Striving Towards Equity:

A Scoping Review of E-Cigarettes, Heated Tobacco Products and Tobacco-Related Disparities

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Executive Summary

Tobacco-related disparities are well-known and have been studied in many different contexts. Tobacco use and exposure to secondhand smoke vary according to race/ethnicity, gender and sexuality, socioeconomic status (SES), age, education, and geography. These disparities disproportionately affect populations facing structural inequities, which include one's living and working conditions, such as neighborhood characteristics, access to health care, and social inclusion. To strive towards health equity – a state in which disparities in health and its determinants as well as structural inequities have been eliminated and everybody has the same fair and just opportunities to be as healthy as possible[1] – it is critical to undertake research that focuses more on the underlying causes of the disparities than on the disparities themselves. It is also essential to address the ways in which these structural inequities are reflected in who is involved in the conduct of the research, implementation, and evaluation processes as well as the primary focus of these endeavors.

Electronic cigarettes (e-cigarettes) and heated tobacco products (HTPs) are relatively new tobacco products. Because of industry claims that these devices may act as cessation aids for smokers, as well as their potential to recruit new tobacco users and retain existing users, it is essential to understand how e-cigarettes and HTPs may affect tobacco-related disparities in order to guide future research and effective regulation.

We searched the existing literature and research in the pipeline for information about the impact of e-cigarettes and HTPs in relation to tobacco disparities. Specifically, we looked at how use, susceptibility, advertising, and access to these products is different across populations, focusing on possible disparities due to race/ethnicity, age, education, gender and sexuality, SES, and geography. In addition, we searched for available information on the use of e-cigarettes as a cessation tool, including which populations have access to them. By mapping the available literature through a scoping review, our goal was to identify research gaps, obtain feedback from funders and experts in the field, and discuss priorities for future research in order to advance health equity.

We identified 81 studies published between 2013-2020. The majority of the studies were cross-sectional and from the US or other high-income countries. All studies were classified according to their overall theme and fell into one of the following categories: use, susceptibility, cessation, advertising, or access. Most of the articles in our sample (n=41) focused on use among different populations. While all studies reported on e-cigarettes, across the whole sample, only one study also reported on HTPs.

Given the evidence available, results of studies focused on **use** showed that overall ever use and current use of e-cigarettes were higher among older adolescents, younger adults, urban residents, LGB individuals, Whites, and males. Much of the evidence on SES, education, and race was mixed. The odds of using fruit-flavored e-cigarettes was higher among adolescents and females while the odds of using tobacco or other flavored e-cigarettes was higher among older adults and males. The odds of using menthol/mint e-cigarettes were found to be higher among

Blacks and Hispanics in the US. Only two studies assessed **susceptibility** to e-cigarettes among adolescents in the US; older adolescents and males were more susceptible than their counterparts while the results for race/ethnicity and SES were mixed.

The use of e-cigarettes for smoking **cessation** attempts was higher among younger smokers, Whites, those with more than a high school degree, and males. Evidence on the effectiveness of e-cigarettes as a cessation aid is inconclusive; there is also very little information about who stops using e-cigarettes.

Evidence on e-cigarette **advertisement exposure** was also mixed, especially in relation to gender, SES, and race, and very limited when addressing age and education disparities. Overall, exposure to e-cigarette ads was higher among Whites, LGBT populations and those living in urban areas. Sources of exposure also varied by race/ethnicity and age. The majority of studies focused on e-cigarette marketing, with only one study assessing the impact of anti-tobacco campaigns.

While several studies have been conducted on vape shop density, fewer studies have explored the means through which different populations **acquire** their e-cigarettes (e.g. vape shops, friends or family, Internet) and **price** paid for them, including the use of promotions. Recent studies in the US found more vape shops located in neighborhoods of lower-SES and where racial/ethnic minorities live.

There has been an increase in the number of funded studies related to tobacco-disparities: more than double the number of studies were funded between 2016-2020 (n=28) compared to 2011-2015 (n=12). Most of these studies focus on disparities in use of e-cigarettes related to age, race, SES, and gender (in this order).

This scoping review has captured the breadth of available literature and studies in the pipeline related to e-cigarettes/HTPs and tobacco-related disparities. The results from the scoping review were discussed in a convening with 25 experts from academia, funding agencies, and civil society. Convening participants identified the following research gaps that need to be addressed in order to advance a health equity agenda to eliminate tobacco-related disparities **(Table Research gaps identified by the convening's participants, ordered alphabetically by category).**

In order to better understand how different factors interact to shape experiences within a broader political, socioeconomical, cultural and regulatory context, participants in the convening also agreed that it is time to change the culture of science. For example, purposively choosing who is funded and what research is prioritized and increasing the number of researchers from groups that have been excluded or marginalized is critical. Researchers should also consider oversampling certain groups to assure sufficient sample size, adopting an intersectional approach, involving their community in their study, and planning and evaluating multilevel interventions.

Table. Research gaps identified by the convening's participants, ordered alphabetically by category

CATEGORY*	KEY RESEARCH GAPS
Access	· Assess online purchasing · Assess use and targeting of price promotions and discounts
Advertising	· Conduct more studies on advertisement and social media, including pro and anti-tobacco messages and understanding who the industry is targeting
Cessation	· Determine the impacts of flavored products on cessation · Assess e-cigarettes' effectiveness for smoking cessation among different populations, especially among populations disproportionately harmed by tobacco products · Assess who quits and who does not quit e-cigarette use · Assess who are the smokers who cannot/will not quit cigarettes with means other than e-cigarettes
Equity (equity should be incorporated into all other categories of research)	· Incorporate an intersectional approach in research, and preferentially doing so using national surveillance systems · Given that equity is as much (if not, more) about process as it is about outcome, increase diversity among researchers by a) prioritizing the funding of researchers from groups that have been excluded or marginalized; b) consider funding mechanisms for smaller universities and community colleges, and c) developing pathways for investment in community-based participatory research · Contextualize findings in the broader social determinants of health · Take a holistic view of tobacco use in the context of noncommunicable diseases and environmental health and justice · Determine impacts on behavioral health groups · Assess structural and social factors as drivers of tobacco-related inequalities · Include and assess indicators of equity in surveillance and studies · Explore aspects of the vaping culture
Industry monitoring	· Examine e-cigarette industry behavior, including looking at tobacco industry documents · Explore the industry's goals: what they are doing versus what they are saying while considering the local cultural context (e.g., IQOS marketed differently in different countries) · Explore the relationships between tobacco and cannabis companies and strategies
Policy	· Conduct cross-country natural experiments to assess impacts of different policies · Assess the impacts of policies on health disparities including, but not limited to, tobacco control policies (e.g., housing policies) · Obtain more information on tobacco-related disparities and e-cigarettes/HTPs from low- and middle-income countries accounting for their regulatory frameworks
Use	· Assess longer-term use and transitions between products, including cannabis · Assess disparities in the use of flavored products and their impacts on initiation · Assess use in the context of cultural norms and stigma
Product	· Be explicit about the type of e-cigarette being studied (e.g., pod versus open system) · Obtain more information on tobacco-related disparities and HTPs
Specific population	· Assess differences among Hispanic sub-groups · Assess generational differences among immigrant populations · Conduct more studies among the LGBTQ population, including sub-groups
General	· Conduct longitudinal studies · Develop standard terminology and definitions for use behaviors and product types · Assess the impacts of interventions that are broader than tobacco control (e.g., increasing minimum wage, housing policies) · Conduct qualitative research for an understanding of the why's (e.g., reasons for use, role of culture, effects of social exclusion) · Assure quality of the research and research proposals

The categories of research are not mutually exclusive, and they can be addressed as part of the same research endeavor.

Proposed principles
Principles can help establish ultimate goals and can guide and inform decision-making, priorities, and practice. In researching e-cigarettes and HTPs, the history of tobacco use and trajectories should be taken into account especially because of the well-documented longstanding practices of the tobacco industry that include targeted marketing to various groups that have been excluded or marginalized and now face persistent disparities. While e-cigarette and HTP use has not started predominantly in those groups, it is important to continuously monitor whether the epidemiology of use is changing over time to avoid further perpetuating or increasing tobacco-related disparities.

The principles below are proposed to help foster a sustained health equity research agenda to support evidence-based interventions related to e-cigarettes and HTPs. While these principles are not new, the novelty of e-cigarettes and HTPs combined with established research on tobacco-related disparities provide a timely opportunity to put them into action. In addition, the COVID-19 pandemic and social movements such as Black Lives Matter have encouraged discussions about health, healthcare, and structural inequities in the U.S. as well as in other parts of the world. The research enterprise can no longer simply document inequities without addressing them. Research, surveillance, and evaluation of e-cigarettes and HTPs should go beyond identifying and monitoring disparities. It should ensure a more comprehensive understanding of mechanisms that create, maintain, and exacerbate health inequity coupled with the development, evaluation and implementation of solutions at scale to promote health equity.

a Research and intervention should not create, maintain, or further increase tobacco-related disparities, even if they may reduce tobacco use in the population as a whole. Study proposals should be required to specify how findings will advance health equity. Evaluation efforts should assess impacts on health equity.

b Research, surveillance, and evaluation efforts assessing the impacts of e-cigarettes and HTPs and interventions to address them should account for both the individual and community levels within the socioeconomic, cultural, and historical contexts that cause inequities; for example, research should examine discrimination as a cause of health inequities and its relationship with exposures and health outcomes.

c Surveillance efforts should be expanded with regard to both sample size and questionnaire content, to provide detailed and generalizable information related to groups that have been excluded or marginalized (e.g., LGBTQ+).

d Groups that have been excluded or marginalized are defined by multiple sociodemographic characteristics, and thus research into tobacco-caused health disparities and the impact on health equity should be designed with an intersectional lens whenever possible.

e Communities that are the focus of or would otherwise be impacted by research should be meaningfully engaged: study results should be shared with communities and, whenever possible, these communities should serve as active collaborators and provide input on research efforts, priorities, and interpretation of the findings.

f Effective and sustained efforts must be implemented to help increase the participation of researchers who bring lived experience and expertise in navigating fundamental causes of tobacco-related disparities to all aspects of the research endeavor. Funding decisions should take into account leadership and involvement of researchers on research teams who are from groups that have been excluded or marginalized. Funding for research focused on advancing health equity and involving affected communities should be expanded.

g The tobacco industry has a long history of targeting groups who have been excluded or marginalized to support its own interests. To prevent the industry from further increasing disparities, research, decision-making, and interventions should not be influenced by or otherwise involve any contribution from the tobacco industry.

Introduction

> ❝ **The primary determinants of disease are mainly economic and social, and therefore its remedies must also be economic and social.** *(Geoffrey Rose, The Strategy of Preventive Medicine)* ❞

The social determinants of health are well-known and have been extensively researched and documented in the public health field. Housing, employment, education, and discrimination are all examples of determinants that impact health both at the individual and population level resulting in health inequities, which are systematic and avoidable differences that impede certain people from reaching their maximum health potential. Health disparities represent differences in health among populations based on several sociodemographic characteristics (e.g., race/ethnicity, religion, nationality, socioeconomic status, age, disability, gender identity).

> "**Health equity** means that everyone has a fair and just opportunity to be as healthy as possible. This requires removing obstacles to health such as poverty, discrimination, and their consequences, including powerlessness and lack of access to good jobs with fair pay, quality education and housing, safe environments, and health care. For the purposes of measurement, health equity means reducing and ultimately eliminating disparities in health and its determinants that adversely affect excluded or marginalized groups."[1]

Tobacco-related disparities have been extensively documented in the literature. In the US, for example, cigarette smoking rates are higher among men, LGB individuals, those with less education, and those of lower SES.[2] American Indians/Alaskan Natives have the highest rates of cigarette use, followed by multiracial individuals, Whites, Blacks, Hispanics, and then Asians.[2] These disparities disproportionately affect populations facing structural inequities (e.g., social inclusion, access to health care); they also result from aggressive marketing strategies of the tobacco industry targeting groups that have been excluded or marginalized (e.g., disproportionate use of menthol among African Americans). The recent introduction of new tobacco products (i.e., e-cigarettes and heated tobacco products) to the market and the involvement of the tobacco industry raise several concerns, mainly that this will undermine the progress made in tobacco control so far.
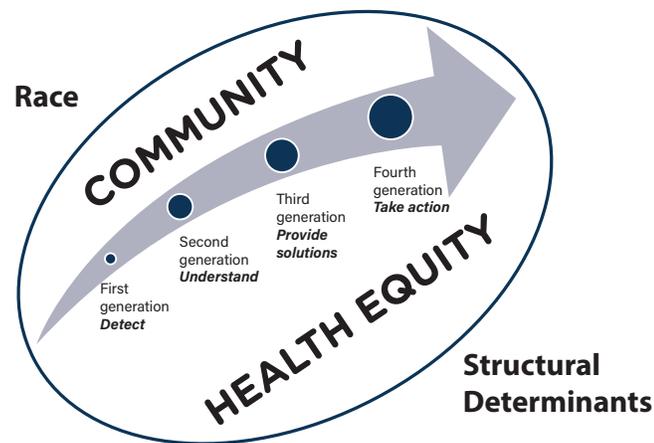
E-cigarettes are electronic devices that heat a liquid to produce an aerosol for inhalation, which often contain nicotine and flavorings, but can also contain THC, CBD, vitamins, and other additives. As of 2014, there were over 450 brands and 7700 unique flavors available for sale on the internet alone.[3] In addition to the wide array of brands and flavors, there are a variety of features (e.g. adjustable power settings, adjustable airflow, modifiable coils) that further increase the customization of these devices. E-cigarette users may have vastly different experiences and exposures to toxic constituents depending on the length of vaping sessions,[4] e-cigarette liquid contents,[4,5] device types[6,7] and device settings.[8,9]

Heated tobacco products (HTPs) are devices that heat tobacco in order to create an aerosol for inhalation. These aerosols contain nicotine and other additives (e.g. flavors). As HTPs have only been on the market for a relatively short period of time, research on HTPs is limited.[10]

As a result of their novelty, lack of research and the heterogeneity of e-cigarettes, regulating these products presents unique challenges with countries adopting many different policies. A global assessment of country policies on e-cigarettes has identified 100 countries so far that have policies on e-cigarettes, though their breadth and stringency vary widely across countries.[11] For example, while 30 countries have banned the sale of all types of e-cigarettes, six do not have regulations on sale beyond age of majority purchase rules.[11] Studies have found that in countries with more restrictive e-cigarette regulations, individuals were more likely to perceive e-cigarettes as more harmful than cigarettes[12] and less likely to notice e-cigarette advertisements.[13] In addition, a US study found that adults living in states with vape-free policies were less likely to use e-cigarettes compared to those living in states without vape-free policies.[14]

While e-cigarettes have gained a lot of interest as a potential cessation tool for smokers and HTPs have been advertised as a product with reduced toxicants when compared to cigarettes, research on their effectiveness is mixed.[10] Given the high use of e-cigarettes among youth in the US,[15] and research suggesting increased odds of cigarette smoking initiation among young people using e-cigarettes,[16] concerns have been raised about the impacts of e-cigarettes and HTPs on health at the population level. These concerns include the dual use of e-cigarettes and cigarette smoking and the potential "gateway" effect of e-cigarette use leading to cigarette use.[17] Therefore, it is critical to evaluate how e-cigarettes and HTPs may exacerbate or diminish existing health disparities, and what actions should be taken to advance health equity.

Figure 1. The HEART paradigm framework developed by Thomas et al.

Thomas SB, et al. 2011.
Annu. Rev. Public Health. 32:399–416

Developed by Thomas et al., the Health Equity Action Research Trajectory (HEART) paradigm provides a framework for advancing health equity through research (**Figure 1**). This framework consists of four research generations: (1) document existing disparities; (2) determine causal relationships that underlie disparities; (3) identify solutions for eliminating disparities using transdisciplinary research, community engagement, and translational research; and (4) take action to eliminate disparities by using public health critical race praxis as a conceptual framework, addressing structure determinants of health through multilevel interventions, using comprehensive evaluation, and engaging in self-reflection as researchers. Despite the authors' focus on eliminating race-related health disparities by addressing its structural determinant (i.e., racism), the framework can be applied to health disparities as a whole. For example, addressing sexism is key to eliminate gender-related disparities. For the purposes of this report, the framework was used to categorize articles into generations in order to describe the current research on e-cigarettes/HTPs, identify research gaps and areas of priority for future research, and develop a set of tobacco-related health equity principles.[18]

Because of the recency of these products, the evidence around e-cigarettes and HTPs and their influence on health equity is still limited, and more data are needed to understand differences across race/ethnicity, age, education, gender and sexuality, SES, and geography, and when these categories intersect. Through a scoping review, this report aims to identify gaps in research, which if filled have the potential to inform interventions to reduce health disparities as they relate to regulating e-cigarettes and HTPs and, consequently, move towards the achievement of health equity.

Specifically, this report aims to **address the following research questions:**

✓ What existing literature, and research in the pipeline, are available about the impact of e-cigarettes/HTPs in advancing tobacco-related health equity?

✓ How do use, susceptibility, advertisement exposure, and access differ across race/ethnicity, age, education, gender and sexuality, SES, and/or urban/rural areas?

✓ Who is using e-cigarettes as a cessation tool? Who is using e-cigarettes to quit successfully? And who has access to them?

Methods

Scoping review

The goal of a scoping review is to map the existing published literature and funded research ("in the pipeline") when certain themes have not been extensively explored, when they are wide-ranging and/or when time constraints exist.[19] Considering the rapid changes in the availability and use of a broad range of e-cigarettes and HTPs, the scoping review methodology was chosen to provide key information in a timely manner. By mapping the existing literature on e-cigarettes/HTPs and health equity, our goal was to identify gaps in research and disseminate findings to funders, policy makers, and experts in the field. The scoping review was based on the six steps proposed by Arksey & O'Malley in their proposed scoping review methodological framework: 1) identify the research questions; 2) identify relevant studies; 3) apply inclusion/exclusion criteria; 4) extract data; and, 5) collate, summarize, and report the results.[19] The sixth step was a consultation meeting with experts in June 2020.

Identifying relevant studies

Based on our research questions and in consultation with a university informationist, our search strategy was developed around two main constructs: 1) e-cigarettes and heated tobacco products AND 2) health equity OR health disparities (**Table 1**). In order to capture articles from public health and social sciences, the following five databases were searched: PubMed, Scopus, Embase, Web of Science, and the Cochrane Library. Results from each database were uploaded to Covidence, a Cochrane technology platform and tool to support systematic reviews. Duplicates were automatically removed. One study was recommended by one participant in the convening (published after our initial search).

Table 1. Search terms

#1	Electronic Nicotine Delivery Systems[mesh] OR Vaping[mesh] OR Electronic Cigarette*[tw] OR E-Cigarette*[tw] OR E-Cig*[tw] OR Vape[tw] OR vaping[tw] OR vaper*[tw] OR JUUL[tw] OR IQOS[tw] OR heat-not-burn[tw] OR heated tobacco products[tw] OR JUULing[tw]
#2	Ethnic groups[mesh] OR Socioeconomic Factors[mesh] OR Social Class[mesh] OR Age Factors[mesh] OR Sex Factors[mesh] OR Race Factors[mesh] OR Educational Status[mesh] OR health equity[mesh] OR health status disparities[mesh] OR Socioeconomic Factor*[tw] OR Inequalit*[tw] OR Sex Factor*[tw] OR Sexualit*[tw] OR Race Factor*[tw] OR Age Factor*[tw] OR sociodemographic*[tw] OR Socioeconomic Status[tw] OR Social Classes[tw] OR health equities[tw] OR Race[tw] OR Adolescen*[tw] OR Youth*[tw] OR Teen*[tw]
#3	#1 AND #2

Study selection

Using Covidence, three researchers (GG, EC, AA) double-coded the titles and abstracts of the studies identified. Studies that met the following inclusion criteria were included: 1) related to e-cigarettes and/or heated tobacco products; and, 2) related to health equity and/or disparities. Finally, due to our broad inclusion criteria, we classified the articles according to three priority definitions as part of this first screening (**Table 2**). Disagreements were resolved by consensus among the three coders. When consensus was not achieved, a fourth researcher (JC) made the final decision. The same procedure was used in the event of different priorities assigned to a study.

Table 2. Definition of priorities used to classify studies based on title and abstract review and number of studies classified in each priority

High priority (n=58)	Articles that clearly discuss implications of e-cigarettes/heated tobacco products in relation to health equity/disparity
Mid priority (n=63)	Articles that do not discuss implications, but do more than just characterize use, susceptibility, cessation, advertising, and access by different populations OR articles that present unique data or perspective on the issue
Low priority (n=637)	Articles that characterize e-cigarette/heated tobacco products use, susceptibility, access, cessation, advertising, and access by different populations

Data extraction

High and mid priority articles were eligible for full text review and data extraction. An initial 15 articles were reviewed by two researchers (GG and EC) to refine data extraction. Once this process was completed, the remaining articles were divided between the two researchers who individually extracted data using Microsoft Excel. The following relevant data were extracted: a) citation; b) objective; c) study design; d) study population; e) key results and conclusion; f) policy/research implications; g) main theme; h) product type (e-cigarettes and/or HTPs); i) funding; j) notes. All studies that did not meet our criteria were reviewed for agreement and excluded by both researchers.

Considering our time constraints, the full text of the low priority articles was not reviewed. However, in order to capture the breadth of the literature, high level data were extracted based on the information available in the abstract and were captured using Microsoft Excel. Extraction focused on: a) publication year; b) study location; c) characteristics of sample population; d) study design; e) data source; f) main theme; g) product type(s). Studies that did not meet the inclusion criteria were excluded. **Figure 2** illustrates the study selection process, and **Table 3** the final number of articles included by priority.

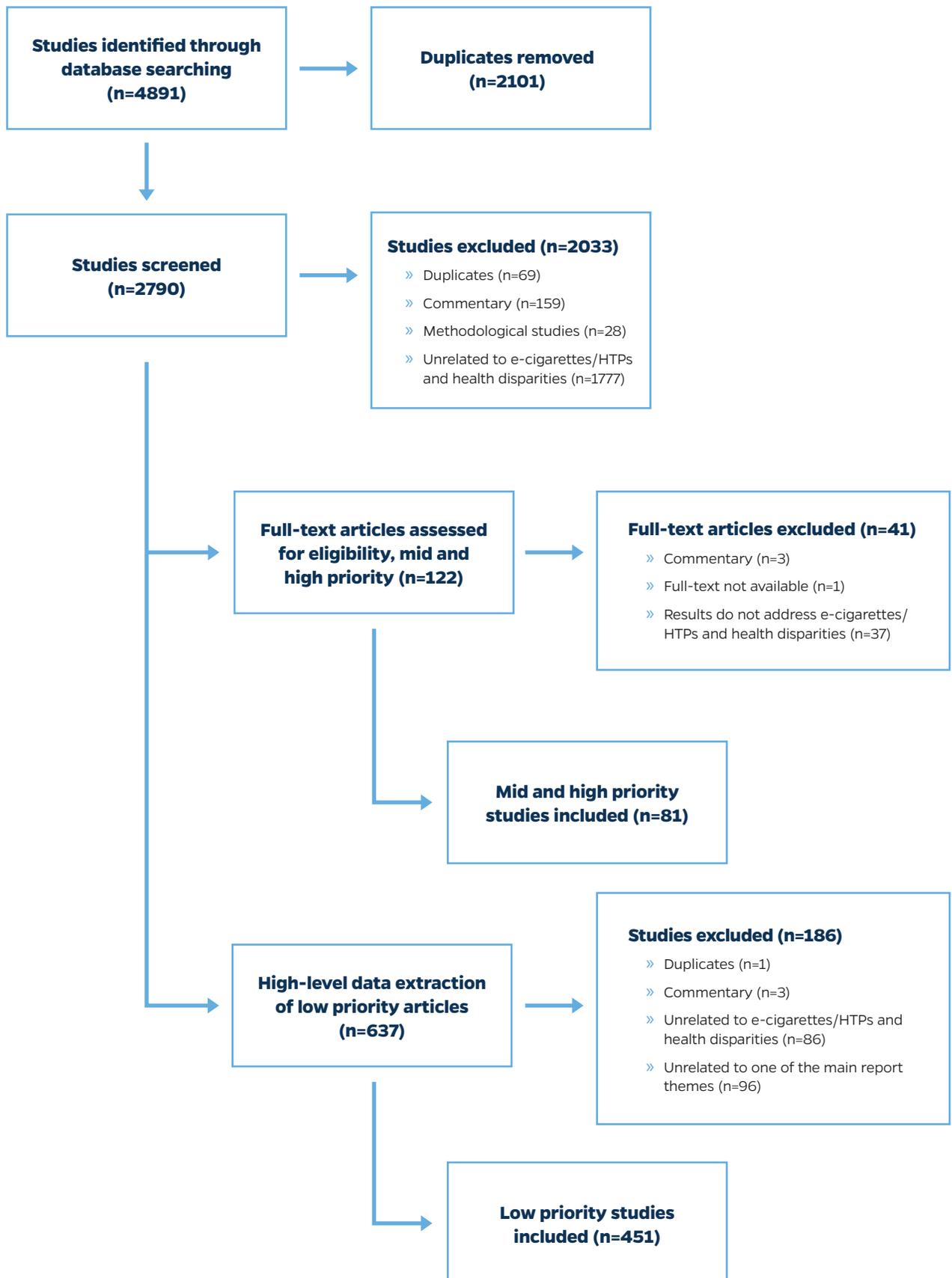*Collating, summarizing, and reporting the results*

With the goal in mind of identifying gaps in research, all studies were categorized into one of these six themes: use, susceptibility, cessation, advertising, and access. These themes emerged based on our research questions and on the coding during full text review. While some of the studies could fall under more than one of these themes, we classified based on the main and overarching theme to report the results in a systematic way. Results are presented thematically and, first, we report on individual-level factors (use, susceptibility to e-cigarette/HTP use, and cessation) followed by population-level factors (advertising and access). Each section is broken-down by the subpopulations addressed in the studies. In some cases, the key findings contain results from articles primarily classified in a different theme.

Research in the pipeline

To capture funded and ongoing studies, we conducted searches in the databases of the following funding organizations and programs for the period 2011 to 2020: National Institutes of Health (NIH), the U.S. FDA's Tobacco Centers of Regulatory Science (TCORS) website, Tobacco-Related Disease Research Program (TRDRP), and Cancer Research UK. Different search methods were used for each of the organizations depending on the capabilities offered on their websites. When available, data extraction captured the following information: a) title of the project; b) principal investigator and institution; c) funding year; d) study location; e) study design; f) characteristics of the sample population; g) theme; and, h) product type(s). We only included studies that stated the objective of addressing disparities.

Table 3. Final number of studies classified in each priority

High priority (n=41)	Articles that clearly discuss implications of e-cigarettes/heated tobacco products in relation to health equity/disparity
Mid priority (n=40)	Articles that do not discuss implications, but do more than just characterize use, susceptibility, cessation, advertising, and access by different populations OR articles that present unique data or perspective on the issue
Low priority (n=451)	Articles that characterize e-cigarette/heated tobacco products use, susceptibility, access, cessation, advertising, and access by different populations

Figure 2. Flowchart of included studies

Studies identified through database searching (n=4891) → Duplicates removed (n=2101)

Studies screened (n=2790) → Studies excluded (n=2033)
- » Duplicates (n=69)
- » Commentary (n=159)
- » Methodological studies (n=28)
- » Unrelated to e-cigarettes/HTPs and health disparities (n=1777)

Full-text articles assessed for eligibility, mid and high priority (n=122) → Full-text articles excluded (n=41)
- » Commentary (n=3)
- » Full-text not available (n=1)
- » Results do not address e-cigarettes/HTPs and health disparities (n=37)

Mid and high priority studies included (n=81)

High-level data extraction of low priority articles (n=637) → Studies excluded (n=186)
- » Duplicates (n=1)
- » Commentary (n=3)
- » Unrelated to e-cigarettes/HTPs and health disparities (n=86)
- » Unrelated to one of the main report themes (n=96)

Low priority studies included (n=451)

Results

Scoping review

A total of 81 high and mid priority studies were identified. **Table 4** shows the overall characteristics of the articles. 451 low priority studies were not included for full text review but were coded based on their abstracts. See **Appendix 1: Overview of low priority studies** for an overview of this literature.

Table 4. Characteristics of mid and high priority studies (N=81)[a]

	Number of studies
Publication/funding year	
2013-2015	14
2015-2020	67
Study location	
US	66
UK	6
Australia	1
Argentina	1
EU	1
Japan	1
Malaysia	1
US and Canada	1
Unspecified	3
Study design	
Cross-sectional	74
Longitudinal	2
Qualitative	1
Review	4
Theme: Use (n=41)	
Age	16
Education	14
Gender	16
LGBT	5
Race/ethnicity	20
SES[b]	15
Urban/rural	2
Theme: Susceptibility to e-cigarette/HTP use (n=2)	
Age	1
Education	0
Gender	2
LGBT	0
Race/ethnicity	2
SES	2
Urban/rural	0

Theme: Cessation (n=13)	
Age	7
Education	2
Gender	5
LGBT	0
Race/ethnicity	7
SES	6
Urban/rural	1
Theme: Advertising (n=13)	
Age	4
Education	2
Gender	6
LGBT	3
Race/ethnicity	9
SES	3
Urban/rural	2
Theme: Access (n=12)	
Age	7
Education	5
Gender	5
LGBT	0
Race/ethnicity	10
SES	9
Urban/rural	1
Product type	
E-cigarettes	80
E-cigarettes and HTP	1

[a]   Studies may have been counted in more than one subgroup (within a theme); therefore, numbers per theme may be larger than the total number of studies within each theme.

[b]   For the purpose of this report, SES is a broad term used to indicate studies assessing household income, poverty, class-differences as well as other indicators of SES, which varied by study.

Use

Extent of literature
Forty-one of the mid/high priority articles focused on the use of e-cigarette (n=40) and/or HTP (n=1) use among various populations. Five studies were published in 2020, nine in 2019, seven in 2018, nine in 2017, eight in 2016, two in 2015, and one in 2014.

Study design
Of these, 37 studies were cross-sectional, one longitudinal, and three reviews.

Populations/locations addressed in the literature
Thirty-three studies were conducted in the US, of which 17 were nationally representative. Two were conducted in the UK, both of which were nationally representative. Two reviews did not focus on a specific location. There was one non-representative study conducted in each of the following locations: Argentina, the EU, Japan, and Malaysia.

Key findings
In a 2017 review, awareness, ever use, and current use of e-cigarettes were found to be higher among older adolescents, younger adults, males, Whites, and those with intermediate/high levels of education. Inconsistent data were found on SES and place of residence.[20] The results below are much in line with the findings of Hartwell's review,[20] though our current review found elevated e-cigarette use among urban residents and mixed results for non-White races and education measures; in addition, we found elevated e-cigarette use among LGB individuals.

One non-representative study examined the association between perceived discrimination and attributions (on the basis of nationality, gender, race/ethnicity, age, religion, physical appearance, sexual orientation, education, income, or disability) and tobacco use (cigarettes, e-cigarettes, cigars, pipes, hookah, and smokeless tobacco). The author found a strong association between perceived discrimination and the use of cigarettes, e-cigarettes, cigars, pipes, and hookah consistent across age, sex, race/ethnicity, and SES; the author concluded that any kind of discrimination increases the risk of tobacco use.[21]

One representative US study found higher ever and current e-cigarette use among those born in the US compared to adult immigrants from Mexico, Central America, or the Caribbean Islands. Ever and current use were also higher among those born in the US than non-US citizens and US citizens who were not born in the US.[22]

Age
Studies focusing on various adult populations found higher ever, current, regular, and daily e-cigarette use among younger adults. This was true when younger adults were compared to their older counterparts among the following populations: smokers, non-smokers, former smokers who quit more than three years ago, non-cigarette combustible tobacco current users, pregnant women, and a general population of adults.[22-30] A study of university students in Texas found that JUUL users were more likely than other e-cigarette users to be younger.[31] Results were consistent across US nationally representative, US non-nationally representative, and non-US studies, with just two exceptions; one study in Hawaii found that those over the age of 65 were more likely to continue using e-cigarettes,[32] and a nationally representative US study found a higher prevalence of use among older, compared to younger, adults who quit smoking in the past 1-3 years.[29]

In another nationally representative study, Soneji et al. found a higher prevalence of daily e-cigarette use among adolescent compared to young adult or older adult users.[33] The odds of fruit-flavored e-cigarette use were higher among adolescent and young adult users than among older adult users, while the odds of tobacco- or other flavored e-cigarette use were lower among adolescent and young adult users than among older adult users. Adolescent and young adult users were also more likely to concurrently use multiple flavor types than were older adult users.[33]

Studies focusing on adolescent populations suggest elevated initiation, ever use, and current use for older than younger adolescents. According to one nationally representative US study, older adolescents were more likely than younger adolescents to initiate e-cigarette use. A systematic review of the US literature found elevated e-cigarette ever and current use for older compared to younger adolescents,[34] though one US nationally representative study found no relation between ever e-cigarette use and age after adjusting for smoking

status.[35] In another nationally representative US study of adolescents, the odds of experimental use versus abstinence was higher with increasing age, while the odds of being a current versus experimental user was higher with lower age.[36]

Education

While several representative and non-representative studies found a higher prevalence of cigarette to e-cigarette switching[37] and e-cigarette awareness and ever/current use among adults with higher education levels,[22,23,26,28,30] others have found elevated ever use, dual use, and continued use among less educated pregnant women, recent cigarette quitters, non-cigarette combustible tobacco users, and adults.[23,24,29,32,37] Evidence suggests these patterns may vary based on smoking status: one study found higher rates of e-cigarette use among less educated adults and former smokers, but the opposite was true among current smokers (i.e., higher e-cigarette use rates among more educated adult current smokers).[38] One study found that those with less education were less likely to trust health professionals or public health sources and more likely to trust e-cigarette companies; those trusting e-cigarette companies more than health professionals had 87% greater odds of e-cigarette ever use.[39] These results are in line with a 2019 review that found mixed evidence on education disparities in e-cigarette use among adults; some studies in this review had contradictory findings and some found no relation between education and e-cigarette use.[40]

In one national longitudinal study of young adults, those who attended college used e-cigarettes at similar rates as those who did not attend college.[41] In a national study of US adolescents, odds of experimental use versus abstinence were higher among those who were in the appropriate grade for their age versus those who were in a lower grade for their age.[36]

One study from Japan found higher HTP use among more educated adults. The opposite was true when the sample was limited to former smokers, with use being higher among those less educated. However, none of these results were significant.[38]

Gender

The vast majority of studies have shown higher awareness, experimental use, ever use, former use, and past 30-day use of e-cigarettes among males versus females across age groups and among various subpopulations and locations.[26,28,29,32,35–37,42–44] However, one US nationally representative study found higher regular e-cigarette use for females than males among adults who quit smoking in the last 1-3 years.[29] Additionally, one study of Californian adolescents found higher prevalence of ever e-cigarette use for Asian girls compared to Asian boys.[45] One study also found that male ever users were significantly less likely than females to report plans to continue e-cigarette use.[27] Three studies found insignificant gender differences in e-cigarette use, with one being an EU-based study[26] and two being US nationally representative studies.[25,28] One study of young adult JUUL users found that, compared to other e-cigarette users, JUUL users were more likely to be male.[31] In one study of adult e-cigarette users, women were more likely than men to report using disposable e-cigarettes, non-tobacco flavors, lower nicotine doses, and first-generation brands of e-cigarettes; men were more likely to report using e-cigarettes in places where smoking tobacco is prohibited, including at home and at work.[46] In a national study of e-cigarette flavor preferences, females were more likely to use fruit- or candy-flavored e-cigarettes, while men were more likely to use tobacco- or other-flavored e-cigarettes.[33,47] Overall, these findings are largely in line with a 2017 review, which found that all articles reporting on gender differences in e-cigarette use found higher use among male versus female adolescents.[34]

LGBT

In line with a 2017 review of the evidence, we found that the literature on e-cigarette use among LGBT populations is still limited.[20] However, available evidence from US nationally and non-nationally representative studies suggests that e-cigarette ever and current use is elevated among LGB adolescents and adults across various smoking statuses (former smokers, current smokers, and current non-cigarette combustible tobacco users),[23,28,48] particularly among female bisexuals and lesbians when compared to their heterosexual counterparts.[49,50] These patterns may not hold true, however, in US states without No Promotion of Homosexuality laws which prohibit public school educators from portraying non-heterosexual activities and

sexual minorities in a positive light. In states without these laws, e-cigarette use among sexual minority youth was comparable to heterosexual youth in a non-representative study.[50] In the one study that reported on transgender populations, e-cigarette use was higher among transgender adolescents when compared to their cisgender counterparts.[48]

Race/ethnicity

Both representative and non-representative US studies have shown elevated rates of cigarette to e-cigarette switching[37] and e-cigarette awareness,[23,28] experimental use, ever use, current use,[37] daily use,[25] and dual-use[51] among White, compared to Black and Hispanic, adolescents,[35,36,45,52] adults,[22,23,27,29] never smokers, current smokers, former smokers, and pregnant women.[24] These results are largely in line with a 2017 review that found e-cigarette awareness, ever use, and current use to be particularly prevalent among Whites.[20] However, two non-representative studies found no relation between race/ethnicity and e-cigarette use, though this may be due to the small sample sizes (n=285[27]; n=599[43]). Additionally, when compared to non-Hispanic adults, Hispanic adults had a higher prevalence of regular e-cigarette use in a representative US study. When this was broken down by smoking status, Hispanic never smokers, current smokers and past 1-3 year quitters had higher rates of regular e-cigarette use than their non-Hispanic counterparts.[29]

Racial disparities in e-cigarette use may also vary based on smoking status. A recent nationally representative study from the US found higher ever and current e-cigarette use among Hispanic, compared to Black and White, adults, and higher use among Black and Hispanic, compared to White, non-cigarette combustible tobacco users (little cigars and cigarillos, traditional cigars, and hookah).[23] Another non-representative study found that Black ever e-cigarette users were more likely to report plans to continue using e-cigarettes compared to Whites and Hispanics among current and former adult smokers.[27]

There is also some evidence from one representative and one non-representative US study suggesting that Hispanic adolescents and adults have a higher prevalence of use than their Black counterparts.[27,53] However, among Hispanic emergency department visitors, speaking Spanish at home was a protective factor against e-cigarette ever-use, especially in higher-income neighborhoods.[42] One representative US study also found elevated odds of mint/menthol–flavored e-cigarette use among Black and Hispanic than among White e-cigarette users.[33] In addition, one national US study found that Black, Hispanic, and Asian adults were more likely than Whites to trust the e-cigarette industry, and that this trust in the e-cigarette industry increased the odds of e-cigarette use.[39]

While more research is needed to evaluate racial minorities beyond Blacks and Hispanics, one representative US study found a higher prevalence of current e-cigarette use among Native Hawaiian and Pacific Islander adults compared to Blacks, Hispanics, and Asians,[54] and a non-representative study found elevated use among Filipinos and Native Hawaiians compared to Whites, Japanese, and other races.[32] When disaggregating Asian American and Pacific Islander adults, one study found no significant differences in past 30-day e-cigarette use by race/ethnicity, though this may be due to limited samples of some subgroups.[44]

Results on racial disparities in e-cigarette use among adolescents do not show a specific pattern. Among a nationally representative sample of adolescents, e-cigarettes were the most commonly used product for all racial/ethnic groups, except for Blacks.[55] While adolescent e-cigarette use increased across most racial groups from 2011-2012 and 2012-2013, an increase among Black adolescents was only seen from 2012-2013.[36] Among a non-representative sample of adolescent females, one study found a higher prevalence among Asians when compared to Hispanics and Whites.[45] One national US study found elevated odds of current use versus experimental use among Black, Mexican American, and "other" Hispanic relative to White adolescents.[36]

SES

In line with the evidence found in two systematic reviews,[20,40] we found that results regarding SES disparities in e-cigarette use are mixed. Two US studies found higher e-cigarette use among low-SES compared to high-SES individuals, among a nationally representative sample[23] and a sample of pregnant women.[24] Another representative study of US adults found higher ever and current use among low-SES adults in unadjusted analyses, but when controlling for smoking status, quitting behavior, and demographic/socioeconomic factors,

use was higher among high-SES adults.[28] Another US study found higher e-cigarette awareness and ever use for those living at or above the poverty level among adults and current cigarette smokers; however, current e-cigarette use was higher for those living below the poverty level among never combustible users and current noncigarette combustible tobacco users.[23] One nationally-representative study found higher income levels among exclusive e-cigarette users, followed by dual users, and then exclusive cigarette smokers.[37] Another study found that increased trust in the e-cigarette industry relative to health professionals or public health sources was associated with lower-SES, linking this trust in e-cigarette companies to higher odds of e-cigarette use.[39] Among university students, compared to other e-cigarette users, JUUL users were more likely to be higher-SES.[31] One national study found no significant associations between e-cigarette use and income among adult smokers,[25] and one EU study found that e-cigarette ever use was not significantly associated with social class.[26]

A UK study found that low-SES adults were more likely than high-SES adults to use e-cigarettes among the full sample and long-term ex-smokers, but the reverse was true for smokers – high-SES smokers were more likely to use e-cigarettes than low-SES smokers.[56] This is in line with another UK study that found elevated e-cigarette initiation among higher income adult smokers.[30]

While two studies, one nationally-representative US study and one study conducted in Argentina, found that adolescents from higher-SES families or schools have a higher prevalence of e-cigarette use,[35,57] two non-representative studies found the opposite.[58,59] These results are similar to a 2019 systematic review that found mixed patterns of e-cigarette current use by SES, with some evidence of higher ever use among low-income adults.[40]

Urban/rural

Two nationally representative US studies reported on urban/rural prevalence disparities and showed increased use or odds of use among those living in metropolitan areas. Regular e-cigarette use was higher for those living in metropolitan areas among both adults and former smokers who quit 1-3 years ago.[29] Those living in metropolitan areas were more likely to report as much or more trust in e-cigarette companies relative to health professionals, and this trust in e-cigarette companies was associated with higher odds of e-cigarette use.[39] In a study examining Malaysian adolescents, most e-cigarette ever users were from rural areas (21.2%). In a review of the evidence, researchers found no clear patterns between e-cigarette use and place of residence.[20]

Susceptibility to e-cigarette/HTP use

Extent of literature
Two articles examining susceptibility were of mid/high priority; both focused on e-cigarettes and were published in 2018.

Study design
One article was cross-sectional, and one was longitudinal.

Populations/locations addressed in the literature
One study addressed gender, SES, and racial/ethnic disparities among 6th grade students in Texas. The other addressed disparities in e-cigarette susceptibility by age, gender, race, and SES among middle and high school students in Connecticut.

Key findings
Susceptibility was assessed by adapting previously validated measures of cigarette smoking, including curiosity in trying e-cigarettes, likelihood of trying e-cigarettes in the next year, and likelihood of using e-cigarettes if their best friend offered them. In a longitudinal study of adolescents in Connecticut, being susceptible to e-cigarette use was a significant predictor of e-cigarette use at the six month follow-up.[60]

Age

The study of adolescents in Connecticut found that middle and high school students susceptible to e-cigarette use were slightly older than non-susceptible students.[60]

➡ **Gender**
Both studies found higher susceptibility to e-cigarette use for males compared to females.[60,61]

➡ **Race/ethnicity**
While one study found 6th grade Hispanic students reported significantly higher e-cigarette susceptibility compared to White students,[61] the other found no difference in e-cigarette susceptibility by race.[60]

➡ **SES**
The study in Texas found higher e-cigarette susceptibility in more economically disadvantaged schools.[61] The study in Connecticut found no difference in e-cigarette susceptibility by school SES.[60]

Cessation

Extent of literature
Thirteen articles primarily focusing on cessation were high/mid priority. All of them focused on e-cigarettes. Of those, 1 was published in 2020, four were published in 2019, two in 2018, two in 2016, one in 2015, one in 2014, and two in 2013.

Study design
Of the 13 studies, 11 were cross-sectional, one was qualitative and, and one was a systematic review of qualitative studies.

Populations/locations addressed in the literature
All studies were from high-income countries: four from the UK and nine from the US (with four being nationally representative). Studies addressed disparities across age, education, gender, SES, and race/ethnicity. One study categorized as use in this report also assessed e-cigarette cessation among Malaysian adolescents. No studies addressed LGBTQ population.

Key findings
There is available evidence suggesting that some people are using e-cigarettes with the intention to quit cigarette smoking. In general, younger smokers, Whites, and males seem to be more likely to use e-cigarettes to try to quit cigarettes; however, most of these data come from non-nationally representative studies in the US. In addition, two nationally representative studies among adults found that more frequent use of e-cigarette increased the likelihood of cessation;[62,63] one non-representative study among adolescents found that those who used e-cigarettes for cessation used both e-cigarettes and cigarettes more frequently.[64]

One study investigating the use of e-cigarettes among head and neck patients (N=106), including use for cessation purposes, did not find any statistically significant differences among e-cigarette users and non-users in terms of age, sex, race, or SES;[65] no further disparities were reported. Two studies discussed the role of health professionals in increasing the odds of quitting smoking or recommending e-cigarettes as a cessation method to patients.

➡ **Age**
Available evidence indicates that e-cigarettes might help more with quit attempts than successful smoking cessation. Levy et al. found an association between frequent past-month e-cigarette use and both quit attempts and smoking cessation for three or more months, with a stronger association with quit attempts. Both associations were particularly strong among participants ages 18-34 compared to older participants.[63] In another study, the odds of intention to quit or quit attempts did not increase with age.[66] Other studies found that being younger and having a shorter smoking history were associated with a higher likelihood of using e-cigarettes for smoking cessation.[67,68]

Dai et al. found that being advised against tobacco use was associated with higher odds of intention to quit in the next 12 months among cigarette only users, e-cigarette only users and dual users.[69]

Education

One study found that those with a college degree and being a dual-user had higher odds of having a high intention to quit smoking and of having made a quit attempt in the past year when compared to having a high school degree or less and smoking only cigarettes.[66] Similarly, ever e-cigarette users in a sample of state tobacco cessation Quitline callers were more likely to have more than a high school diploma;[70] these callers were also more likely to had made several smoking quit attempts.

Gender

One US-nationally representative study found a higher probability of 3-month cessation among male e-cigarette users compared to female users, despite women reporting increased e-cigarette current use or switching to e-cigarettes for smoking cessation attempts.[62] No other interactions between cessation and sociodemographic factors were found.[62] In another study, the odds of intention to quit did not vary by gender.[66] A systematic review of qualitative studies examining inequalities and use of non-combustible nicotine products for smoking reduction found gender differences in one study of their sample (n=3). In this study, female participants shared that smoking reduction was not a priority for them because they were busy taking care of their families.[71]

Despite a larger increase in tobacco screening among female compared to male students, females were less likely to be advised against tobacco use.[69]

Race/ethnicity

Only studies from the US presented data on race with some mixed results: Whites were more likely to use e-cigarettes as a cessation device,[64,67] but Asians and Native Hawaiians were more likely to have tried e-cigarettes only (compared to FDA-approved NRT products) for smoking cessation compared to Whites.[68] Another study with a national sample of adults found that being Black was associated with higher odds of high intention to quit and attempt to quit in the past year when compared to being White.[66] One study found that among state tobacco cessation Quitline callers, ever e-cigarette users were more likely to be White, have more than a high school diploma, have private health insurance, and make several quit attempts.[70] The majority of e-cigarette users reported using e-cigarettes for cessation purposes or to switch away from other tobacco products; however, e-cigarette users were less likely to be abstinent from tobacco products other than e-cigarettes.[70]

One study presented results on race among youth, finding associations between being White and an established smoker (more than 100 cigarettes in lifetime) and using e-cigarettes for cessation: those who used e-cigarettes for cessation reported more frequent use of both e-cigarettes and cigarettes.[64] Another study found that health professionals were more likely to screen White adolescent students for tobacco use than other minorities; Hispanics were less likely than Whites to be advised against tobacco use.[69]

SES

One study in the US found that the odds of intention to quit did not vary by SES.[66] One study found that Stop Smoking Service (SSS) practitioners in England reported no perceived differences in use by low and high-SES clients.[72] Nevertheless, some practitioners indicated that SES could be associated with differences in use: they felt that high-SES smokers treated e-cigarettes as a cessation device, which would be enabled by an environment without other nicotine users; on the other hand, lower-SES smokers would become e-cigarette users and would not necessarily quit cigarettes, because of their interactions with other nicotine users, having work breaks for nicotine use, or not experiencing work restrictions on using nicotine.[72] Analysis of SSS clients' self-report monitoring data indicated increased e-cigarette use among home carers, retirees, and prisoners, all who do not experience work restrictions to use.[72]

Culture seems to be an important piece to understand tobacco disparities in the UK in relation to SES. Thirlway (2019) used a class lens to analyze the use of e-cigarettes and smoking cessation among working-class and middle-class smokers.[73,74] In her two-year ethnographic study, the author found that concerns with nicotine addiction was seen as a reason to not use e-cigarettes for cessation purposes or shaped e-cigarette use patterns among working-class smokers in Northern England. The author also suggested that this would be more of a

concern for the working-class in comparison to the middle-class, who might consider switching to e-cigarettes as a health benefit. Most of those using e-cigarettes talked about planning to reduce the nicotine concentration in their e-cigarette liquid and eventually stop vaping. The majority of the participants who switched to vaping named money as the primary reason for doing so, with users finding different ways to make vaping cheap: either by using a pen-type e-cigarette (cheaper) or by buying a more refined e-cigarette (more expensive initial investment) and using it with cheaper liquid. Some participants reported using e-cigarettes regularly and saving their cigarettes only for special occasions. Users who stressed using e-cigarettes as a cessation device saw sweet flavors as unimportant for quitting and maybe even addictive. The author concluded working-class smokers are more concerned with being able to spend less money on their addiction than with their health.

Lucherini et al. highlighted how social, cultural, and economic factors were essential to understand participants' pessimistic and optimistic views in relation to e-cigarette use for smoking cessation and reduction, despite an overall prevalence of pessimistic views.[71] They found that low-SES participants shared more optimistic views regarding using e-cigarettes than other nicotine replacement treatments. Nevertheless, potential product harm was also a common concern in relation to e-cigarettes due to their novelty.[71]

Urban/rural
One cross-sectional study assessed cessation of e-cigarettes while also examining prevalence among Malaysian adolescents.[75] Adolescents living in urban and rural areas had a similar prevalence of e-cigarette cessation. In addition, users in general reported they were more likely to stop the use of e-cigarettes if they were currently using non-nicotine e-cigarettes.[75]

Advertising
Extent of literature
Thirteen mid and high priority studies focused on disparities related to advertising. All of these studies focused on e-cigarettes; none examined HTPs.

Study design
All of the 13 studies were cross-sectional.

Populations/locations addressed in the literature
Most of the mid and high priority studies were conducted in the United States (n=11), of which five were nationally representative. One study was conducted in the US and Canada, and one was not specific to an area as it was an analysis of Twitter ads. Four studies were published in 2019, two in 2018, one in 2017, one in 2016, two in 2015, and three in 2014.

Key findings
These studies suggest higher exposure to e-cigarette advertisements among Whites, LGBT populations, and those who live in urban areas. The evidence surrounding gender is mixed, though there is some evidence of elevated exposure among males. Evidence on SES is also mixed, and more evidence is needed regarding education and age disparities.

One study examined disparities in advertising based on primary language spoken at home among Hispanic adults. While non-English speakers were more likely to hear about e-cigarettes from the news, native English speakers were more likely to find out about e-cigarettes through friends and family. The highest exposure to storefronts, billboards, and the internet was found among non-native English speakers, followed by native English speakers and then non-English speakers.[76]

Age
Research findings on age disparities in advertising were unclear, as the populations and advertising measurements varied across studies. A national study of US adolescents found that e-cigarette advertisement exposure across different sources (retail, internet, TV/movies, newspapers/magazine) was higher among students in higher grade levels.[77] Another national study found that exposure to, searching for, and sharing

e-cigarette-related information was associated with younger age. This study did not specify the content of the information nor the sources of exposure to information by demographics.[78] A third nationally representative study found that adolescents were more likely than older adults to report exposure to advertisements on television and digital marketing, but were less likely to report exposure in the retail environment, radio, and print media.[79] One non-representative study found elevated POS advertising density in areas with fewer adolescents and more young adults.[80]

Education

Both studies reporting on educational disparities in e-cigarette advertising were US nationally representative studies. One found that e-cigarette advertisement exposure was highest among those with some college, followed by participants with a 4-year college degree or more, and then participants with a high school diploma or less.[79] Likewise, having more education was associated with exposure to and searching for e-cigarette information and having less education was associated with only sharing information, although the content of information was not assessed by the study.[78]

Gender

Evidence surrounding gender disparities related to e-cigarette advertising is mixed, with some evidence of slightly elevated exposure among males. One national study found elevated overall advertisement exposure among males versus females when examining retail, print, television, radio, and digital marketing.[79] Another representative study found higher exposure to e-cigarette information via television, radio, print media or internet for men than women.[78] A study examining vaping-related handles on Twitter found disproportionately male audiences for vaporizers and e-liquid handles.[81] On the internet and in newspapers and magazines, however, exposure was reported more frequently by females than males in a national US study.[77] In a study examining tobacco print ads, e-cigarette ads were commonly found in magazines with primarily male audiences, such as Rolling Stone, Men's Journal, and Maxim. Ads for Blu e-cigarettes, on the other hand, were found in some magazines targeting women, such as Star and Us Weekly.[82] In a non-representative study, e-cigarette commercial exposure was more heavily associated with e-cigarette use among females than males,[83] suggesting females may be more susceptible to the advertising they are exposed to.

LGBT

All studies examining e-cigarette advertisements and LGBT status were nationally representative US studies. One study found LGBT, compared to non-LGBT, adults were significantly more likely to report exposure to, searching for, and sharing e-cigarette advertisements, among both adults and smokers.[84] LGBT and non-LGBT individuals were equally likely to report being exposed to tobacco control messaging.[84] In a second nationally representative study that further disaggregated these populations, bisexual women reported higher e-cigarette advertisement exposure than heterosexual and lesbian women, and gay and heterosexual men reported higher exposure than men who identified as something else.[85] LGBT adults were less likely to report exposure to e-cigarette content on regular television, but significantly more likely to report exposure to, searching for, and sharing content on a variety of online sources (i.e. Facebook, YouTube, video streaming websites, Twitter, Tumblr).[84] However, another study found that LGB status was not associated with exposure to or searching for e-cigarette information, but LGB respondents were more likely to share e-cigarette information.[78]

Race/ethnicity

Results generally suggest higher exposure among Whites compared to other races, though evidence varied depending on the measure (e.g. exposure at the individual level versus at the community level) and the nature of the study (e.g. representative versus non-representative). Evidence from two representative studies and one non-representative study suggested elevated advertisement exposure among Whites versus Blacks and other races.[79,85,86] The non-representative-study also found that e-cigarette advertisement increased over time; this increase was greater for Whites than Blacks.[86] One study found audiences for vaporizer and e-liquid Twitter handles were disproportionately White compared with the Twitter median average.[81] Another found e-cigarette

print ads occurred in magazines whose audiences consisted mainly of Whites, and ads tended to feature White models above those of other races.[82] In a representative US study, Whites were more likely to be exposed to e-cigarette information than other races and more likely to share information after being exposed than Blacks. However, Hispanics were more likely to share e-cigarette information.[78]

A non-representative study found increased e-cigarette advertising density among neighborhoods with more Black and Hispanic residents, compared to neighborhoods with more White residents.[80] Another found a higher prevalence of e-cigarette promotions, but not advertisements, in communities with a higher percentage of Black residents. The same study, however, found a greater variety of products advertised in high-disadvantage Black communities and low-disadvantage White communities.[87] Though the prevalence of promotions was higher in Black communities, use was not. This may suggest recent efforts by the vaping industry to expand its customer base beyond Whites. Evidence from a non-representative study also suggested that advertisement exposure is significantly related to e-cigarette use among Blacks, but not Whites.[86] One study examining advertising on Tribal lands in California found no significant difference in exterior e-cigarette advertising on and off Tribal lands.[88]

Sources of e-cigarette advertisement also differed by race. While more White versus Black and other race adolescents and adults reported encountering advertisements in stores and the internet,[77,86] more Blacks than Whites reported exposure to advertisements on the radio or television.[77,86] Exposure to newspaper or magazine advertisements was comparable across racial groups.[86]

SES
One representative study found that SES was not associated with exposure to or sharing of e-cigarette information, but higher SES was associated with searching for e-cigarette information.[78] One non-representative study found a higher intensity of point-of-sale e-cigarette advertising in lower-SES neighborhoods.[80] A third non-representative study found that higher SES was associated with greater e-cigarette advertising exposure, and higher advertisement exposure was associated with more frequent e-cigarette use.[89]

Urban/rural
Two non-representative studies focusing on urban/rural disparities in advertising found higher advertisement density in urban, compared to rural, areas.[80,87]

Access

Extent of literature
Twelve mid/high priority studies primarily discussed e-cigarettes in relation to access by conducting retailer evaluations (e.g. availability of e-cigarettes in certain retailers, vape shop density), assessing the means through which people acquire their devices, including if they use price promotions, and assessing cost. None of these studies examined access as it relates to HTPs.

Study design
All studies were cross-sectional. Two were published in 2020, one in 2019, three in 2018, one in 2017, three in 2016, one in 2015, and one in 2014.

Populations/locations addressed in the literature
All but one study, which was conducted in Australia, were from the US. The majority of these studies (n=7) had retailers as their sample, assessing age, gender, racial/ethnical, and socioeconomic factors at the neighborhood level. Three assessed retailers at the national level. One studied focused on adolescents and four on adults, accounting for sociodemographic differences within these groups.

Key findings
While earlier national studies found e-cigarette retailers to be more prevalent further from schools and in higher income neighborhoods with more White residents,[90] recent studies found an increased density of retailers in lower-income areas and where racial/ethnic minorities and live.[91-94] Nevertheless, the definition of

an e-cigarette retailer varied across the studies (e.g., vape shops, tobacco retailers, community pharmacies). Overall, evidence on how people acquire their e-cigarettes and how much they pay is still limited. Based on the studies we identified, there were multiple sources for acquiring products, from vape shops and tobacco retailers to the Internet and friends and family that varied depending on the population. The evidence also shows that price promotions might be used to attract consumers in general.[88,95] Overall, available evidence indicated that e-cigarettes might be cheaper than traditional cigarettes and therefore accessible for disadvantaged/vulnerable populations[73,90,96,97] for a variety of different reasons, such as tax imbalance compared to cigarettes[90] and the availability of different types of e-cigarettes.[74,97] One of the few studies comparing different types of e-cigarettes (specifically, vape pen and mod) found that mod use was associated with spending more money in vape shops and intention to use e-cigarettes as a cessation device was associated with spending less money. This same study also found a significant decrease in participants' monthly spending on nicotine delivery devices (cigarettes and/ or e-cigarettes) after e-cigarette initiation; yet, those who spent less money on e-cigarettes still used traditional cigarettes, possibly indicating that those spending more might be more successful in using e-cigarettes for smoking cessation.[97]

Age

Three studies reported on age differences when assessing retailer density. The earlier national study assessing availability of e-cigarettes did not find retailers near K-12 schools;[90] another one found that vape shops in urban areas were located in areas with a higher population of 18-44 years old, whereas associations between age and vape shop density were less evident in non-urban areas.[94] A study in Orange County, CA, did not find any statistically significant difference in terms of age (under 18 and 18-24) between census tracts with and without vape shops.[91]

The one study that focused on adolescents reported on their many ways of acquiring an e-cigarette, such as from a friend, family member or unrelated person, vape shop, retail location, and the Internet.[98] High school adolescents were more likely to acquire their e-cigarettes from a vape shop or retail outlet (12th grade) or from a friend (10th and 9th grades) compared to middle-school adolescents.[98] One study found that younger adults (18-24 versus 25-34 years) were more likely to visit a vape shop; those visiting vape shops were more likely to have used e-cigarettes in the past 30 days.[99] Sears et al. did not find any statistically significant age difference on spending money in vape shops. Customers who spent less than $50 were on average 29.5 years old while those who spent $50 or more were 26.5 years on average; customers spending less in vape shops were more likely to use e-cigarettes for cessation.[97] The one study assessing price promotion use did not find any age differences in use among adult e-cigarette users.[95]

Education

One national study found that vape shops were less likely to be located in census tracts with higher education in urban areas;[94] similarly, a study in Orange County, CA, found that vape shops were located in tracts with lower education.[91]

One study assessing the use of price promotions among e-cigarette users did not find any difference in use by education.[95] Education was also not correlated with visiting a vape shop[99] nor with the amount spent in vape shops.[97]

Gender

Only one of the studies assessing retailer density reported on gender, which was not significantly associated with density. Other studies also did not find statistically significant differences between males and females in the way they obtain their e-cigarettes,[98] vape shop visits,[99] and use of price promotions among e-cigarette users;[95] however, one study found that men spent more money in vape shops than women.[97]

Race/ethnicity

While Rose et al. found that e-cigarette availability was slightly lower in stores in Black and Hispanic neighborhoods,[90] more recent evidence does not support this finding. One study using national data and assessing both urban and non-urban areas showed that vape shops were located in census tracts with a

higher proportion of minority populations: Hispanics (urban/non-urban), Asians (urban), and Blacks (non-urban).[94] These findings are consistent with other studies at the city level that found more vape stores located in census tracts with more Asians, Hispanics, and foreign-born population[91] and that licensed alcohol outlets with e-cigarette availability were located predominantly in non-White neighborhoods.[92] In addition, findings from another study at the national level reported that vape shops were more densely distributed in school districts with more Asians and Blacks.[93] Similarly, vape shops were located closer to schools where more Asians, Blacks, and Hispanics resided whereas distance to schools increased with a higher population of Whites and those in poverty.[93] E-cigarette availability across pharmacies in St. Louis, MO, did not vary by neighborhood racial distribution.[100] Although one study found that e-cigarettes were more available in stores within a 1-mile radius of Tribal lands in California, tribal members were offered discounts for purchasing tobacco products only at stores on Tribal lands.[88]

The evidence on the means of acquiring e-cigarettes, including the use of promotions, is still limited. One study assessing the use of price promotion among e-cigarette users did not find any difference in use by race.[95] On one hand, Hispanic adults and other races compared to Whites were more likely to visit a vape shop;[90] on the other hand, White adolescents had higher odds of obtaining their e-cigarettes from a vape shop or from a friend compared to Hispanics and Blacks, respectively.[98]

➡️ **SES**

The findings related to SES are mixed among the three national studies assessing retailer density: Rose et al. found that e-cigarettes were more available in stores in neighborhoods with higher median household income across the country;[90] Venugopal et al. found that a school district's poverty was not related to the distribution of vape shops, but the distance to vape shops increased with a higher population in poverty;[93] further, Dai et al. found vape shops were more likely to be concentrated in tracts with less owner-occupied housing units in both urban and non-urban areas.[94] Results at the subnational level are similar: e-cigarettes were found to be available across pharmacies in St. Louis, MO, regardless of the neighborhood poverty rate;[100] on the other hand, in Baltimore, MD, licensed alcohol outlets with e-cigarette availability were located predominantly in lower-income neighborhoods[92] and in Orange County, CA, more vape shops were located in census tracts among the 2nd poverty tertile compared to the lowest poverty tertile, and no differences were found between the 2nd poverty tertile and the highest.[91]

One US-study found that young adults visiting vape shops reported not having financial challenges (i.e., they met their basic financial needs and had extra money left).[99] Another one did not find any significant difference in money spent in vape shops in Louisville, KY, by SES. Socioeconomically disadvantaged Australian smokers reported that the most common way to acquire their e-cigarettes was from a friend or stranger; the next most common way was from a tobacco shop.[96]

➡️ **Urban/rural**

Only one study reported differences related to urbanicity. Dai et al. found that vape shops were concentrated in large metropolitan areas and in areas with larger populations in both urban and non-urban areas.[94]

Research in the pipeline

In general, the information available regarding studies in the pipeline was limited. We identified 41 studies across all organizations and programs from 2011 to the present that informed the intention to address tobacco-related disparities (**Table 5**). In addition, due to the diverse information available and time constraints, we did not cross-reference to see if publications were already available. Results presented here are intended to show the breadth of funded studies so far.

Table 5. Characteristics of studies in the pipeline addressing disparities (N=41)

	Number of studies
Funding organization or program	
National Institutes of Health (NIH)	13
U.S. FDA's Tobacco Centers of Regulatory Science (TCORS)	9
Tobacco-Related Disease Research Program (TRDRP)	12
Cancer Research UK	7
First funding year	
2011-2015	12
2016-2020	28
Not available	1
Study location	
US	16
UK	5
Other	2
Not available	18
Study design	
Cross-sectional	2
Longitudinal	10
Mixed methods	6
Simulation modeling	3
Other	9
Not available	11
Sample population[a]	
Age	22
Education	3
Gender	14
LGBT	5

	Number of studies
Race/ethnicity	21
SES[b]	16
Urban/rural	2
Smoking status[c]	4
Theme	
Access	2
Advertising	4
Cessation	3
Switching from cigarettes to e-cigarettes	3
Health effects	4
Prevalence	19
Other	6
Product type	
Alternative tobacco products/ Other tobacco products/ Alternative nicotine products	9
E-cigarettes	19
Multiple tobacco products	13

[a]   Sample population refers to the characteristics of the population being studies, including variables being collected.

[b]   For the purpose of this report, SES is a broad term used to indicate studies assessing household income, poverty, class-differences as well as other indicators of SES, which varied by study.

[c]   Smoking status captured if studies were also assessing the smoking status of the population, including current cigarette smokers, former cigarette smokers, those who have never used cigarettes, or dual users.

Discussion

This scoping review aimed to characterize the literature on e-cigarettes and HTPs in relation to tobacco-related disparities and health equity. While the evidence on HTPs is limited, the number of studies on e-cigarettes and health disparities has increased over time with the vast majority of them being from high-income countries. In addition, most of the literature on the themes reported here focused on disparities, failing to account for the broader social determinants of health in understanding the root-causes of these disparities and the strategies needed to advance health equity.

While the evidence around susceptibility was limited to two studies among adolescents in the US, several studies focused on e-cigarette use. Ever and current use were more prevalent among older adolescents, young adults, males, Whites, urban residents, and LGB individuals. Use of fruit-flavored e-cigarettes was higher among adolescents and women, whereas use of tobacco and other flavored e-cigarettes was higher among young adults and men. The vast majority of low-priority studies were also on use with very few assessing susceptibility to e-cigarette use.

All studies assessing the use of e-cigarettes for smoking cessation relied on cross-sectional or qualitative data and did not account for the type of device being used nor if flavored e-cigarettes were being used. These data showed that younger smokers, those with more than a high school degree, Whites, and males seemed to be more likely to use e-cigarettes in cigarette smoking quit attempts; nevertheless, there is a lack of critical details available, including who eventually quits e-cigarettes.

Overall, there was higher advertisement exposure among Whites, LGBT populations, and people living in urban areas. However, several mediating factors influenced the exposure among and within groups, such as the source of advertising (e.g., Internet versus television). Only one study assessed the impact of anti-tobacco campaigns; understanding how different groups receive these messages would help to further tailor campaigns and increase their efficacy.[84] One study among Hispanic adults assessed advertisement exposure based on the primary language spoken at home; the overall result that non-English speakers were the least exposed group to certain forms of advertisement reinforces the need for discussion around acculturation in increasing use of tobacco products.[76]

Similarly, studies assessing access to e-cigarettes should be considered according to the study's design and the variables assessed. For example, studies varied in their definition of an e-cigarette retailer (e.g., vape shops, licensed alcohol outlets). Yet, the evidence showed that vape shops were more likely to be concentrated in neighborhoods of lower-SES and with higher concentrations of Blacks, Hispanics, and Asians. The evidence on means of acquiring e-cigarettes, use of price promotions, and users' monthly expenses is limited.

In terms of study populations, most of the studies reported outcomes by age, SES, and race/ethnicity; nevertheless, outcomes for racial groups beyond Black and Hispanic in the mid and high priority were limited. Few studies (including research in the pipeline) focused on LGBT individuals, and only two studies in the mid and high priority sample included transgender people; out of the 451 studies in the low priority sample, only 26 reported outcomes on LGBT populations. Research focusing on LGBTQ+ populations face the additional challenge that large nationally or state-representative surveys do not collect information on these populations (see **Appendix 2: Assessment of US surveillance systems**). Similarly, there are not many studies reporting on outcomes by geography (urban/rural), which is a concern in the US where previous research has shown high rates of tobacco use among rural subpopulations and mixed results for e-cigarette use.[101]

Research in the pipeline showed an increase in the funding of projects addressing tobacco-related disparities over time. Based on the available information, there are 10 studies categorized as longitudinal, which might help to address the lack of causality among the outcomes reported by this scoping review. Despite use being the major focus of most studies, several other domains were captured in the funded projects, such as advertising, switching from cigarettes and other tobacco products to e-cigarettes, cessation, and access. However, more efforts are needed to address gaps related to specific populations. We did not identify any currently funded studies on HTPs and health equity among the funding agencies and programs included in our search.

Convening with experts – research gaps and priorities

In June 2020, we held a two-day convening with 25 experts from academia, funding agencies, and non-profit organizations in the US and the UK. Participants were invited considering their extensive work in tobacco control and/ or health equity. The goal of the convening was to discuss the research gaps and limitations identified by this report to collectively establish priorities that will support progress on a health equity research agenda related to e-cigarettes/ HTPs (**Table 6**). Participants had the opportunity to review the report before the convening and to share their opinions with the whole group.

Overall, participants recognized the importance of discussing tobacco-related disparities and that, in moving forward with a research agenda, health equity should be at the front and center of all priorities. There was concern that e-cigarettes and HTPs could further increase tobacco-related disparities; proactively monitoring trends in use behaviors and counteracting inappropriate use of these products are essential steps. This includes optimizing use of the current national surveillance systems.

Participants also agreed that e-cigarettes and HTPs present new challenges that require research to adapt at a much faster pace: (a) how to obtain sufficiently sized cohorts of sole e-cigarette users and dual users to understand implications on health and to help establish causality with other factors of interest; and, (b) how to study a very heterogeneous and rapidly changing marketplace with many different products that have very different nicotine delivery profiles. Considering that the root causes of many health outcomes are usually shared (e.g., racism, inequitable policies), there are lessons across different outcomes that could support this endeavor. For example, it is worth considering how studies on obesity incorporate internalized racism and historical inequities to their study design,[102,103] and if/how these methods might be applicable to tobacco control. Researchers, reviewers, and journals should incorporate several standards when writing, reviewing, and publishing articles on health equity so that the role of social determinants of health in increasing inequities is critically examined.[104] While it is essential to include gender, sexual orientation, race, SES, etc. as analytical categories, research would be strengthened if authors used them in the broader socioeconomic and political context; that means considering sexism, homophobia, racism, poverty, etc. as drivers of health inequities.[104]

Participants also highlighted that achieving a culture of health requires changes to the culture of science mainly in relation to funding and considering ways of measuring impacts of researchers other than number of peer-reviewed articles. To start, there needs to be more concerted and purposive efforts in choosing who is funded and what research is prioritized. For example, funding researchers from groups that have been excluded or marginalized might result in more relevant research questions given their lived experience.[105] These are ways to value evidence from perspectives beyond the dominant scientific perspective; other ways include incorporating the perspectives and obtaining input from communities, especially those affected by these issues. Further, calls for proposals should include a requirement for researchers to indicate how their proposed work will inform improvements in health equity.[104]

Table 6. Research gaps identified by the convening's participants, ordered alphabetically by category

CATEGORY*	KEY RESEARCH GAPS
Access	· Assess online purchasing · Assess use and targeting of price promotions and discounts
Advertising	· Conduct more studies on advertisement and social media, including pro and anti-tobacco messages and understanding who the industry is targeting
Cessation	· Determine the impacts of flavored products on cessation · Assess e-cigarettes' effectiveness for smoking cessation among different populations, especially among populations disproportionately harmed by tobacco products · Assess who quits and who does not quit e-cigarette use · Assess who are the smokers who cannot/will not quit cigarettes with means other than e-cigarettes
Equity (equity should be incorporated into all other categories of research)	· Incorporate an intersectional approach in research, and preferentially approach in research, and preferentially doing so using national surveillance systems · Given that equity is as much (if not, more) about process as it is about outcome, increase diversity among researchers by a) prioritizing the funding of researchers from groups that have been excluded or marginalized; b) consider funding mechanisms for smaller universities and community colleges, and c) developing pathways for investment in community-based participatory research · Contextualize findings in the broader social determinants of health · Take a holistic view of tobacco use in the context of noncommunicable diseases and environmental health and justice · Determine impacts on behavioral health groups · Assess structural and social factors as drivers of tobacco-related inequalities · Include and assess indicators of equity in surveillance and studies · Explore aspects of the vaping culture
Industry monitoring	· Examine e-cigarette industry behavior, including looking at tobacco industry documents · Explore the industry's goals: what they are doing versus what they are saying while considering the local cultural context (e.g., IQOS marketed differently in different countries) · Explore the relationships between tobacco and cannabis companies and strategies
Policy	· Conduct cross-country natural experiments to assess impacts of different policies · Assess the impacts of policies on health disparities including, but not limited to, tobacco control policies (e.g., housing policies) · Obtain more information on tobacco-related disparities and e-cigarettes/HTPs from low- and middle-income countries accounting for their regulatory frameworks
Prevalence	· Assess longer-term use and transitions between products, including cannabis · Assess disparities in the use of flavored products and their impacts on initiation · Assess use in the context of cultural norms and stigma
Product	· Be explicit about the type of e-cigarette being studied (e.g., pod versus open system) · Obtain more information on tobacco-related disparities and HTPs
Specific population	· Assess differences among Hispanic sub-groups · Assess generational differences among immigrant populations · Conduct more studies among the LGBTQ population, including sub-groups
General	· Conduct longitudinal studies · Develop standard terminology and definitions for use behaviors and product types · Assess the impacts of interventions that are broader than tobacco control (e.g., increasing minimum wage, housing policies) · Conduct qualitative research for an understanding of the why's (e.g., reasons for use, role of culture, effects of social exclusion) · Assure quality of the research and research proposals

The categories of research are not mutually exclusive, and they can be addressed as part of the same research endeavor.

Moving towards the 4th generation

Reporting and understanding health disparities are essential to measure progress in achieving equity.[18,106] However, as proposed by the HEART framework, moving towards a 4th generation of research through multilevel interventions, comprehensive evaluations, and researchers' self-reflection is essential to address the structural determinants of disparities in order to eliminate them.[18] Studies in our sample could be categorized in the following generations based on the HEART framework and their overall objective: 30 studies in the first (documented existing disparities), 38 in the second (determined causal relationships that underlie disparities), and 13 in the third (identified solutions for eliminating disparities). Nevertheless, studies classified in the second generation still failed to recognize the social determinants of health as a cause of e-cigarette use; and, although the ones in the third generation are trying to answer what intervention works and for whom, they did not apply the three principles delineated by Thomas et al.: transdisciplinary, community-engagement, and translation of evidence-based practices.[18]

Several steps might be taken to support stronger research across all generations. One important first step is the need to oversample certain groups in order to be able to obtain stable estimates for these groups.[107] Our results showed that exploring the various LGBT populations (e.g., female bisexual versus male bisexual versus gay versus lesbian versus transgender) revealed different trends regarding e-cigarette use and exposure to advertising.[85] In addition, intersectionality may help to elucidate health disparities since it considers how multiple sociodemographic factors interplay to shape these disparities.[108] An intersectional approach also considers the sociodemographic factors within the broader social, political, cultural, and regulatory contexts,[108] helping to further inform policies and future research. Further, community-based participatory research (CBPR), a full partnership with the population being studied from the conception to the implementation of the research and even intervention, has the potential to address inequities by empowering the community, incorporating local knowledge and perspectives in the study design and analysis, and providing resources to the studied community.[109] CBPR is only one way to engage with the community in research;[17] when it is not an appropriate research method, other methods of obtaining community input and involvement should be considered. For example, Begay et al. teamed with American Indian/American Native health practitioners to collect data on e-cigarette availability and reinforced the importance of engaging other community members and Tribal governments in advocating for stronger tobacco control laws.[88] Further, developing multilevel interventions is key in addressing interpersonal, organizational, community, educational, occupational, environmental, and political factors resulting in health;[110] studies assessing the impact of multilevel interventions will require robust methods, including more mixed-methods research.[18]

Limitations and strengths

There are some limitations of this review. Our priority classification of the articles was based on the study's relevance to health equity rather than the quality of the study. While lack of quality assessment is a limitation of a scoping review,[19] we can consider the study designs of the included articles to provide some insight into the quality of this literature. The vast majority of the studies (74 of 81) were cross-sectional. While this type of study design is important for investigating certain exposures and outcomes, they represent a snapshot at one point in time and thus causality between exposures and outcomes cannot be ascertained. In addition, if the sample size is not large enough, there may not be sufficient power to detect statistically significant differences in associations across subpopulations, which was an issue in some studies in our sample especially when assessing race/ethnicity and LGBTQ+ populations. For example, analyses of race/ethnicity were restricted to Whites versus Non-whites in some studies because the other race/ethnicity groups were too small. Also, when participants are not randomly selected from the whole population, results might not be generalizable beyond the study sample. In total, 31 studies across the themes of access, advertising, cessation, and prevalence used nationally representative samples. Lack of statistical power and of randomization are both of particular concern to properly detect and monitor disparities. Furthermore, in cross sectional studies participants are often asked to remember past behaviors, which could result in recall bias. Considering the moral and cultural factors around smoking and nicotine addiction, participants might answer questions in a socially acceptable manner rather than reporting on their actual behavior (i.e. social desirability bias, which is not limited to cross-sectional

studies). Overall, the literature on health disparities/equity in relation to e-cigarettes and HTPs is mainly cross-sectional, which would be classified as of low-quality per Cochrane standards. Yet, cross-sectional studies can provide valuable information in a timely manner and generate hypotheses to explore in future studies.

We did not review studies reporting on tobacco use without specifying e-cigarettes and/or HTPs in the abstract, so we might have missed some relevant articles. We also did not include studies reporting on vaping other substances (e.g. THC, CBD) as we were interested in tobacco-related disparities. We did not account for contextual and regulatory factors to interpret the results, yet the majority of studies were from the US. While we indicate the country of origin of non-U.S. studies, we have discussed all the available evidence regardless of its origin. Research on e-cigarettes and HTPs present several additional challenges that lower its quality, mainly the lack of standardization across studies (e.g., how to measure the details of e-cigarette use behaviors).

This report aimed to capture the breadth of the available literature: our search was not restricted to a certain timeframe, country, language, subpopulation, or study design, and included studies funded over the past few years. In addition, the information presented here was discussed with experts from civil society, academia, and funding organizations in a two-day convening. This diverse group of experts provided valuable insights regarding the findings and draft report, which have been incorporated into this final version.

As indicated by the HEART framework, identifying and documenting disparities is the first step to advance a research agenda that focuses on eliminating them. Cross-sectional studies conducted with scientific rigor can support this first step. In the context of e-cigarettes/HTPs and health equity, which is still an emerging topic, data from the cross-sectional studies in conjunction with data from the other types of studies presented here helped guide the identification of research gaps and priorities to advance our understanding of the topic as well as proposed principles to support a research agenda focused on eliminating tobacco-related disparities. While higher quality research is needed, it is also important to move ahead in the trajectory towards the next generations of research, which right now would be establishing causality and examining social determinants of health. Interventions that have been shown to be effective for the population as a whole should be assessed across different populations to guide future initiatives to advance health equity.

Proposed principles

Principles can help establish ultimate goals and can guide and inform decision-making, priorities, and practice. In researching e-cigarettes and HTPs, the history of tobacco use and trajectories should be taken into account especially because of the well-documented longstanding practices of the tobacco industry that include targeted marketing to various groups that have been excluded or marginalized and now face persistent disparities. While e-cigarette and HTP use has not started predominantly in those groups, it is important to continuously monitor whether the epidemiology of use is changing over time to avoid further perpetuating or increasing tobacco-related disparities.

The principles below are proposed to help foster a sustained health equity research agenda to support evidence-based interventions related to e-cigarettes and HTPs. While these principles are not new, the novelty of e-cigarettes and HTPs combined with established research on tobacco-related disparities provide a timely opportunity to put them into action. In addition, the COVID-19 pandemic and social movements such as Black Lives Matter have encouraged discussions about health, healthcare, and structural inequities in the U.S. as well as in other parts of the world. The research enterprise can no longer simply document inequities without addressing them. Research, surveillance, and evaluation of e-cigarettes and HTPs should go beyond identifying and monitoring disparities. It should ensure a more comprehensive understanding of mechanisms that create, maintain, and exacerbate health inequity coupled with the development, evaluation and implementation of solutions at scale to promote health equity.

a Research and interventions should not create, maintain, or further increase tobacco-related disparities, even if they may reduce tobacco use in the population as a whole. Study proposals should be required to specify how findings will advance health equity. Evaluation efforts should assess impacts on health equity.

b Research, surveillance, and evaluation efforts assessing the impacts of e-cigarettes and HTPs and interventions to address them should account for both the individual and community levels within the socioeconomic, cultural, and historical contexts that cause inequities; for example, research should examine discrimination as a cause of health inequities and its relationship with exposures and health outcomes.

c Surveillance efforts should be expanded with regard to both sample size and questionnaire content, to provide detailed and generalizable information related to groups that have been excluded or marginalized (e.g., LGBTQ+).

d Groups that have been excluded or marginalized are defined by multiple sociodemographic characteristics, and thus research into tobacco-caused health disparities and the impact on health equity should be designed with an intersectional lens whenever possible.

e Communities that are the focus of or would otherwise be impacted by research should be meaningfully engaged: study results should be shared with communities and, whenever possible, these communities should serve as active collaborators and provide input on research efforts, priorities, and interpretation of the findings.

f Effective and sustained efforts must be implemented to help increase the participation of researchers who bring lived experience and expertise in navigating fundamental causes of tobacco-related disparities in all aspects of the research endeavor. Funding decisions should take into account leadership and involvement of researchers on research teams who are from groups that have been excluded or marginalized. Funding for research focused on advancing health equity and involving affected communities should be expanded.

g The tobacco industry has a long history of targeting groups who have been excluded or marginalized to support its own interests. To prevent the industry from further increasing disparities, research, decision-making, and interventions should not be influenced by or otherwise involve any contribution from the tobacco industry.

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Appendix 1: Overview of low priority studies

Characteristics of low priority studies (n=451)

	Number of studies
Publication year	
2011-2015	77
2016-2020	374
Study location	
Australia	7
Canada	15
European Union	11
France	10
Germany	9
Hong Kong	5
Malaysia	6
Mexico	4
Poland	7
South Korea	13
Taiwan	5
UK	19
US	237
Multiple countries	3
Other	56
Not available	44
Study design	
Cross-sectional	361
Longitudinal	52
Mixed methods	6
Qualitative	6
Review	10
Report	3
Other	4
Not available	9
Data source	
Newly collected data	197
Canadian Student Tobacco Alcohol and Drugs Survey	5
Eurobarometer	6
Global Youth Tobacco Survey	6
International Tobacco Control Policy Study	5
Korea Youth Risk Behavior	5
National Health Interview Survey	9

	Number of studies
National Adult Tobacco Survey	9
National Youth Tobacco Survey	29
Population Assessment of Tobacco and Health	22
Youth Risk Behavior Surveillance System	7
Multiple sources	8
Other	120
Not available	23
Study population	
Age	432
Education	93
Gender	333
LGBT	26
Race/ethnicity	243
SES[a]	215
Urban/rural	25
Smoking status (current smokers, dual-users, never smokers)	343
Theme: Use (n=355)	
Age	345
Education	80
Gender	281
LGBT	24
Race/ethnicity	189
SES[a]	171
Urban/rural	21
Theme: Susceptibility to e-cigarette/HTP use (n=14)	
Age	14
Education	3
Gender	9
LGBT	0
Race/ethnicity	9
SES	5
Urban/rural	0

Characteristics of low priority studies (n=451)

	Number of studies
Theme: Cessation (n=41)	
Age	38
Education	6
Gender	23
LGBT	1
Race/ethnicity	24
SES	18
Urban/rural	0
Theme: Advertising (n=32)	
Age	27
Education	4
Gender	16
LGBT	1
Race/ethnicity	17
SES	16
Urban/rural	2
Theme: Access (n=9)	
Age	8
Education	0
Gender	4
LGBT	0
Race/ethnicity	4
SES	5
Urban/rural	2
Product type	
E-cigarettes	439
HTPs	4
E-cigarettes and HTPs	8

[a] For the purpose of this report, SES is a broad term used to indicate studies assessing household income, poverty, class-differences as well as other indicators of SES, which varied by study.

Appendix 2: Assessment of US surveillance systems

National surveillance systems provide an opportunity for consistent and efficient data collection that may allow the monitoring of changing e-cigarette and HTP trends. We examined 12 national US surveillance systems to identify the information collected and existing gaps related to e-cigarettes/HTPs and health equity.

The most recent available versions of 17 surveys were assessed in August 2020 for inclusion of questions relating to e-cigarettes, HTPs, and possible indicators of health equity. A broad definition of health equity indicators was employed in order to capture information about a wide range of variables that may provide insight into health equity and e-cigarettes/HTPs. In cases where surveillance systems had multiple surveys, each survey was assessed separately for the questions of interest and information was combined when appropriate (e.g. BRFSS core and BRFSS optional surveys were analyzed as a single system), resulting in a total of 12 systems analyzed. Further information about each of the 12 systems can be found in **Table A1**. The majority of the surveillance systems were cross-sectional (n=10). Five are administered approximately annually, five are administered on an irregular basis, and two are administered every 2-4 years.

Table A2 describes the presence of questions evaluating topics related to sociodemographic characteristics and health equity in each of the 12 systems evaluated. None of the 12 systems assessed religion, internet access, incarceration, pollution, exposure to alcohol use/ads, or access to childcare. NHIS was the only system to assess transportation access, engagement with art, access to green space/parks, and perceived neighborhood safety. Of the 12 systems that assessed race, only five (BRFSS, NATS, NHIS, PATH youth, TUS-CPS) disaggregated racial minorities. When systems included questions about ethnicity, the most common options included non-Hispanic/non-Latino/non-Spanish, Mexican/Mexican American/Chicano/Chicana, Puerto Rican, and Cuban. Three systems (YRBS middle, national, and standard) included only Hispanic/Latino or non-Hispanic/non-Latino as options for ethnicity and six provided an 'other' option for ethnicity. All systems assessed gender identity, of which seven included only male and female as options. The remaining five systems used a variety of techniques to assess gender identities beyond male and female - including transgender as an option for gender (n=1), as a separate question (n=3), or as an option for sexual orientation (n=1). AIATS also included "Two-Spirit" as an option for gender. Eight systems assessed sexual orientation. The most common options listed for sexual orientation were gay or lesbian, bisexual, and heterosexual or straight. Among the systems evaluated, SES measures beyond household income included ability to pay bills; parental education; parental income; where respondents would place themselves on a ladder; receipt of federal/state/local assistance; money received per week from jobs, allowances, etc. (for youth); if respondents worked for pay in jobs like babysitting or yard work (for youth); overtime pay amount; income from other places (e.g. interest-bearing accounts, investments, rental income, etc.); and income from Supplemental Security Income/Social Security Disability Income. Among the six systems that included a question about disabilities, all asked "Because of a physical, mental, or emotional condition, do you have serious difficulty concentrating, remembering, or making decisions?" or similar. Two included other measures of disability status, such as difficulty hearing, difficulty bathing/dressing, difficulty seeing, and use of a walker or cane. Examples of mental health measures include depression, anxiety, trouble sleeping, suicidal intent, suicidal attempts, and schizophrenia diagnosis. Unique measures of demographics/equity included access to places like movies, libraries, or places of worship; physical abuse by dating partner; skipping medication to save money; meal skipping due to lack of money; neighborhood walkability; access to bus/transit stops; and access to playgrounds.

Table A3 describes the inclusion of questions on various measures related to e-cigarettes and HTPs. None of the systems assessed exposure to HTP advertising, use of HTPs for cessation, access to HTPs (i.e. where HTPs were obtained, use of discounts to buy HTPs, price paid for HTPs), susceptibility to HTPs, or reasons for HTP use. Most of the systems (n=10) included questions about e-cigarettes; exceptions include ANATS (developed in 2010) and BRFSS. Few systems assessed e-cigarette device type (n=4), e-cigarette brand (n=4), susceptibility to e-cigarettes (n=4), reasons for e-cigarette use (n=4), price paid for e-cigarette (n=3), use of discount to buy e-cigarette (n=3), and exposure to e-cigarette advertising (n=3). Questions about e-cigarette source (n=7), flavor (n=6), flavor type (n=6), and use of e-cigarettes for cessation (n=6) were slightly more common. All systems that assessed the use of flavored e-cigarettes also asked the type of flavor used. PATH included the most detailed questions on frequency of e-cigarette use, such as refill frequency, puffs/session, and devices used/

day. It is also important to note that these systems all distinguished between HTPs and e-cigarettes. Unique measures related to e-cigarettes/HTPs included second-hand vaping exposure, exposure to warning labels on e-cigarettes, difficulty in purchasing e-cigarettes online and in a store (among youth), use of e-cigarettes for sacred or ceremonial purposes (among American Indians), changes in e-cigarette nicotine concentration used over time, elevated insurance premiums due to tobacco use, and price paid for e-cigarette liquid.

While these systems include a wide range of variables and provide a rich dataset to be used for analyses, it is important to note that there are several topics that warrant more attention. Of note, questions about HTPs are limited in number and scope. While use of these products is currently low in the United States, it is critical that variables related to HTPs are monitored in case these trends begin to shift. In addition, none of the systems assess religion, internet access, incarceration, pollution, exposure to alcohol use/ads, or access to childcare, despite their relevance to health outcomes. Access to housing, citizenship status, employment status, exposure to traumatic experiences, food access, health insurance status, occupation, pregnancy status, and transgender identity were assessed in fewer than half of the systems assessed. Because of the complex and historical nature of health inequities, it is critical to assess a wide range of variables that have relevance to health equity in order to better understand the root causes of tobacco-related disparities and the best avenues for moving towards health equity. Questions must also include appropriate response options that allow respondents to select a choice accurate for their situation. For example, gender identity questions should include transgender and other as options, in addition to male and female. Race and ethnicity questions should disaggregate where applicable. Disability questions should include specific options (e.g. trouble hearing, trouble seeing). Creating a standardized set of questions, particularly pertaining to e-cigarettes/HTPs and socio-demographic characteristics, across systems may alleviate some of these issues by providing a framework for assessing these topics. Including a comprehensive set of well-developed questions about health equity and e-cigarettes/HTPs in nationally representative systems will provide a foundation for first generation health disparities research, while also steering research into the second generation by improving our understanding of the underlying causes of e-cigarette/HTP disparities.

Table A1. Description of surveillance systems

System Name	Abbreviated Name	Year of Survey Evaluated	System Type	Survey Frequency	Survey Population	Sponsor Organization/ Adminstrator
Alaska Native Adult Tobacco Survey	ANATS	2010	Cross-sectional	Irregular	Alaska Native adults aged 18+	Developed by CDC, Administered by health professionals/ localities
American Indian Adult Tobacco Survey, core + supplement	AIATS	2018	Cross-sectional	Irregular	American Indian adults aged 18+	Developed by CDC, Administered by health professionals/ localities
Behavioral Risk Factor Surveillance System, core + optional	BRFSS	2019	Cross-sectional Opt: Irregular	Core: Annually	US adults aged 18+	Developed by CDC, Administered by states
Current Population Survey (CPS) + Tobacco Use Supplement (TUS)	TUS-CPS	CPS: N/A TUS: 2018-19	Cross-sectional	CPS: Monthly TUS: Every 3-4 years	US residents aged 16+	CPS: US Census Bureau TUS: NCI-sponsored Administered by US Census Bureau's CPS
National Adult Tobacco Survey	NATS	2013-14	Cross-sectional	Irregular	US adults aged 18+	CDC/FDA
National Youth Tobacco Survey	NYTS	2019	Cross-sectional	Annually	US youth grade 6-12	CDC/FDA
National Health Interview Survey	NHIS	2020	Cross-sectional	Annually	US households	NCHS, US Census Bureau
Population Assessment of Tobacco and Health, adult	PATH, adult	2018-19	Longitudinal	Approx. annually	US adults	NIH/FDA
Population Assessment of Tobacco and Health, youth and parent*	PATH, youth	2018-19	Longitudinal	Approx. annually	US youth	NIH/FDA
Youth Risk Behavior Surveillance System, middle school	YRBS, mid	2019	Cross-sectional	Irregular	US middle schoolers	Developed by CDC, Administered by localities
Youth Risk Behavior Surveillance System, national	YRBS, nat	2019	Cross-sectional	Every 2 years	US 9-12th graders	CDC
Youth Risk Behavior Surveillance System, standard	YRBS, stan	2019	Cross-sectional	Irregular	US 9-12th graders	Developed by CDC, Administered by localities

*The PATH parent survey is administered to parents and asks about both the parent and the child. For the purposes of this table, PATH youth includes questions asked to the child and asked to the parent about the child.

Table A2. Demographic and health equity questions assessed by surveillance system

In the table below, "Y" is used to denote when a system assess a given topic. "N" is used to denote when a system does not assess the given topic. The column titled "#Ys" includes a count of the number of systems that assess a given topic.

	ANATS	AIATS	BRFSS	TUS-CPS	NATS	NYTS	NHIS	PATH adult	PATH youth	YRBS mid	YRBS nat	YRBS stan	#Ys
Access to housing	N	Y	Y	N	Y	N	Y	Y	N	N	N	N	5
Access to medical care	Y	Y	Y	Y	N	N	Y	Y	N	N	Y	Y	8
Age	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	11
Alcohol use	N	N	Y	N	N	N	Y	Y	Y	Y	Y	Y	7
Citizenship status	N	N	N	Y	N	N	Y	Y	Y	N	N	N	4
Disability status	N	N	Y	Y	N	Y	Y	N	Y	N	Y	N	6
Education	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	12
Employment status	N	N	Y	Y	Y	N	Y	Y	N	N	N	N	5
Ethnicity	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	11
Exposure to traumatic experiences	N	N	N	N	N	N	N	N	N	N	Y	Y	2
Food access	N	N	Y	N	N	N	Y	N	N	Y	Y	Y	5
Gender identity	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	12
Health insurance status	Y	N	Y	N	N	N	Y	Y	N	N	N	N	4
Income	Y	Y	Y	Y	Y	N	Y	Y	N	N	N	N	7
Language	Y	N	N	Y	Y	Y	Y	Y	Y	N	Y	N	8
Location	Y	N	Y	Y	Y	N	Y	Y	Y	N	N	N	7
Medical conditions	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	Y	9
Mental health	N	N	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	9
Occupation	N	N	Y	Y	N	N	Y	Y	N	N	N	N	4
Pregnancy status	N	Y	Y	N	N	N	Y	Y	Y	N	N	N	5
Race	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	12
Sexual orientation	Y	Y	N	N	Y	N	Y	Y	Y	N	Y	Y	8
Transgender identity	N	Y	Y	N	Y	N	N	Y	Y	N	N	N	5

No systems assessed religion, internet access, incarceration, pollution, exposure to alcohol use/ads, or access to childcare. NHIS was the only system to assess transportation access, engagement with art, access to green space/parks, and perceived neighborhood safety.

Table A3. Tobacco-related questions assessed by surveillance system

In the table below, "Y" is used to denote when a system assess a given topic. "N" is used to denote when a system does not assess the given topic. The column titled "#Ys" includes a count of the number of systems that assess a given topic.

	ANATS	AIATS	BRFSS	TUS-CPS	NATS	NYTS	NHIS	PATH adult	PATH youth	YRBS mid	YRBS nat	YRBS stan	#Ys
Cigarette use	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	12
Other tobacco use	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	11
E-cig use	N	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	10
E-cig device type	N	N	N	Y	N	Y	N	Y	Y	N	N	N	4
E-cig brand	N	Y	N	N	N	Y	N	Y	Y	N	N	N	4
Reasons for e-cig use	N	N	N	Y	N	Y	N	Y	Y	N	N	N	4
Susceptibility to e-cigs	N	N	N	N	Y	Y	N	Y	Y	N	N	N	4
Price paid for e-cig	N	N	N	Y	N	N	N	Y	Y	N	N	N	3
Use of discount to buy e-cig	N	N	N	N	Y	N	N	Y	Y	N	N	N	3
E-cig source	N	N	N	Y	N	Y	N	Y	Y	Y	Y	Y	7
E-cig ad exposure	N	N	N	N	N	Y	N	Y	Y	N	N	N	3
Cessation with e-cigs	N	Y	N	Y	Y	Y	N	Y	Y	N	N	N	6
E-cig flavor	N	Y	N	Y	Y	Y	N	Y	Y	N	N	N	6
E-cig flavor type	N	Y	N	Y	Y	Y	N	Y	Y	N	N	N	6
HTP use	N	N	N	Y	N	Y	N	Y	Y	N	N	N	4
HTP flavor	N	N	N	N	N	Y	N	N	N	N	N	N	1
HTP flavor type	N	N	N	N	N	Y	N	N	N	N	N	N	1

No systems assessed HTP advertising exposure, HTP source, use of HTPs for cessation, use of discounts to buy HTPs, HTP price, susceptibility to HTPs, or reasons for HTP use.

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