



Documenting the emergence of electronic nicotine delivery systems as a disruptive technology in nicotine and tobacco science



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HIGHLIGHTS

- E-cigarettes represent a “disruptive technology” in nicotine and tobacco science.
- Through 2014, opinion articles on e-cigarettes were published as often as empirical research.
- Human subject research on e-cigarettes has been largely descriptive.
- Experimental and intervention studies of e-cigarettes are needed.

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ABSTRACT

Background: The emergence of electronic nicotine delivery systems (ENDS, or “e-cigarettes”) has resulted in nicotine and tobacco scientists committing increased resources to studying these products. Despite this surge of research on various topics related to e-cigarettes, it is important to characterize the evolving e-cigarette research landscape as a way to identify important future research directions. The purpose of this review was to broadly categorize published scholarly work on e-cigarettes using a structured, multi-level coding scheme.

Methods: A systematic literature search was conducted to collect articles on e-cigarettes that were published in peer-reviewed journals from 2006 through 2014. Studies were classified through 3 coding waves. Articles were first divided into research reports, literature reviews and opinions/editorials. Research reports were further categorized to determine the proportion of these studies using human participants. Finally, human studies were classified based on their methodologies: descriptive, predictive, explanatory, and intervention.

Results: Research reports ($n = 224$) and opinions/editorials ($n = 248$) were published at similar rates during this time period. All types of articles showed exponential rates of increase in more recent years. 76.4% of human research studies were descriptive in nature, with very little research employing experimental (6.8%) or intervention-based methodologies (5.4%).

Conclusions: This review reinforces the idea that e-cigarettes are a disruptive technology exerting substantial influence on nicotine and tobacco science. This review also suggests that opinions on e-cigarettes may be outpacing our scientific understanding of these devices. Our findings highlight the need for more e-cigarette research involving experimental, intervention, and longitudinal designs.

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Contents

1.	Introduction	180
2.	Methods	180
	2.1. Acquisition of articles.	180
	2.2. Coding of articles.	180
3.	Results	181
	3.1. Waves 1 and 2.	181

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3.2. Wave 3	181
4. Discussion	181
5. Conclusion	183
Role of funding sources	183
Contributors	183
Conflict of interest	183
Acknowledgements	183
References	183

1. Introduction

Electronic nicotine delivery systems (ENDS), also known as electronic cigarettes or e-cigarettes, were introduced into the global marketplace in 2006. Since their introduction, the availability and popularity of these devices have increased exponentially to the point where “vape,” the colloquial term for using ENDS, was chosen as the Oxford English Dictionary’s Word of the Year in 2014. Recent reports estimate that 8.5% of US adults have used these products at least once during their lifetime (King, Patel, Nguyen, & Dube, 2015), and rates of ever-use have been steadily increasing (McMillen, Gottlieb, Shaefer, Winickoff, & Klein, 2015). This increase in use likely stems from greater availability, marketing, and diversity of e-cigarette products, with new brands of ENDS and new flavors of e-cigarette liquids being constantly introduced into the marketplace (Zhu et al., 2014). Growing popularity and expanding availability suggest that ENDS constitute an emerging phenomenon in the global marketplace.

This emergence has raised important questions regarding the safety, efficacy, and population impact of these devices. There are conflicting viewpoints in the public health community on how ENDS may impact smoking: some believe that ENDS may facilitate smoking cessation via harm reduction (Nitzkin, 2014), while others characterize ENDS as a potential “gateway” for a new generation of nicotine-dependent individuals (Grana, 2013). Issues like flavorings and chemical composition of e-cigarette liquids often drive these disagreements in the public health community. To resolve debates like these, many professional organizations have called for systematic research with sound methodologies so that the safety and efficacy of ENDS can be better understood (e.g., Brandon et al., 2015). The nicotine and tobacco research community has consequentially placed emphasis on understanding the role that ENDS play in this scientific domain. Hundreds of scholarly research articles on ENDS have been published since the product was introduced into the general marketplace. Zyoud, Al-Jabi, and Sweileh (2014) used bibliometric methods to describe this emergence of international ENDS research, and they reported that ENDS research output had increased exponentially in more recent years. Pepper and Eissenberg (2014) used a similar strategy to compare the relative growth of ENDS research to that of waterpipe tobacco, and they suggested that nicotine and tobacco scientists may be more interested in studying ENDS than traditional tobacco products. These reviews support the idea that ENDS represent a “disruptive technology” that is rapidly evolving into a central component of nicotine and tobacco research (Abrams, 2014; Fagerström, Etter, & Unger, 2015; Pechacek, Nayak, Gregory, Weaver, & Eriksen, 2016).

Despite the proliferation of ENDS research in recent years, many important areas of study remain unaddressed. The need for informative research on ENDS is becoming critical, as regulatory agencies are developing guidelines for monitoring ENDS manufacturing and distribution (Food and Drug Administration, 2016) and professional organizations are releasing position papers and policy recommendations (Bhatnagar et al., 2014). For instance, several professional organizations have suggested sweeping regulations of ENDS, including a complete ban on flavored e-cigarette liquids (Crowley, 2015; Schraufnagel et al., 2014). However, it remains unclear the degree to which flavorings serve to entice youth to initiate nicotine use versus facilitate harm reduction

(by encouraging transition from smoking to vaping). As a critical mass of research on ENDS develops, systematic reviews and meta-analyses will continue to be used to summarize important research findings. However, it is also useful to take a “50,000 ft view” of the landscape of ENDS research, as such an approach would help identify unaddressed research questions. To provide such a perspective, the purpose of this review was to systematically compile and classify articles in academic journals that were directly related to ENDS using a structured, multi-level coding scheme. Insight into the broad balance of academic publications on ENDS would be useful in evaluating the potential impact of future research and minimizing “wasted” research resources (Chalmers et al., 2014).

2. Methods

2.1. Acquisition of articles

A systematic literature search for publications in academic journals was conducted using PubMed, PsycInfo, and Web of Science. Articles published between January 2006 and December 2014 were collected. Searches for the terms “e-cigarette,” “electronic cigarette,” and/or “electronic nicotine” in the title, abstract, or topic identified potentially relevant articles that were reviewed by trained coders.

2.2. Coding of articles

Duplicate articles, articles not written in the English language, and articles not focused explicitly on ENDS were excluded from the sample. Coding was conducted in three waves, with each successive wave focusing on more specific subsections of the literature. In Wave 1, all included articles were classified into three broad categories: 1) primary research reports; 2) literature reviews, meta-analyses, and position papers from research or clinical organizations; 3) opinions, editorials, and letters to editors. In Wave 2, primary research reports that enrolled human participants were differentiated from those that did not.

Finally, in Wave 3, ENDS research articles involving human participants were coded into one of four categories, three of which were adapted from a derivation of study designs described by Bailey (2008): 1) descriptive research, which uses an exploratory design aimed at describing a phenomenon and its common and unique characteristics; 2) predictive research, which identifies factors influencing change in a phenomenon over time without the use of experimental manipulation; 3) explanatory research, which evaluates mechanisms and causes underlying a phenomenon through experimental manipulation. A fourth category, intervention research, was added to capture a small, yet highly important, research area regarding ENDS—studies evaluating the efficacy of ENDS as aids for smoking reduction and/or cessation. Including this fourth category allowed for the coding scheme to more accurately reflect the traditional goals of the scientific method in health research: “to describe, explain, predict, and sometimes control the world in which we live” (Polgar & Thomas, 2013, p. 7).

Classification criteria for all three waves were agreed upon a priori. Articles were coded by two independent raters, with 87.8% agreement. Discrepant ratings were reviewed by a third rater and assigned a final code.

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