

Addressing tobacco-related health disparities

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ABSTRACT

Aims The aim of this review is to outline a transdisciplinary research framework for identifying, explaining and intervening to address tobacco-related health disparities (TRHD). We will show the importance of an approach that integrates the human life-cycle (developmental) and tobacco addiction cycle (behavioral) for interventions that address group-specific vulnerabilities. **Methods** The existing empirical knowledge base on tobacco-related health disparities is mapped onto a conceptual framework built around life-cycle and addiction cycle trajectories for disparate population groups. **Findings** Current knowledge about developmental trajectories of tobacco use is based on general population studies with minimal information on group differences. At the national level, early onset of tobacco use is associated with a high level of tobacco dependence, low number of quit attempts, long-term smoking history and tobacco-related health harm. These relationships cannot be assumed for all population groups: African Americans and Asian Americans typically have a later age of tobacco use onset compared to European Americans, yet health consequences of smoking are higher among African Americans but not Asian Americans. Even less is known about group differences in the temporal progression from smoking onset to daily smoking. Determining the time-frame from initial to regular smoking seems crucial for targeted secondary prevention, before the establishment of addictive tobacco use patterns. Group-specific data characterizing the duration from daily tobacco use to a quit attempt or request for cessation treatment are also scant. **Conclusions** A comprehensive, integrated, transdisciplinary framework is needed to guide efforts to understand tobacco-related health disparities and to increase the effectiveness of evidence-based interventions delivered in culturally appropriate and economically practicable ways, while optimizing the balance between demand for and access to services.

Keywords Addiction, conceptual framework, ethnicity, health disparities, life cycle, multidisciplinary approach, tobacco, treatment.

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INTRODUCTION

A major goal of Healthy People 2010 is to improve health and eliminate health disparities across gender, race, ethnicity, education, income, disability, geographic location and sexual orientation. The importance of identifying and addressing disparities in health outcomes (i.e. morbidity, mortality and quality of life) has garnered the increasing attention of researchers, the health-care system and policy makers [1–6]. Tobacco use is the leading cause of preventable disease and death in the United States [7]; thus, addressing disparities in tobacco

use and its downstream consequences is a public health imperative [8]. As one example, African American youths begin smoking later in life than white youths; by adulthood, African American smoking prevalence rates are comparable to Whites, yet African Americans have higher lung cancer rates [9]. The diversity of priority populations that experience disparities (racial/ethnic and low socio-economic groups) and the heterogeneity within them, along with cultural and social challenges inherent to addressing life-style and behavioral issues, requires a framework for accurately assessing disparities throughout the tobacco addiction cycle and strategically crafting

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interventions. A focus on health disparities might also provide insights to address the impact of tobacco on the total population.

A major challenge for intervention is that disparities in health outcomes may arise at various points in the cycle of tobacco use, exposure, cessation and health care for related consequences. With a premature mortality risk of approximately 50%, the health risks of tobacco use are related directly to daily consumption and duration of tobacco use [10] deriving from addiction (i.e. compulsive use). Claiming close to half a million lives annually in the United States alone, tobacco addiction is a chronic relapsing disorder as per DSM-IV-TR [11], responsible for largely unexplained disparities in several categories of morbidity (e.g. coronary heart disease, stroke and various cancers) [9,10]. The objective of this paper is to outline a transdisciplinary research framework for identifying, explaining and intervening to address tobacco-related health disparities (TRHD). We will show the importance of an approach that integrates the human life-cycle (developmental) and tobacco addiction cycle (behavioral) for interventions that address group-specific vulnerabilities.

PERSPECTIVES ON HEALTH DISPARITIES

Although consensus across disciplines on the definition of health disparities has yet to be reached, as discussed here, TRHD represents differences in patterns, prevention and treatment of tobacco use; the risk, incidence, morbidity, mortality and burden of tobacco-related illness that exist among specific population groups in the United States; and related infrastructure, access to resources and environmental tobacco smoke exposure [8]. Theoretical constructs germane to health disparities include inequity, social marginalization and economic inequality [2,12,13]. Although the meanings of these constructs may vary slightly, each term is used to describe the excess health burden or risk experienced by individuals or population groups. Health disparities have been identified for most major chronic conditions such as cancer and cardiovascular disease and associated risk factors such as obesity and substance use, including tobacco.

Frequently, groups that experience disparities are historically underserved and defined by socio-economic status (e.g. education, occupation, income, poverty/wealth) race and ethnicity [14]. Disparities may also be defined by geographic location, sexual orientation, gender, marital status and age, which might all interact at individual and group levels. In defining these categories in relationship to tobacco use, we acknowledge that the term 'group' could apply to other populations such as those with psychiatric comorbidities or sub-

stance use disorders. Disparities for some health conditions may partly reflect biological variation, but explanatory factors are strongly rooted in group differences in socio-economic resources and position, cultural beliefs and practices and prejudice and discrimination at both institutional and individual levels (for a review, see [15]).

Understanding how disparities arise and how they might potentially be addressed requires examination throughout the life-cycle to identify critical explanatory factors and interactions within a given social milieu. For example, social stigma and discrimination are associated with disparities in multiple ways. Whether perceived, institutionalized or internalized [16], discrimination is associated with adverse physiological, psychosocial and life-style effects [17]. The effect of discrimination [5] remains difficult to isolate, yet woven insidiously into important interactions from childhood to adulthood. Discrimination impacts health outcomes by resulting in stress, decreased quality of life and reduced access to resources, systems and knowledge. Stress, in turn, results in neuroendocrine and immunological vulnerability that enhance susceptibility to cancers and cardiovascular disease, conditions that account for most tobacco-related mortality. A recent Institute of Medicine (IOM) report recognized the importance of discrimination, finding extensive and consistent disparities across a range of medical conditions and health-care services that occurred independently of insurance status, income and education [5]. The confounding of race and socio-economic status (SES) remains a challenging problem for health disparities research [14].

Rather than originating from a single factor, health disparities arise through multiple mechanisms whose relative influences may vary across the life-span. In addition, several small or imperceptible differences in health status and processes may accumulate over the life-course and lead to disparities in health outcomes [18]. For example, social conditions that occur during pregnancy, the neonatal period and childhood have been linked to disparate health outcomes in adulthood and older age [19–21]. As individuals grow and mature, their susceptibility to various environmental influences, modeled behaviors and experiences shape views on health and healing, as well as their behaviors and interactions within systems of health care [22,23]. For example, views held towards health-related interactions within a particular context can alter the demand for treatment and the degree of trust and compliance with prescribed treatment regimens [5,24]. This is also observed with recruiting into and retaining select populations in tobacco cessation intervention research [25]. Moreover, existing treatment may not be accessible or applicable to some disparate populations [26]. Consequently, three

separate, yet interacting dimensions are the characteristics of individuals (e.g. genetic predispositions, SES) and behaviors (e.g. addiction whose biopsychosocial nature and etiology are recognized), all within social and ecological context. For instance, SES may operate within various macro-level contexts, such as neighborhood or community-level poverty or at the inter- and intrapersonal levels. Because health disparities arise at various points along the natural history of a disease or within the chain of provision of care [5], transdisciplinary research designs that can navigate the maze of potentially relevant factors influencing the health processes of interest are warranted.

Thus, in seeking to address health disparities, it is important to recognize explanatory factors, their interactions at individual and multiple levels across the life-span, and the groups affected to devise rational interventions. A rational approach for addressing a given health disparity might include first hypothesizing then documenting the disparity. Next, explanatory research would identify the causes so that putative causative factors can be addressed. This would include evaluations within the broader context of confounding issues. We argue that these stepwise tasks will at times evolve only through varied socio-ecological and culturally appropriate means of observation. Because factors and dimensional variables may not yet have been identified, initial mixed methods in quantitative and qualitative inquiry may be required before hypotheses are generated [27]. Moreover, it is important to reconcile theoretical scientific approaches (e.g. sampling, hypothesis testing, etc.) with the practical yield of ameliorating human lives.

ADDRESSING HEALTH DISPARITIES WITHIN THE CYCLE OF TOBACCO USE AND ADDICTION

The cycle of tobacco dependence is characterized by a progression of steps from initial to increasing use, then compulsive use with a high frequency of relapse upon cessation [11]. Identifying and tracking the specific phases and critical periods when health disparities emerge requires understanding how the natural history of a chronic relapsing disorder such as tobacco addiction relates to the individual life-cycle of addiction and disease-related consequences. Once a health disparity has been identified, preventive and treatment intervention can be rationally constructed to improve health outcomes among disparate populations.

Most tobacco-related health consequences are a product of duration of tobacco use along with magnitude of daily consumption, which varies throughout the cycle of tobacco addiction [10,11]. Prominent features of tobacco use, compared to other substances, are that users

show the highest proportion of those addicted (whose use is thus compulsive) to those having any life-time use [28], the highest relapse rates after cessation [29] and the highest substance-related mortality [7]. Typical indicators of morbidity (e.g. coronary heart disease, chronic obstructive pulmonary disease, dental/periodontal problems, etc.), mortality (e.g. cancers, myocardial infarct, stroke) or decreased quality of life (decreased physical performance, absenteeism) usually reach a clinical threshold during the second half of the life-span, after decades of cumulative exposure [30].

The cycle of tobacco use and addiction

Despite the large breadth of knowledge garnered over the last few decades regarding the cycle of tobacco use and its consequences, much remains unknown, particularly for populations experiencing disparities. The natural history of tobacco use, the risk of addiction and tobacco-related health consequences vary according to internal and external determinants (Fig. 1). Several challenges currently faced by the field (e.g. lack of measurement invariance of commonly used instruments for assessing dependence) have come to light as a result of this problem [31,32], which in turn has consequences for treatment selection [33]. Overall, a better characterization of the course of tobacco use, addiction and cessation is needed. For example, once regular smoking is established, adolescents and young adult quit rates remain at 4–5% per year and drop to 3% among older adult smokers [29,34–36]. Most adolescent and adult smokers try to quit on their own (via ‘cold turkey’ or acute abstinence), experience withdrawal, fail and desire formal treatment. Such treatment is accessible differentially across groups [37].

Variations in smoking patterns and the cycle of tobacco addiction occur among disparate populations. For example, on average African Americans and some Asian Americans begin smoking regularly after the age of 18 [38], and very little is known about addiction processes during the adolescent stage for racial and ethnic groups who do not smoke regularly until young adulthood. Furthermore, Hispanic American and African American regular smokers are more likely to remain light smokers (smoking < 10 or 15 cigarettes per day) [9], among whom the cycle of addiction is poorly understood. Commonly used current measures of dependence [e.g. Fagerström Test for Nicotine Dependence (FTND)] [39] have low validity among light smokers [40]. Additionally, measures of dependence may vary by ethnicity [40,41]. Disparate populations also might live within social contexts (e.g. poverty, cultural and belief aspects, discrimination) that influence the cycle of tobacco use and dependence. Therefore, it is critical to integrate these variables into investigations that seek to understand this

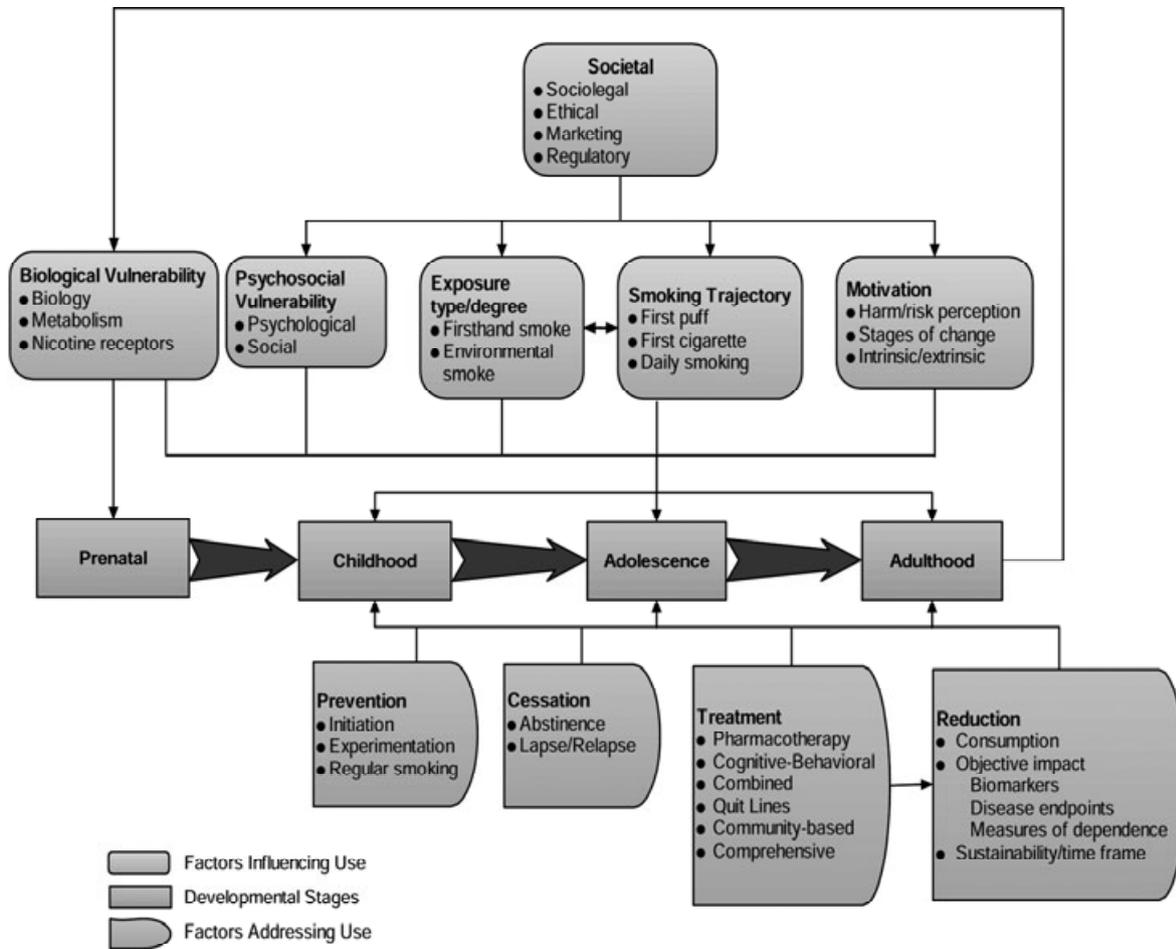


Figure 1 Factors influencing tobacco use throughout the life-span

cycle, while remembering that relationships (weighting) between variables within the general population may not be similar to effects that generate disparities.

Table 1 provides examples of TRHD. Notably, such disparities fall into categories spanning current tobacco use or exposure, consumption, morbidity, treatment and cessation. Immediately apparent is the diversity in differences across, but also within, variously defined groups (e.g. age, socio-economic, ethnicity, etc.). Marked heterogeneity is also seen in the magnitude of disparities. The goal herein is to propose a system that broadly incorporates the most influential variables and relationships. Rather than enumerating all potential factors for a given group, an overall approach to TRHD should first consider the general cycle of tobacco addiction as it might apply to the bulk of the general population. The framework can then be used to compare disparate groups' experiences and the antecedents and consequences of events at different points in the addiction cycle. This model should thus be applicable to all groups while exhibiting some differences across populations.

Factors influencing trajectories of tobacco use, exposure and addiction

Exposure to tobacco use impacts the human organism from the earliest time-point in human development, affecting fetal neuronal organization [42] and producing serious health consequences among infants such as sudden infant death syndrome (SIDS), otitis media, respiratory infections and predisposition to asthma. Both human and laboratory animal studies show that adolescents have greater vulnerability to tobacco use and addiction compared to adults [43,44]. The observation that tobacco use frequently starts during childhood and adolescence suggests that interactions between early developmental processes, smoke exposure and trajectory influence patterns of tobacco use and addiction throughout the life-cycle [43,45]. Figure 1 illustrates factors shown previously to influence the life-cycle of tobacco use and addiction.

Whether considered on a clinical or population level, tobacco use and addiction progress typically through a

Table 1 Examples of tobacco-related health disparities [8].

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- Current tobacco use:
 - Those with a Graduate Education Diploma (GED) have more than twice the smoking prevalence rate of the overall population
 - American Indians and Alaskan Natives have twice the use prevalence of Asians and Hispanics
 - One in three blue-collar and service workers smokes compared to one in five white-collar workers
 - Lesbian and bisexual women are more likely to smoke than heterosexual women
 - The disabled are 1.5 times more likely to smoke
 - African Americans born in the United States are more likely to smoke than foreign-born Africans living in the United States
 - Number of cigarettes smoked per day: as groups, African Americans, Hispanics and Asians have a greater proportion of light smokers, but there is a lack of smoking cessation interventions geared toward light smokers
 - Morbidity:
 - African American youths begin smoking later in life than white youths; by adulthood, African American smoking prevalence rates are comparable to Whites, yet African Americans have higher lung cancer rates
 - Quitting:
 - One-half of those at or above poverty level succeeds in quitting smoking, compared to only one-third of those below poverty level
 - Blue-collar and service workers are not as successful in quitting smoking as white-collar workers, despite the same number of quit attempts
 - Becoming a former smoker is positively related to socio-economic position (those with higher socio-economic position are more successful at quitting) across all racial/ethnic groups and in the total population. Men are more likely to become former smokers than women in all racial/ethnic groups except for the white population)
 - Treatment: quitting advice from a health-care provider is less likely to be given to younger patients, men, African Americans, the uninsured, light smokers and those with less education
 - Interactions:
 - Blue-collar workers are more likely to be smokers and to be exposed to occupational hazards that may interact with their smoking to increase risk of disease
 - Schizophrenics and polyaddicted people are also more likely to be smokers
 - Training: while disparate populations are less likely to receive advice to quit, efforts to increase the percentage of under-represented minorities in the health professions have met with limited success
 - Exposure to secondhand smoke: compared to white-collar workers, blue-collar and service workers are significantly less likely to be protected by smoke-free policies at work, and have thus higher exposures to secondhand smoke at the work-site
 - Marketing of tobacco products: in-store and over the counter promotions of tobacco products disproportionately target racial and ethnic minorities
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series of stages that include intent to use, initiation, experimentation, regular use, addictive use [46], cessation and relapse. Variables found to influence those stages are displayed in Fig. 2. For example, the degree of marketing of tobacco products influences the intention to smoke which has been shown to reliably predict initial use [47]. However, trajectories are not always linear and some smokers eschew addiction despite ongoing consumption (e.g. chippers) [48].

Research has begun to elucidate factors associated with progression through these early stages; however, tobacco use trajectories are substantially modulated by context [49–52]. Context is broadly comprised of socio-environmental and cultural factors during initiation and experimentation. Although some studies have examined the influence of peers, family and the media on the early stages of adolescent smoking, very few studies have considered the ethnic variations in these effects [50]. In addition, ongoing population and laboratory studies suggest that biological factors (e.g. genetic, pharmacological) and nicotine reinforcement contribute strongly to the establishment of regular and addictive patterns of use

[53–55]. Such biological predisposition may extend to cancer-related risk [53,56]. Furthermore, throughout all stages of tobacco addiction both psychological vulnerabilities (e.g. stress, discrimination) and psychiatric and substance use comorbidities [57,58] may occur. Illustrating this, a recent study with a multi-ethnic sample revealed that depressive symptoms were associated significantly with intention to smoke after controlling for language-use acculturation, SES, gender and ethnicity [59]. Several theories have been implicated in the progression of tobacco use. However, none of the theories simultaneously considers the full biopsychosocial spectrum of determinants as they might apply to generating disparities in tobacco-related health outcomes across the cycle of tobacco use.

Currently, tobacco use developmental trajectories mostly refer to the general population with little information on group differences [52,60,61]. At the national level, early onset of tobacco use is associated with a high level of tobacco dependence, low number of quit attempts, long-term smoking history and tobacco-related health harm [62–64]. However, these relationships

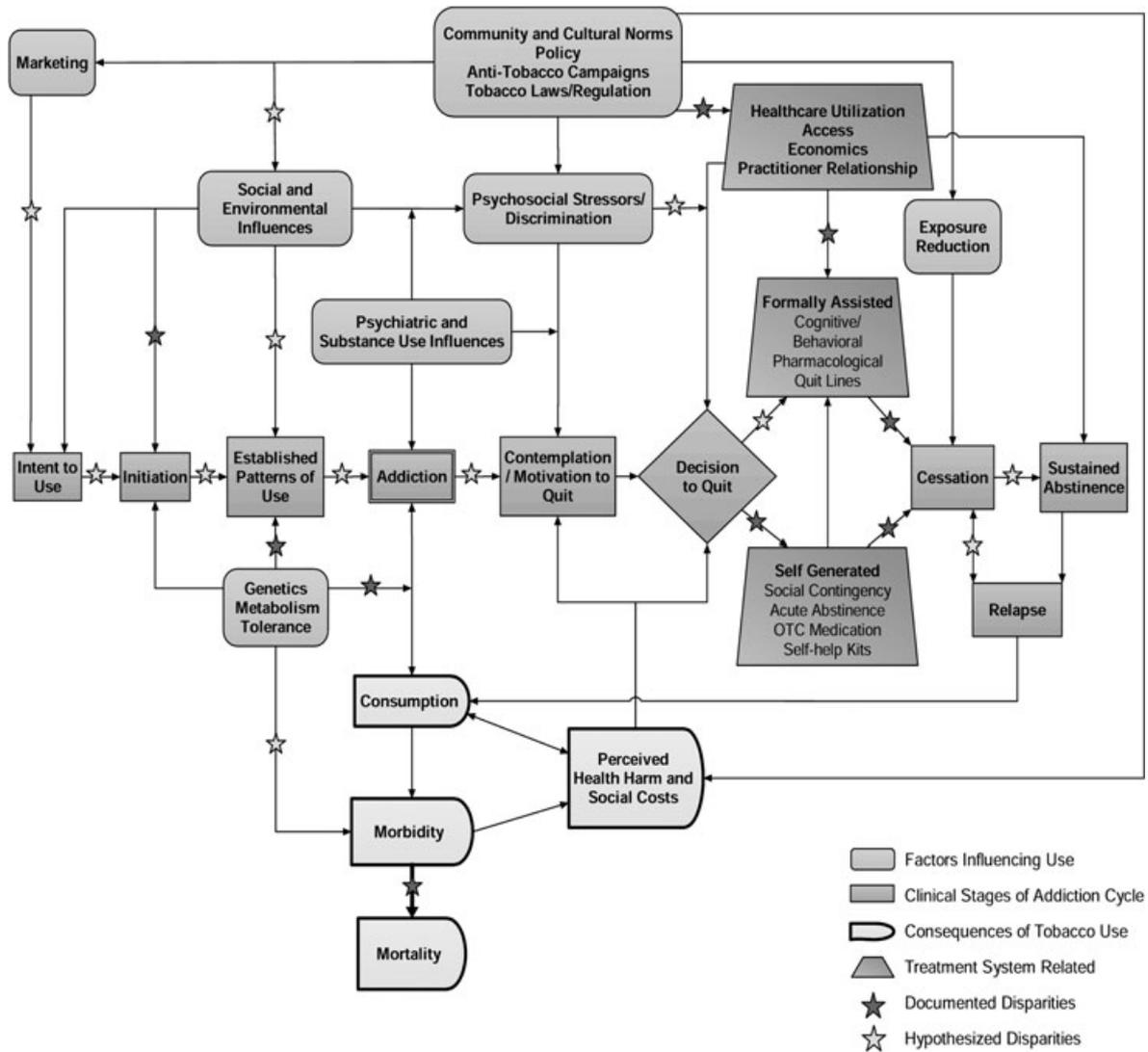


Figure 2 Heuristic model of the tobacco addiction cycle

cannot be assumed for all population groups. As mentioned, African Americans and Asian Americans typically have a later age of tobacco use onset compared to European Americans [38]; however, health consequences of smoking are higher among African Americans, but not Asian Americans. Even less is known about group differences in the temporal progression from smoking onset to established or daily smoking. Determining the time-frame from initial to regular smoking seems crucial for targeted secondary prevention, before the establishment of addictive tobacco use patterns [45,60,65]. Group-specific data characterizing the duration from daily tobacco use to a quit attempt or request for cessation treatment are also scant [63,66].

A lack of longitudinal survey data poses a challenge to elucidating factors that influence trajectories of tobacco use. Such data would capture differences in the development of tobacco addiction across and within ethnic

groups (e.g. acculturation) [67]. Despite large group differences in tobacco use prevalence, few data indicate how tobacco use and addiction produce consequences (i.e. morbidity, mortality, social costs) for specific populations. Because the disease end-points in question require so long (i.e. decades) to manifest, and potential cofactors exist, causal relationships between tobacco use and health consequences remain imprecise. Fluctuations in tobacco use prevalence across age groups by ethnicity (patterns of consumption over the life-cycle) [18] make it difficult to compute the effects of cumulative years of smoking on the individual or the population group. For example, recent evidence suggests an etiological interaction between race/ethnicity and tobacco exposure, with African Americans and Native Hawaiians more susceptible than other groups to the carcinogenic effects of cigarette smoke. Additionally, factors underlying the ethnic divergence would operate more strongly at lower

dosages [68]. The field has begun to examine how differences in nicotine metabolism might influence tobacco use trajectories as well as response to interventions [69,70]. Preliminary evidence suggests that group differences partly reflect biophysiological predispositions (pharmacological/metabolism, neurodevelopment, medical conditions, etc.) to exposure, use and health consequences [71,72]. Thus, it is critical to retain a biologically informed socio-environmental perspective of the life-cycle factors that contribute to TRHD [68].

While there is some consensus that addiction results from combined biological, social and psychological predispositions [11], uniform characterization and assessment of the degree of tobacco dependence has not occurred. The most commonly used assessment tools to define dependence, which also indicate eligibility for various treatment medications, are inconsistent. The absence of a universally accepted definition of tobacco dependence impedes specifying the etiological pathways to nicotine and tobacco addiction and skews the treatment selection process to the disadvantage of select groups such as African Americans [33,72].

Although several treatments can help smokers to make a successful quit attempt, they vary in efficacy, effectiveness, reach and impact [73]. Given that cessation at any age confers increased survival and other health gains [74,75], the timing and success of quit attempts represent key prognostic factors for reducing health harm from tobacco use and exposure (Fig. 2). Because many successful quitters relapse over time and no specific intervention has been shown to prevent relapse [76], it is crucial to focus resources on including those eligible in the most effective initial cessation attempts.

Consequently, it is important to consider both the potential variations in timing, duration, type and severity of tobacco use as they relate to TRHD. While not proving causality, using appropriate surveillance to track the natural history of use for the emergence of morbid entities and TRHD provides a time-based systematic approach for planning appropriate interventions. This and the processes outlined below derive thus from the integration of steps outlined above in 'Perspectives on health disparities' as applied to age-appropriate factors from Fig. 1 with addiction or intervention-stage variables from Fig. 2.

Intervention approach for tobacco-related health disparities

Currently, the only scientifically proven ways to address tobacco use and/or addiction are to prevent initiation, achieve cessation (total abstinence) among users and prevent relapse by former users [77,78]. Offsetting TRHD thus requires a series of interventions, whether at a primary level (preventing initiation), secondary level

(cessation) or tertiary level (addressing health consequences such as hospitalizations and mortality). Although often considered separately, prevention, cessation and treatment exist on a continuum of preventive intervention.

A useful model should facilitate the conceptual mapping of interventions according to clinical or community-level variables, yet few data sets are designed with this in mind [6]. Hence, there is a need to develop a comprehensive conceptual framework to inform future study designs that will allow its testing on both scientific and practical levels. We inform our conceptual model development with lessons learned from interventions on the general population of smokers and current treatment approaches. These solutions have not been applied uniformly; lessons learned from some groups may not apply to others. For instance, the ecological model was effective in addressing multi-dimensional factors that affect health status and designing specific interventions [79]. The ecological framework presents health as a product of the interdependence between the individual and ecological subsystems (e.g. community, culture, physical and social environment). As such, economic and social conditions become health determinants. We adopt similar variables in the proposed model. However, a multi-step process is required to study and address TRHD that emerge throughout the life-span. First, an understanding of the tobacco use and addiction cycle is needed. Here, establishing the nature and magnitude of disparities rests upon accurate surveillance data. From there, explanatory research can begin to examine how various factors are relevant to a disparate population. Because disparities have been found to arise by pathways that are linked to different variables throughout the life-cycle, a conceptual model that integrates factors operating within the cycle of tobacco use and addiction into the human life-cycle is instrumental.

Illustrating this, ethnic heterogeneity in tobacco use trajectories and factors that interact with trajectories call for socio-culturally targeted interventions. Establishing the differences in the natural history and time-course of trajectories in various samples (e.g. population-based for public health and cessation-seeking for clinical practice) provides inferences to anticipate health risks. This, in turn, informs translation and resource allocation for interventions tailored to disparities according to group receptivity.

Interventions that contribute to decreasing tobacco use include reducing tobacco supply, preventing or delaying onset, preventing regular use and increasing cessation through behavioral and pharmacological approaches (for a review, see [80]). Examples of current interventions that achieve these outcomes include school-based programs, restrictions on sales, increased

Table 2 Integrated steps to address tobacco-related health disparities.

1	Understanding the natural history or life-cycle of tobacco addiction and attributable health consequences and how this life-cycle differs among various disparate groups
2	Developing appropriate surveillance and explanatory research methodologies (measures, processes and operative systems) for empirical analyses and that are valid within given developmental, biopsychosocial and cultural contexts
3	Designing and testing effective, acceptable, practical interventions through clinical, public health or combined models
4	Disseminating and tracking changes in demand and access to interventions geared to address tobacco addiction and related health consequences for disproportionately impacted populations
5	Ongoing evaluation of steps 1–4 by decision makers, scientists and stakeholders, including persons from groups that experience disparities

prices, formal fines, enforcing social structures and policies, anti-tobacco media and advertising campaigns and quitlines. Little is known about the effectiveness of these interventions for disparate groups or their ability to reduce disparities throughout the addictive cycle.

Cessation interventions for the general population: issues for disparate groups

Over the last four decades, two complementary approaches to tobacco cessation have emerged. The clinical model has primarily examined cessation efficacy (achieved by the individual) through clinical trials using pharmacotherapies and/or behavioral counseling [81,82]. Medications have often been used in conjunction with brief counseling by health providers [83]. Behavioral interventions include manuals, brief counseling, group counseling, and computer-based interventions [84]. Extensions of individual approaches have emerged from the health-care setting to non-traditional providers, group programs, telephone quitlines and self-help approaches. For example, evidence shows that telephone-based cessation services (i.e. quitlines) are an effective tool to help tobacco users to quit; recent data showed their effectiveness for young adults [85,86]. Telephone quitlines and internet systems can deliver a variety of resources, including counseling support and advice, regardless of geographic location and race/ethnicity. However, limited research on their effectiveness for disparate groups has surfaced [87].

The public health model targets broad segments of the general population through reduction in opportunities to smoke by implementing policies that include smoking bans as well as interventions at the community, work, residential and school levels. Combined clinical and public health interventions and policies, both public [e.g. availability of over-the-counter (OTC) medications] and private (e.g. employer-based or work-site cessation programs) have led to an understanding of factors affecting tobacco use. A major policy initiative

that is being debated is the proposal for granting regulatory authority to the Food and Drug Administration over manufacturing, marketing, labeling, distribution and sale of tobacco products [88]. Among several other anticipated effects, this regulatory authority would probably lead to reduced tobacco use among adolescent smokers. While these policies have impacted smoking rates among the general population, the effects of public policies on large subgroups (e.g. low socio-economic status women) should be evaluated.

Some proposed therapeutic approaches to reduce tobacco use and tobacco-attributable disease focus on decreasing the level of toxin exposure among users, i.e. 'harm reduction' [45,89,90]. Because disease burden in the population is related not only to harm among users but also to prevalence (which in turn is related to initiation and cessation), harm reduction approaches should be evaluated with respect to their 'total' effect on the health of a given group or population [78]. A few studies have started to consider the 'impact' (defined as efficacy \times participation) [91] rather than the strict efficacy of given interventions, as the best indication of the effectiveness of an intervention. As such, treatment and cessation approaches that consider the full spectrum of TRHD require further empirical investigation.

Disparities in the need for and receipt of treatment may hinge upon a number of contextual and intrapersonal factors. An important step might be to inventory existing evidence-based practices that have demonstrated impact on health disparities. A more specific discussion of how interventions should be tailored for specific groups is beyond the scope of this discourse.

To date, few studies have examined how higher-order regulatory community norms and social effects of marketing interact with individual vulnerabilities or resilience factors to produce disparate health consequences. Components of a stepwise systematic approach to treatment and cessation include intrapersonal (e.g. motivation, awareness, acceptability, therapeutic yield) and systemic factors (e.g. type, availability, access, policies) are listed in Table 2.

Balancing access and demand within the current US health-care system

Access to and demand for self-help or formally assisted health care are important for cessation; thus disparities might result from differential access to interventions and health systems. Within the general US population, recent evidence indicates that current barriers to cessation access include being uninsured, or not having insurance coverage for effective cessation methods [92]. A recent report shows increasing disparities due to less frequent advice to quit received by both poor and Hispanic hospitalized patients [7]. In addition, factors influencing the demand for treatment may be operative. For example, even among the insured or those who could be reimbursed for cessation services, lack of awareness among both consumers and the health care delivery system remains [92]. Difficulty in navigating the systems involved in accessing reimbursable health care may also impede the treatment process. Consequently, many smokers underutilize available cessation methods. Such barriers seem to be exacerbated among youth, the socio-economically and educationally disadvantaged and various minority ethnic groups who may be accessing interventions with lower cessation impact (defined as efficacy \times participation) [91].

Differential demand might also be operative. For example, compared with white smokers, African American and Hispanic smokers were less likely to use nicotine replacement therapy (NRT) during quit attempts in an 'equal access' health-care system (Veterans Administration) [93]. Because treatment is dispensed mainly upon request, it is important to consider the demand, availability and access to cessation treatment to match services optimally to need. Simply put, an individual who perceives harm from smoking is more likely to move towards an 'action stage' [94] for quitting (i.e. a person's 'demand' for treatment) if that individual is aware that effective treatment is available (access). As such, unawareness and perceived or actual barriers to accessing treatments might lower demand.

Hence, disparities in both 'demand' and 'access' can contribute to TRHD. One challenge in planning interventions is how changes that impact one step or outcome within a network of interacting events might play out differentially across groups. For instance, if one group has a greater propensity to access a given treatment (e.g. telephone quitlines) compared to another, the relative value of increasing access to that treatment versus others shown to work better in other groups calls for accurate projections and monitoring of resulting effects, such as 'reach' and 'impact'.

While the introduction of OTC nicotine replacement therapy cessation aids increased the number of quit

attempts overall in the US population [95,96], OTC availability might have decreased access to cessation treatment aids by those with lesser income because it is no longer reimbursed unless prescribed. One study showed that when the nicotine patch and gum became available OTC, rates of use by non-white minorities dropped sixfold [97]. Therefore, health policy changes that seemingly benefit the total population may actually deter subgroups from accessing proven ways of achieving tobacco cessation. This illustrates the importance of anticipating how system-wide changes might impact various groups differentially.

Currently, the capacity of the health-care system to address smoking cessation still lags behind policy recommendations and national goals. Thus, an optimal approach to addressing TRHD may require adjusting the current cessation-related health-care delivery. For example, traditional models have considered physicians and their practices as the main care providers. Given the development of effective non-medical channels (e.g. quit lines, self-help kits, internet-based modalities, pharmacists, dentists and other channels) and recent findings showing the powerful effects of organizational change for effective prevention (e.g. cancer screening) [98], the appropriateness of non-traditional models should be evaluated for disparate groups. Because tobacco addiction is a chronic condition, the community-based chronic care model [99], which has been instrumental in reducing several indicators of other chronic illnesses (e.g. cardiovascular disease), deserves exploration. Beyond health-care systems, programs to reduce disparities in the use of specific interventions may also need to involve communities and education, research and training [10] to increase minority group representation.

Proposed model for addressing TRHD

We use a rational approach to develop the conceptual framework of tobacco-related health disparities (see 'Perspectives on health disparities'). It is based on themes of life-cycle development (Fig. 1) pertaining to the experience of tobacco use. We identify the emergence of disparities at key junctures of the life-cycle where transitions of predispositions and behaviors might occur resulting in addiction-driven consumption or health consequences (Fig. 2). As suggested by another recent model [6], the TRHD model explicitly acknowledges that the tobacco addiction cycle is embedded in community-related dynamics and is sensitive to group-specific factors and, importantly, intervention-related variables (Fig. 2).

The framework incorporates the various streams of influence leading to tobacco-related disparities in the

population. Reference points for primary prevention might be initiation, or even conception, to avert prenatal neural vulnerability to the addictive cycle [42]. For treatment and cessation, the pivotal starting point at a clinical level in the tobacco addiction cycle is the individual's decision to quit. Identifying this event and its consequences is complicated by a number of subtle influences that may be operative, yet are not captured by current measures. The heuristic model illustrates the complexity of operationalizing both endogenous and exogenous processes on a developmental continuum. Distinguishing between 'dynamic' variables that can be modified (e.g. behavioral) and 'static' variables which are not amenable to change and can serve only as moderator variables (e.g. genetic and historical variables) could also serve to guide research. The framework should allow for identifying where, within the cycle of tobacco addiction, a disparity is first appearing. The model prompts recognition of variables proximal to a disparity outcome, but not necessarily all of its determinants. Gaps in knowledge are flagged as requiring further investigation and, if needed, developing alternate theoretical frameworks. Thus, one way the current model can be used is as a basic approach to generate submodels that apply more specifically to discrete segments of the cycle for various populations and test which paths can be modified or deleted. Categories of variables delineated in Fig. 2 can be divided further. For example, the multi-factorial nature of socio-economic status might be refined by including time-varying measures of education, income, wealth or occupation. Alternatively, poverty, uninsurance or having a primary-care medical home might have a more dramatic impact [100]. 'Cultural influences' might include peer pressure, family dynamics, situational opportunities for tobacco use, social or religious rituals and acculturation. Because of the potentially complex forces that underlie movement through the addiction cycle and postulated vulnerabilities of a disparate group, a major challenge is to refine our understanding of the measurement of key constructs and processes to guide studies of TRHD.

The model thus provides the structure to formulate ways in which intrapersonal, social, regulatory, treatment and other factors differentiate group or individually specific experiences throughout life. This information is critical to provide researchers with a theoretical framework to articulate research designs within the larger contexts of the stages of the tobacco addiction cycle and life-span. Of note, group differences in longevity may vary and thereby affect analyses of behaviors and experiences among elderly populations. Also, such differences impact the level of demand for treatment of tobacco-related consequences. As such, the heuristic model of tobacco addiction seeks to integrate the addictive cycle with the impact of interventions (Fig. 2). For visual representation, it is

roughly divided into two sides: (i) the natural history of tobacco use; and (ii) interventions for tobacco addiction and consequences. Steps to integrate the full model are listed in Table 2.

Thus, we have constructed a transdisciplinary framework for identifying and addressing TRHD. Methodological issues are beyond the scope of this paper. Briefly, the particular scientific question should focus the approach and form a strategic starting point with examination identifying relationships between proximal (e.g. smoking onset, consumption, exposure, etc.), distal (quit attempts, cessation, relapse) and ultimate (health consequences, mortality) variables involved. This would also include proceeding across inter- and intraindividual as well as environmental levels, with attention to relevant factors as depicted in the heuristic model of tobacco addiction (Fig. 2).

While the implementation of the model is beyond the context of this report, it is important to illustrate its integration and application to approach tobacco-related disparities. We will thus consider examples of such application in a separate paper.

CONCLUSIONS

Overall, tobacco-related health disparities emerge from incremental and multi-dimensional effects. The field of TRHD provides an opportunity to expand our vision of applying research findings to solving complex real-world problems. Because of its multi-factorial nature and chronicity, tobacco addiction exemplifies disorders whose amelioration requires interventions based on integrating targeted models of prevention and chronic care with integral components linked through various communication media. It is hoped that by overcoming the limitations of current theories, surveys and intervention paradigms to construct new frameworks for research, we will devise rational solutions to transdisciplinary health problems.

In looking towards the future, we are left with a few questions: how do we define success in reducing health disparities, especially given suboptimal existing interventions for the general population of tobacco users? What variables will be used to estimate the cost-yield that informs the merits of a given approach or intervention? What values and principles will govern these evolving issues that impact scientists, care providers and policy makers who seek to mitigate health disparities? Any systematic approach would need to adapt to ongoing societal changes. The model proposed herein constitutes one approach that will need updating as the field discovers other influential variables and helpful insights. It is a call for action to stimulate new research avenues by challenging existing paradigms in order to address significant gaps in research on understudied and underserved popula-

tions. This, in turn, will advance the science that ultimately benefits public health. Our collective responsibility as concerned citizens who cherish the diversity within our society should guide our progress, as the challenges of this field promise to remain with us for years to come.

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