**Using Systems Science to Advance Health Equity in Tobacco Control**

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This project uses systems science to better understand racial/ethnic and socioeconomic disparities in smoking and to identify opportunities for change. Using multiple techniques, including the iceberg model, causal loop diagramming, and the impact gaps canvas, we demonstrate that traditional tobacco control efforts fail to consider the root causes of smoking inequities, such as neighborhood segregation and financial strain, among populations burdened by tobacco use. To reduce racial/ethnic and socioeconomic disparities in smoking, traditional stakeholders in tobacco control must partner with new stakeholders to address these root causes.

In this paper we first describe the public health problem of tobacco use in the United States (US). Next, informed by a scholarly review of the literature, we describe how the field of tobacco control has embraced high-risk and population-level approaches to reduce smoking and present factors typically found in conceptual models of smoking using a causal loop diagram. We then discuss why a priority population approach is needed and offer an updated model of smoking. Next, we present excerpts from interviews with stakeholders who provided feedback on the updated model. We conclude by identifying new stakeholders critical to advancing health equity in tobacco control and summarize additional key insights from this project.

**Smoking in the US**

Smoking has been a pervasive health problem in the US for decades. In 1965, smoking reached an all-time high – approximately 42% of adults were smokers. However, after increasing evidence implicating smoking as a primary cause of lung cancer, public perceptions of smoking began to shift making it less and less socially acceptable.[1,2](http://f1000.com/work/citation?ids=2861989,1303055&pre=&pre=&suf=&suf=&sa=0,0)

Despite considerable progress, tobacco use remains the leading cause of preventable death. In 2019, approximately 34 million adults smoked cigarettes,[3](http://f1000.com/work/citation?ids=8328210&pre=&suf=&sa=0) the most commonly used tobacco product.[4](http://f1000.com/work/citation?ids=2970026&pre=&suf=&sa=0) Each year, $170 billion is spent treating smoking-related diseases.[3](http://f1000.com/work/citation?ids=8328210&pre=&suf=&sa=0)

**Disparities in Smoking**

Although overall smoking prevalence dropped by 50 percentage points between 1965 and 2015, stark disparities in smoking and related health outcomes by race/ethnicity, income, education, psychological distress, disability, sexual orientation and health insurance status remain.[4](http://f1000.com/work/citation?ids=2970026&pre=&suf=&sa=0),[5](http://f1000.com/work/citation?ids=8328259&pre=&suf=&sa=0),[6](http://f1000.com/work/citation?ids=8328269&pre=&suf=&sa=0),[7](http://f1000.com/work/citation?ids=8328271&pre=&suf=&sa=0),[8](http://f1000.com/work/citation?ids=8328717&pre=&suf=&sa=0)Of particular concern are many racial/ethnic and socioeconomic disparities, such as:

* 43% of American Indians/Alaska Natives use tobacco products compared to 27% of those who are not American Indian/Alaska Native;6
* Smoking rates are twice as high for those living below the federal poverty line (FPL) as those living at or above the FPL;4,7
* Smoking prevalence is higher among those with a General Education Diploma (GED) (34.1%) or high school diploma (19.8%) than those with a graduate degree (3.6%).4,7

Smoking harms nearly every organ in the body, is known to cause chronic bronchitis, emphysema, and heart disease, and increases risk of at least 15 types of cancers. Nearly one third of all cancer deaths and 87% of lung cancer deaths are attributable to smoking.[9](http://f1000.com/work/citation?ids=8328780&pre=&suf=&sa=0) Disparities in smoking prevalence and exposure have considerable implications for health outcomes and equity. For example:

* African Americans are more likely to be diagnosed with lung cancer and to die of smoking-related diseases than Whites.[8](http://f1000.com/work/citation?ids=8328717&pre=&suf=&sa=0)
* Latinos are more likely to be diagnosed with later stage tobacco-related cancers.[8](http://f1000.com/work/citation?ids=8328717&pre=&suf=&sa=0)
* Those with low socioeconomic status experience higher rates of tobacco-related cancers, such as lung, oral, and pharyngeal cancers.[10](http://f1000.com/work/citation?ids=8328850&pre=&suf=&sa=0)

**Traditional Focus of Tobacco Control**

Tobacco control interventions and policies have been driven, in part, by conventional mental models of public health research and practice. Thirty-five years ago, British epidemiologist Geoffrey Rose highlighted public health’s “high risk” approach, in which screening processes identify those individuals most at risk for a health problem in order to target resources to those most likely to benefit.[11](http://f1000.com/work/citation?ids=4561342&pre=&suf=&sa=0) He suggested an alternative “population” approach mental model that he argued would have a larger overall impact. By changing norms and environments that increase risk exposure, this approach would slightly reduce risks for a large number of people, rather than greatly reducing risk for a few.

Initially grounded in high-risk approaches, theoretical models of smoking focused on individual-level risk factors, and more recently have expanded to incorporate a population approach by including environmental factors associated with smoking. We conducted a rapid review of PubMed to identify research that used systems science approaches to develop theoretical models of smoking. Twelve models were identified out of the 264 articles screened. The constructs included in Figure 1 were commonly found in existing theoretical models.

Individual-level factors commonly found in conceptual models of smoking include cravings and addiction, perceptions about the harms of smoking, preference for menthol cigarettes, stress, and sense of control (Figure 1, green text). Robust literature demonstrates that cigarettes are an **addictive** product and that smoking results in **cravings** for more cigarettes.[12](http://f1000.com/work/citation?ids=411587&pre=&suf=&sa=0) In addition, studies show that individuals’ **beliefs about the harms of tobacco use** are associated with smoking.[13,14](http://f1000.com/work/citation?ids=8431938,8431940&pre=&pre=&suf=&suf=&sa=0,0) Lower perceived harm is associated with smoking initiation among non-smokers and continued tobacco use among current smokers. Studies show that a **preference for menthol cigarettes,** a type of flavored cigarette used by approximately one-third of smokers, is associated with greater bioavailability of nicotine, greater addiction, and more difficulty quitting.[15,16](http://f1000.com/work/citation?ids=8431942,8431941&pre=&pre=&suf=&suf=&sa=0,0) In addition, despite the well-known harm of cigarettes, menthol cigarettes were historically marketed as a healthier option for smokers. Some menthol cigarette smokers perceive lower harms from smoking mentholated cigarettes.[15](http://f1000.com/work/citation?ids=8431942&pre=&suf=&sa=0) The association between **stress** and smoking is also well-documented.[17](http://f1000.com/work/citation?ids=8431943&pre=&suf=&sa=0) Smoking is a coping behavior for stress and has been shown to provide stress relief.[17,18](http://f1000.com/work/citation?ids=8431943,6766673&pre=&pre=&suf=&suf=&sa=0,0) The literature also identifies **sense of control**, which we define as a feeling of control over one’s well-being, as an important factor associated with smoking. Greater feelings of control lower the likelihood of smoking.[19](http://f1000.com/work/citation?ids=8431947&pre=&suf=&sa=0)

 *Figure 1.* Traditional Conceptual Map of Smoking

The **green** and **blue** colors reflect individual- and environmental-level factors associated with smoking, respectively. The + and – signs represent the arrow polarity, where + indicates the variables move in the same direction, and – indicates the variables move in the opposite direction. For example, as stress increases, tobacco use increases. In contrast, as access to cessation services increases, tobacco use decreases.

Environmental factors commonly associated with smoking (Figure 1, blue text) include the **tobacco industry**, and more specifically industry marketing, including control over product and flavor availability and tobacco prices in the retail environment. Studies show that exposure to **tobacco marketing** increases the likelihood of smoking.[20](http://f1000.com/work/citation?ids=6273719&pre=&suf=&sa=0) Smoking risk is theorized to increase incrementally with repeated exposure to tobacco marketing.[21](http://f1000.com/work/citation?ids=8431950&pre=&suf=&sa=0) Advertisements attract new consumers and act as cues to smoke for current and former smokers. **Cheaper prices** are also associated with smoking as the lower cost increases access to the product.[22](http://f1000.com/work/citation?ids=8465313&pre=&suf=&sa=0) Other important environmental factors include social and environmental **norms around smoking**, **tobacco use among family and friends**, and **access to cessation services**. Individuals are more likely to smoke if they perceive that smoking is approved by friends and family members or society broadly. In addition, smokers without access to cessation services are less likely to quit.[23](http://f1000.com/work/citation?ids=8431952&pre=&suf=&sa=0)

**Priority Population Approach**

Although Rose’s landmark work describing population approaches to public health has been widely embraced, some critics argue that population approaches disproportionately benefit those groups generally at lowest risks of health problems.[24](http://f1000.com/work/citation?ids=843725&pre=&suf=&sa=0) Certain sub-populations, due to shared social circumstances, may face cumulative and concentrated environmental hazards, placing them at greater “risk of risks” and therefore least likely to benefit from population-wide interventions. An approach that instead focuses on priority population aims to reduce social vulnerability while capitalizing on community strengths, using intersectoral and participatory strategies to reduce discrimination and targeted marketing, ameliorate financial strain or other byproducts of tobacco control initiatives, and empower youth and others with vested interests to take political action. The Iceberg Model [25](http://f1000.com/work/citation?ids=8465316&pre=&suf=&sa=0) (Figure 2) is useful for visualizing the underlying structures (resources and power; discrimination and marginalization) and mental models (focus on individual-level risk behaviors and prioritization of population-level change) that maintain tobacco use disparities among priority populations in the US.



*Figure 2*. Iceberg Model of Tobacco use Disparities

Grounded in a priority population approach, we propose that to effectively reduce disparities in smoking it is critical to consider the root causes of the individual and environmental factors traditionally associated with smoking. To identify these we turned to two theories focused on the social determinants of health and health disparities. Fundamental cause theory identifies root causes, like socioeconomic status, residential segregation, and stigma, that limit access to key resources necessary for maintaining health.26-29 Social stress theory argues that social hierarchies produce higher exposure to stress and fewer coping resources among socially disadvantaged groups.30-32 We present factors that are root causes of smoking among racial/ethnic minorities and lower socioeconomic groups (Figure 3, red text).



*Figure 3.* Updated Conceptual Map of Smoking Among Priority Populations

Using these theories, we hypothesize that **low-wage work** may represent a root cause of smoking among individuals of lower socioeconomic status. Smokers may not have access to cessation services if employed in low-wage work that does not provide insurance that covers this service. Low-wage work may also increase **financial strain** that, in turn, increases stress and lowers feelings of control, which increases the likelihood of smoking. Similarly, **housing instability** may represent a root cause of smoking because it increases financial strain and stress.33 Finally, **marginalization** may be an important root cause of smoking among racial/ethnic minority and lower socioeconomic groups. Marginalization in the US has resulted in **neighborhood segregation** and **discrimination**, which allows for **targeted** marketing of tobacco products based on neighborhood demographic characteristics.3[4](http://f1000.com/work/citation?ids=5435059&pre=&suf=&sa=0) Communities that have been historically marginalized may also have lower **social capital,** or the effective functioning of social groups through a sense of shared understanding and trust, and higher levels of stress, which again increases the likelihood of smoking.35

**Interviews**

We conducted qualitative interviews with stakeholders in tobacco control to gather feedback on our updated conceptual model. Feedback was integrated and is reflected in the model (Figure 3) presented in this work. Semi-structured interviews were conducted in person or by phone with a convenience sample of seven traditional and non-traditional stakeholders in tobacco control. Excerpts from interviews are presented below.

In response to feedback from an advocate in an ***equity organization,*** the word ‘targeted’ was added to ‘tobacco marketing’ in the updated conceptual model of smoking. The advocate stated: “That should be *predatory* tobacco marketing rather than just tobacco marketing.” We also added ‘tobacco industry’ to the model after the advocate asked: “Where is the tobacco industry?”

An ***academic*** stated: “What about adding an arrow from ‘normalization of smoking’ to ‘homes/workplaces that permit smoking’?”

A ***smoker*** reviewed the model: “It looks like you covered a wide-base of what I consider items that cause people to use tobacco.” The smoker then discussed reasons for initiating and touched on several components in the model:

“I started using chewing tobacco around 11 or 12 and a few years after I tried my first cigarette….Older friends and other kids in the community that I looked up to [chewed tobacco]…I had a blue-collar job when out of school and was around a lot of people who smoked and was encouraged to go on smoke breaks. Now I am the lone soldier going on smoke breaks… I definitely feel the impact of the price…and that is another one of the …cons.”

Interviews were also used to gather feedback on whether or not stakeholders found the model useful.

For example, a ***mental health practitioner*** stated: “me, as a psychologist, focuses on the green [individual-level factors in the model] first. Being able to take a step back and think about all the other factors…it could broaden people’s perspectives in terms of thinking about where we can intervene.”

An advocate from an ***equity organization*** reflected on the model saying: “To me this is a commitment to long-term...” The advocate also discussed the importance of expanding stakeholders to include non-traditional partners:

 “… it also helps to identify who partners may be…you're going to need to work with folks who are working on housing issues, you're going to need to work with folks who are trying to increase access to healthcare, all these different partners are going to be involved.”

Overall, stakeholders interviewed agreed that the constructs included in the updated conceptual model are important for smoking and provided suggestions to improve the model. Those interviewed noted the importance of considering root causes of smoking to effectively reduce disparities in priority populations.

**Implications for Tobacco Control Policy**

Persistent disparities in smoking and related disease suggest that novel tobacco control policies are needed. A smoke-free air policy for public housing, a national menthol cigarette ban, and minimum price laws are all policies hypothesized to advance health equity in tobacco control. Yet discussion of these policies often fails to consider the root causes of smoking among racial/ethnic minority and lower socioeconomic groups (see the Impact Gaps Canvas in the Systems Map slides), and may therefore fail to account for potential unintended consequences that our updated systems map reveal.

*Smoke-free air.* In July 2018 the Department of Housing and Urban Development required that public housing units implement a smoke-free policy that prohibits the use of tobacco products.36 Using our initial systems map, the policy could be expected to reduce smoking among residents of public housing by reducing tobacco use among family and friends, which subsequently reduces pro-smoking norms and perceptions of tobacco use as low risk. These processes are reinforcing, resulting in further reductions in tobacco use among family and friends and more smoke-free homes, as illustrated in the causal loops excerpted from our systems map in Figure 4.



Smoke-free Air Policy

*Figure 4.* Expected Impacts of the Smoke-free Air Policy

Reinforcing loops in the model are indicated with an ‘R’ and represent relationships that will continue to grow, or reinforce, over time.

 On the other hand, it is likely that some residents of public housing who smoke may violate the smoke-free air policy, especially in light of tobacco’s addictive properties. Violation of the policy may result in housing instability, which, in our updated map, increases financial strain and stress and simultaneously reduces feelings of control, thus having the unintended consequence of increasing smoking, and leaving residents at further risk of housing instability (see Figure 5).

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Violation of the Smoke-free Air Policy

*Figure 5.* Unintended Impacts of the Smoke-free Air Policy

*Menthol ban.* The Food and Drug Administration is considering implementing a menthol cigarette ban. Due to a long history of targeted marketing, menthol cigarettes are disproportionately used among racial/ethnic minority and lower-income smokers.37 Considering traditional models of smoking, a menthol cigarette ban is expected to reduce tobacco use because a significant portion of menthol cigarette smokers are expected to quit if they no longer have access to their preferred product. On the other hand, our systems map suggests that neighborhood segregation and discrimination will allow for the tobacco industry to continue targeted marketing of other tobacco products.

*Minimum price laws (MPLs).* MPLs set a floor price below which a tobacco product cannot be sold. Several cities have implemented MPLs recently. Raising tobacco prices is an evidence-based strategy to reduce tobacco use, as many people will reduce their cigarette consumption or quit in the face of a price hike.[22](http://f1000.com/work/citation?ids=8465313&pre=&suf=&sa=0) Different from other price policies, MPLs raise prices on the cheapest products the most.3[8](http://f1000.com/work/citation?ids=7236495&pre=&suf=&sa=0) If low income smokers pay less for their cigarettes and tobacco prices are cheaper in predominantly African American or lower income neighborhoods, as research suggests,39-41 lower income and African American populations stand to gain the most health benefits from MPLs through the price-focused loop. Higher prices, however, might also trigger the financial strain loop, and increase smoking.

**Stakeholders to Advance Health Equity**

To create policies that address root causes, we need to consider who has a seat at the table when making decisions about policies and implementation, especially those focused on priority populations. Traditional stakeholders include government representatives, academic researchers/practitioners, health systems administrators, and tobacco control advocacy groups.

While these perspectives are important, other stakeholders should be included to ensure policies do not further burden priority populations. Using our updated model, we identified the following new stakeholders to include in tobacco control:

1. Smokers are the intended beneficiaries of tobacco control policies and interventions.
2. Housing officials play a role in the creation, implementation, and enforcement of housing-related smoking policies.
3. Tobacco retailers are gatekeepers to cigarettes and an intermediary between the tobacco industry and smokers. They understand the environment that policies ultimately aim to address.
4. Community-based organizations can provide recommendations to enhance priority population input and promote social change.
5. Social service agencies can provide guidance on where tobacco control policies fit within the broader system of care.
6. Mental health practitioners can provide support with stress management and inform how and when mental health services may be needed in the context of policy change.
7. Law enforcement agencies can contribute to equitable enforcement of policies.

**Summary of** **Key Insights**

Based on the findings from this project, we recommend the following for tobacco control programs and advocacy organizations:

* + - 1. Broaden the stakeholders involved to include smokers, retailers, housing officials, retailers, law enforcement, social service agencies, mental health practitioners, and community-based organizations so priority populations are effectively heard and not burdened further.
			2. Consider the intended *and unintended* consequences of policies and programs, with particular attention to additional supports that may be needed to counter increased stress and financial strain.
			3. Adopt a *priority population approach*, as opposed to a focus solely on population-level change, so reducing socioeconomic and racial/ethnic disparities in smoking is a key goal.

**Conclusions**

 Smoking causes significant adverse health outcomes, with some subgroups shouldering most of the disease burden. Prior conceptual models of smoking that offer high-risk and population-level approaches to tobacco control fail to address the root causes of disparate smoking rates and resulting inequitable health outcomes.

To address this gap, we developed an updated conceptual model of smoking for priority populations that accounts for the root causes of smoking. Our proposed systems map, which can be used to anticipate the intended and unintended effects of tobacco control interventions and policies, demonstrates that new types of stakeholders who can address these root causes must be engaged in tobacco control. Through effective collaboration, there are opportunities to ensure equitable benefits of tobacco control and reduce health disparities.

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