 U.S. adult surveys were included for analysis of reasons people chose e-cigs and perceived acceptance of use of ENDS. Among the 729 respondents (49% female) who self-reported ever-use of ENDS products, switchers (former smoker, recent ENDS user) identified ENDS as 'less harmful to me than regular cigarettes' as a highly important reason for use [35]. Finally, a 2016 systematic literature review by Tomaszewski [36] evaluated nine publications to understand why people chose to use e-cigs. From her review, Tomaszewski summarized that e-cigs

were viewed as less harmful to health than traditional cigarettes among the majority of e-cig users.

In our review of the literature focusing on the perceptions of e-cig use during pregnancy, four of the seven studies concluded that participants believed e-cigs were safer than traditional cigarettes during pregnancy [18, 27, 30, 31]. Participants in the study by England *et al.* [29] identified nicotine-containing products as harmful to use during pregnancy, but most often mentioned ENDS as the least harmful of those products. The study by Kahr *et al.* [28] concluded that e-cigs were safer than traditional cigarettes in general, but not safe during pregnancy unless used as a smoking cessation aid. While Mark *et al.* [26] concluded that the majority of e-cig ever-users considered e-cigs to be less harmful to a pregnant woman or her baby, the majority of never-users disagreed with that perception. The perception of e-cigs as a safer and healthier alternative to traditional cigarettes may be a common theme noted among the general population and in our review of the literature specific to pregnancy, however, there remains a lack of evidence-based research clearly defining the risks of e-cig use on the mother and baby. This uncertainty about potential adverse health implications of e-cig use during pregnancy, therefore, creates a public health concern.

To complicate the general public's uncertainty of the health impacts of e-cig use, healthcare providers are also plagued with a degree of uncertainty due to this lacking and conflicting information about the safety of e-cig use, specifically during pregnancy. In a 2012 survey among members of the American College of Obstetricians and Gynecologists, only 5% of participants (obstetricians and gynecologists) felt informed about the health effects of noncombustible products such as e-cigs [37]. Twenty-nine percent of participating providers believed e-cigs may cause adverse health effects during pregnancy yet still viewed the products as safer than traditional cigarettes. Among respondents, 13.5% believed e-cigs and traditional cigarettes had the same health effects, while almost 14% presumed e-cigs had no adverse health effects [37].

The second common perception identified in our research, that pregnant women may view e-cigs as

an aid to smoking cessation, was a perception also recognized among the general population [33, 35, 36, 38, 39]. When evaluating e-cigs as an aid to smoking cessation, Choi and Forster [33] reported 44.5% of those aware of e-cigs agreed e-cigs can help people quit smoking. Similarly, Tan, Lee, Bigman [39] reported that over 60% of the traditional smokers who used e-cigs believed the devices could help people quit smoking regular cigarettes completely. Additionally, earlier reports evaluating perceptions of e-cig use among non-pregnant participants reported 44.5–77% of people believed e-cigs could be used to help tobacco users quit smoking [14, 33]. Using a Mechanical Turk platform, Bauhoff, Montero and Scharf [38] surveyed 796 adult smokers and non-smokers (48% female respondents) and evaluated their perceptions of e-cigs. In this sample, the top reason current smokers indicated using e-cigs was to help reduce or quit smoking (56%). Similarly, Pechacek *et al.* [35] found 80.9% of the survey group identified as ‘switchers’ (former smoker, recent ENDS user) reported that ENDS helped them quit cigarettes. In addition, in a comprehensive literature review related to perceptions of the health impacts of e-cig use, Tomaszewski [36] also cited smoking cessation as a common reason for initiating e-cig use.

In the context of pregnancy, five of the reviewed studies for this analysis indicated the perception that e-cigs can be used as an effective smoking cessation aid during the prenatal period [26, 27, 29–31]. Mark *et al.* [26] reported that almost three-fourths of their participants believed that e-cigs could assist with smoking cessation. Ashford *et al.* [27] reported more than 50% of surveyed respondents initiated e-cig use for smoking cessation. Fallin, Miller, Assef and Ashford [30], and England *et al.* [29] reported smoking cessation as a theme for e-cig use among their focus group participants. Finally, the participant in the Farquhar, Mark, Terplan, Chisolm [31] case study also indicated that e-cigs made it easier for her to reduce the number of cigarettes smoked and could potentially help her to quit smoking altogether.

Due to the perception of e-cigs as a smoking cessation tool, e-cig users may engage in ‘dual-use’ of traditional cigarettes and e-cigs in pregnancy [18, 27, 29, 30]. Dual use is a term describing when a tobacco user cuts down on traditional cigarettes, but adds another form of tobacco such as e-cigs [40]. In pregnancy, dual use may occur as patients initiate e-cig use, or increase use, due to the perception of increased safety of e-cigs [18]. Ashford *et al.* [27] reported nearly all (88%) of the study participants who were e-cig users were dual users. England *et al.* [29] also noted this trend toward dual use, reporting that the few who tried using ENDS to quit smoking became dual users instead.

Pregnancy is a motivator for women to quit smoking; however, there are no evidence-based strategies shown, to date, to be safe and effective at assisting pregnant women to quit smoking. Recently, the U.S. Preventive Services Task Force, (a panel of national experts in prevention and evidence-based medicine) reported that evidence of using electronic nicotine delivery systems as a smoking cessation tool during pregnancy is insufficient [41]. Further research on the health implications of e-cig use and the efficacy of using e-cigs as an aid to smoking cessation in pregnancy is important. Novel interventions are needed to support smoking cessation attempts among pregnant women, using evidenced-based approaches.

Limitations

There are limitations to this literature review. First, only seven studies were identified which addressed perceptions and e-cig use during pregnancy, and one of these was a case study of only one individual. All seven studies relied on participant self-report of tobacco use. In addition, the participants in the qualitative assessment by Kahr *et al.* [28] were enrolled in CP (a group model of prenatal care designed to deliver comprehensive pregnancy/birth education to women in facilitator-led group discussions), which may limit study findings due to the fact that participants had potentially already received education about the harmful effects of tobacco and nicotine on maternal and fetal health prior to the focus groups. Finally, the seven included studies were

conducted in the United States; therefore, the perceptions of e-cig safety and use summarized in this review may not be generalizable to an international audience due to varying regulations governing e-cig use in other countries.

Conclusion

Results of this literature review, based on currently available publications from January 2006 to October 2016, highlight perceptions about e-cig use during pregnancy, an important health issue with major public health implications. Of the seven studies reviewed, most participants believed e-cigs may pose risks to maternal and child health, but also believed they may be safer and potentially healthier than traditional cigarettes, and may assist with smoking cessation during pregnancy. While some individuals perceived e-cigs as a tool for smoking cessation, current research on the impact of e-cig use on pregnancy outcomes is not available, and e-cigs are not an approved smoking cessation aid. There is no safe level of nicotine consumption during pregnancy. Providers therefore should continue to warn women of the potential adverse maternal and fetal health implications associated with nicotine consumption in any form.

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Conflict of interest statement

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Appendix 1. Search strategy: InfoKat Discovery

#	Query	Results
S12	(electronic cigarette) AND (pregnan*) AND (practice)	10
S11	(electronic cigarette) AND (pregnan*) AND (perception)	8
S10	(electronic cigarette) AND (pregnan*) AND (attitude)	6
S9	(electronic cigarette) AND (pregnan*) AND (belief)	1
S8	(electronic cigarette) AND (pregnan*) AND (behavior)	7
S7	(e-cig) and (pregnan*)	38
S6	(electronic nicotine delivery systems) AND (pregnan*)	37
S5	(smoking) AND (pregnancy) AND (electronic cigarette)	139
S4	(electronic cigarette) AND (pregnan*)	226
S3	electronic cigarette	2,220
S2	(smoking) AND (pregnan*)	19,663
S1	smoking	129,231

Note: searches were performed on March 21, 2016 and October 20, 2016.