Results from a Population Dynamics Model of the Consequences of Menthol Cigarettes for Smoking Prevalence and Disease Risks[1]

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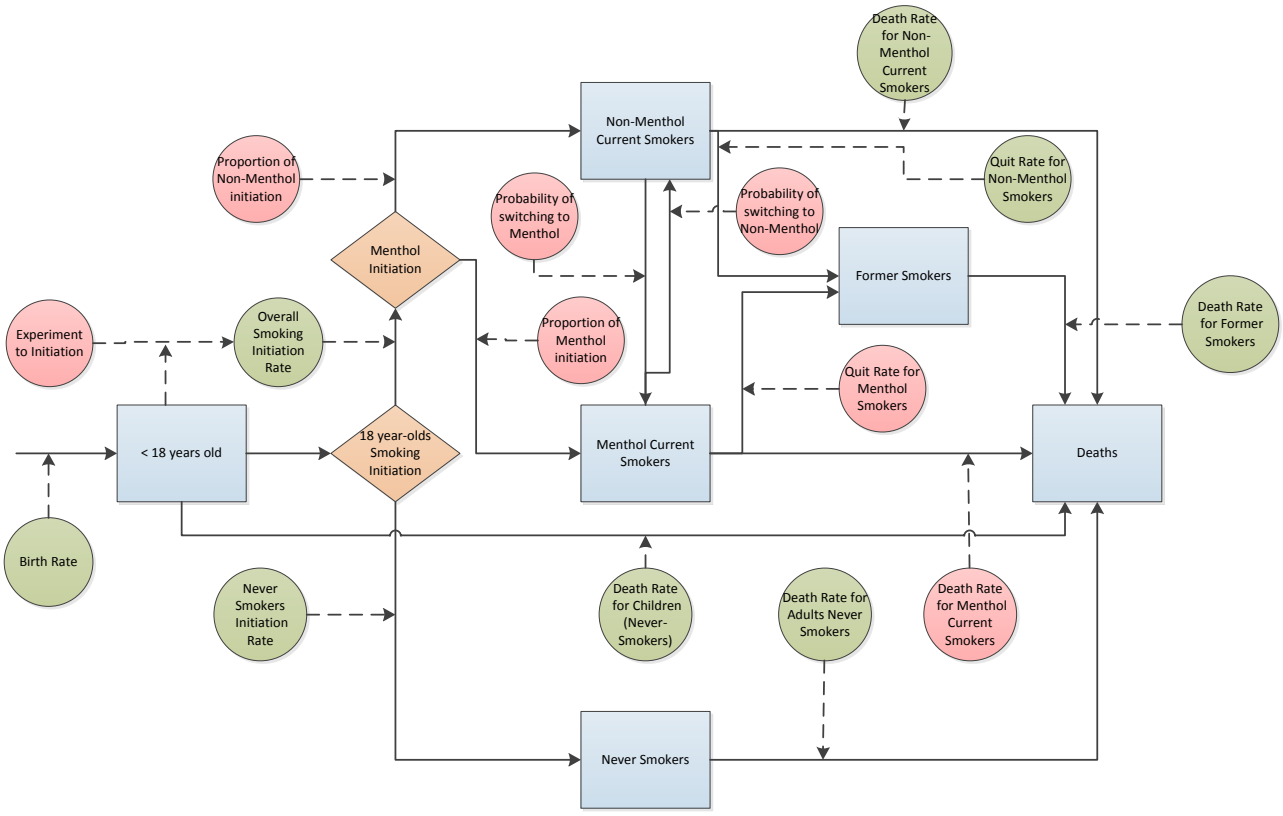
This document describes the constructs of, and results from, the model commissioned by the Tobacco Products Scientific Advisory Committee (TPSAC) to estimate the consequences of menthol cigarette smoking on the U.S population. The model is an extension and modification of a population dynamics model previously developed to track smoking prevalence and smoking related risks, which has been extensively discussed in the literature.[1-7] The following figure shows the general organization of the model, as modified to address menthol cigarettes:

Menthol Model Block Simulation Diagram



The boxes (compartments) represent the stock of individuals in different categories at a given time; the arrows represent the flow between compartments; and the circles represent parameters that modify the flow. Red circles refer to parameters related to menthol smoking while green circles refer to the other parameters. Diamonds represent the event of smoking initiation, concentrated at a single age.

Following is a description of the constructs of the model:

Definition of dynamic (time-dependent) variables:

$P(a,t) = US\ population\ of\ age\ a\ in\ year\ t$

$N(a,t) = Population\ of\ never-smokers\ of\ age\ a\ in\ year\ t$

$F(a,t,q) = Population\ of\ former-smokers\ of\ age\ a, in\ year\ t, that\ quit\ q\ years\ ago$

$C(a,t) = Population\ of\ current-smokers\ of\ age\ a\ in\ year\ t$

$C_m(a,t) = Population\ of\ current\ menthol-smokers\ of\ age\ a\ in\ year\ t$

$C_n(a,t) = Population\ of\ current\ non-menthol-smokers\ of\ age\ a\ in\ year\ t$

$\pi_N(a,t) = Prevalence\ of\ never-smokers\ of\ age\ a\ in\ year\ t$

$\pi'_N(t) = Adult\ prevalence\ of\ never-smokers\ in\ year\ t$

$\pi_F(a,t) = Prevalence\ of\ former-smokers\ of\ age\ a\ in\ year\ t$

$\pi'_F(t) = Adult\ prevalence\ of\ former-smokers\ in\ year\ t$

$\pi_C(a,t) = Prevalence\ of\ current-smokers\ of\ age\ a\ in\ year\ t$

$\pi'_C(t) = Adult\ prevalence\ of\ curent-smokers\ in\ year\ t$

$\pi_{C_m}(a,t) = Prevalence\ of\ current\ menthol\ -smokers\ of\ age\ a\ in\ year\ t$

$\pi'_{C_m}(t) = Adult\ prevalence\ of\ current\ menthol-smokers\ in\ year\ t$

$\pi_{C_n}(a,t) = Prevalence\ of\ current\ non-menthol\ -smokers\ of\ age\ a\ in\ year\ t$

$\pi'_{C_n}(t) = Adult\ prevalence\ of\ current\ non-menthol-smokers\ in\ year\ t$

$D(t) = Total\ deaths\ in\ year\ t$

Definition of Non-dynamic variables and parameters:

$\mu(a) = Overall\ death\ rate\ for\ individuals\ of\ age\ a$

$\mu_N(a) = Death\ rate\ among\ non-smokers\ of\ age\ a$

$\mu_F(a,q) = Death\ rate\ among\ former-smokers\ of\ age\ a\ \ who\ quit\ q\ years\ ago$

$\mu_C(a) = Death\ rate\ among\ current-smokers\ of\ age\ a$

$\mu_{C_m}(a) = Death\ rate\ among\ current\ menthol-smokers\ of\ age\ a$

$\mu_{C_n}(a) = Death\ rate\ among\ current\ non-menthol-smokers\ of\ age\ a$

$\rho(a) = Overall\ smoking\ quit\ rate\ for\ individuals\ of\ age\ a$

$\rho_{C_m}(a) = Smoking\ quit\ rate\ for\ menthol\ smokers\ of\ age\ a$

$\rho_{C_n}(a) = Smoking\ quit\ rate\ for\ non-menthol\ smokers\ of\ age\ a$

$S_{m2n} = Switching\ rate\ from\ menthol\ to\ non-menthol\ among\ current\ menthol\ smokers$

$S_{n2m} = Switching\ rate\ from\ non-menthol\ to\ menthol\ among\ current\ menthol\ smokers$

$I = Smoking\ initiation\ age$

$\gamma = Overall\ smoking\ initiation\ rate$

$\gamma_{C_m} = Smoking\ initiation\ rate\ for\ menthol\ smokers$

$\gamma_{C_n} = Smoking\ initiation\ rate\ for\ non-menthol\ smokers$

$RR(a,q) = Relative\ risk\ of\ death\ for\ a\ former\ smoker\ of\ age\ a\ who\ quit\ q\ years\ ago - q = 0\ implies\ current\ smoker$

$K_1 = Mortality\ risk\ ratio\ \left(\frac{Menthol}{Non-Menthol}\right)$

$K_2 = Quit\ rates\ ratio\ \left(\frac{Menthol}{Non-Menthol}\right)$

$K_3 = Proportion\ of\ Menthol\ among\ Initiators$

$K_4 = Proportion\ of\ Menthol\ among\ Experimenters$

$K_5 = Ratio\ of\ Yields\ from\ Experimenter\ to\ Established\ Smoker\ \left(\frac{Menthol}{Non-Menthol}\right)$

Dynamic (time-dependent) relationships:

$N(0,t) = P(0,t)$

$N(a,t) = N(a-1,t-1) \times \left(1-\mu_N(a)\right)\ for\ a \neq I$

$N(a,t) = N(a-1,t-1) \times \left(1-\mu_N(a)\right) \times \left(1-\gamma_{C_m}-\gamma_{C_n}\right)\ for\ a = I$

$F(a,t,q) = 0\ \ for\ a-q \leq I$

$$F(a,t,1) = C_m(a-1,t-1) \times \left(1-\mu_{C_m}(a-1)\right) \times \rho_{C_m}(a-1) + C_n(a-1,t-1) \times \left(1-\mu_{C_n}(a-1)\right) \times \rho_{C_n}(a-1)\ for\ a-q > I$$

$F(a,t,q) = F(a-1,t-1,q-1) \times \left(1-\mu_{C_F}(a-1,q-1)\right)\ \ for\ a-q > I\ and\ q > 1$

$C_m(a,t) = 0\ for\ a < I$

$C_m(a,t) = \gamma_{C_m} \times N(a-1,t-1) \times \left(1-\mu_N(a-1)\right)\ for\ a = I$

$$C_m(a,t) = C_m(a-1,t-1) \times \left(1-\mu_{C_m}(a-1)\right) \times \left(1-\rho_{C_m}(a-1)\right) \times \left(1-S_{m2n}(a-1)\right) + C_n(a-1,t-1) \times \left(1-\mu_{C_n}(a-1)\right) \times \left(1-\rho_{C_n}(a-1)\right) \times\ S_{n2m}\ \ for\ a > I$$

$C_n(a,t) = 0\ for\ a < I$

$C_n(a,t) = \gamma_{C_n} \times N(a-1,t-1) \times \left(1-\mu_N(a-1)\right)\ for\ a = I$

$$C_n(a,t) = C_n(a-1,t-1) \times \left(1-\mu_{C_n}(a-1)\right) \times \left(1-\rho_{C_n}(a-1)\right) \times \left(1-S_{n2m}(a-1)\right) + C_m(a-1,t-1) \times \left(1-\mu_{C_m}(a-1)\right) \times \left(1-\rho_{C_m}(a-1)\right) \times\ S_{m2n}\ for\ a > I$$

$$P(a,t) = N(a,t) + \sum_{q=1}^{q=30+} F(a,t,q) + C_m(a,t) + C_n(a,t)$$

$$\pi_N(a,t) = \frac{N(a,t)}{P(a,t)}$$

$$\pi'_N(t) = \frac{\sum_{a=18}^{a=100} N(a,t)}{\sum_{a=18}^{a=100} P(a,t)}$$

$$\pi_F(a,t) = \frac{\sum_{q=1}^{q=30+} F(a,t,q)}{P(a,t)}$$

$$\pi'_F(t) = \frac{\sum_{a=18}^{a=100}\sum_{q=1}^{q=30+} F(a,t,q)}{\sum_{a=18}^{a=100} P(a,t)}$$

$$\pi_{C_m}(a,t) = \frac{C_m(a,t)}{P(a,t)}$$

$$\pi'_{C_m}(t) = \frac{\sum_{a=18}^{a=100} C_m(a,t)}{\sum_{a=18}^{a=100} P(a,t)}$$

$$\pi_{C_n}(a,t) = \frac{C_n(a,t)}{P(a,t)}$$

$$\pi'_{C_n}(t) = \frac{\sum_{a=18}^{a=100} C_n(a,t)}{\sum_{a=18}^{a=100} P(a,t)}$$

$$D(t) = \sum_{a=0}^{a=100} N(a,t) \times \mu_N(a) + \sum_{a=0}^{a=100}\sum_{q=1}^{q=30+} F(a,t,q) \times \mu_F(a,q) + \sum_{a=0}^{a=100} C_m(a,t) \times \mu_{C_m}(a) + \sum_{a=0}^{a=100} C_n(a,t) \times \mu_{C_n}(a)$$

Non-dynamic relationships:

- Expressions related to mortality risks and derivation of death rates for current-, former- and never-smokers given overall death rates $\mu(a)$ in 2010.

$$K_1 = \frac{\mu_{C_m}(a)}{\mu_{C_n}(a)}$$

$$\mu_F(a,q) = \mu_N(a) \times RR(a,q)$$

$$\mu_{C_m}(a) = K_1 \times \mu_N(a) \times RR(a,0)$$

$$\mu_{C_n}(a) = \mu_N(a) \times RR(a,0)$$

$$\mu(a) = \mu_N(a) \times \pi_N(a,2010) + \left(\sum_{q=1}^{q=30+} \mu_N(a) \times RR(a,q) \times \pi_F(a,2010,q) \right) + K_1 \times \mu_N(a) \times RR(a,0) \times \pi_{C_m}(a,2010) + \mu_N(a) \times RR(a,0) \times \pi_{C_n}(a,2010) \quad \rightarrow$$

$$\mu_N(a) = \frac{\mu(a)}{\pi_N(a,2010) + \sum_{q=1}^{q=30+} \left(RR(a,q) \times \pi_F(a,2010,q) \right) + K_1 \times RR(a,0) \times \pi_{C_m}(a,2010) + RR(a,0) \times \pi_{C_n}(a,2010)}$$

Expressions related to quit rates and derivation of quit rates for menthol and non-menthol smokers given overall quit rates $\rho(a)$ in 2010.

$$K_2 = \frac{\rho_{C_m}(a)}{\rho_{C_n}(a)}$$

$$\rho_{C_m}(a) = K_2 \times \rho_{C_n}(a)$$

$$\rho(a) = K_2 \times \rho_{C_n}(a) \times \pi_{C_m}(a,2010) + \rho_{C_n}(a) \times \pi_{C_n}(a,2010) \quad \rightarrow$$

$$\rho_{C_n} = \frac{\rho(a)}{K_2 \times \pi_{C_m}(a,2010) + \pi_{C_n}(a,2010)}$$

- Expressions related to the initiation rate and derivation of initiation rate under the counterfactual scenario (in which menthol cigarettes do not exist) given overall smoking initiation rate γ in 2010.

$$\gamma = \gamma_{C_m} + \gamma_{C_n}$$

$$\gamma_{C_m} = K_3 \times \gamma$$

$$\gamma_{C_n} = (1 - K_3 \times \gamma)$$

$Let\ W\ be\ the\ size\ of\ a\ cohort\ of\ potential\ experimenters, E\ the\ proportion\ of\ experimenters\ in\ that\ cohort, Y_m\ the\ proportion\ of\ menthol\ experimenters\ that\ become\ established\ smokers, and\ Y_n\ the\ proportion\ of\ non-menthol\ experimenters\ that\ become\ established\ smokers; then, W \times E\ \times K_4\ is\ the\ number\ of\ menthol\ experimenters\ and\ W \times E\ \times (1-K_4)\ is\ the\ number\ of\ non-menthol\ experimenters.$

$It\ follows\ that:$

$$W \times E \times K_4 \times Y_m + W \times E \times (1-K_4) \times Y_n = W \times \gamma$$

$Given\ that\ \frac{Y_m}{Y_n} = K_5,\ \ then$

$$W \times E \times K_4 \times K_5 \times Y_n + W \times E \times (1-K_4) \times Y_n = W \times \gamma \quad or$$

$$Y_n = \frac{\gamma}{E \times \left(K_4 \times K_5 + (1-K_4)\right)}$$

$Let\ \gamma'\ be\ the\ initiation\ rate\ under\ the\ counterfactual, then, assuming\ the\ same\ proportion\ of\ experimenters\ as\ in\ the\ status-quo\ scenario:$

$$W \times E \times Y_n = W \times \gamma' \ \ or$$

$$\gamma' = E \times Y_n = \frac{E \times \gamma}{E \times \left(K_4 \times K_5 + (1-K_4)\right)} = \frac{\gamma}{K_4 \times K_5 + (1-K_4)}$$

Description of the Model

The model projects the US population, distinguished by age (0 to 100) and smoking status, over the period 2010-2050. Smoking status is categorized by current smokers of menthol cigarettes, current smokers of non-menthol cigarettes, never smokers and former smokers. The latter group is further divided by years quit. The model tracks former smokers from 1 to 30 years quit.

Each year, for the next 40 years (2010 to 2050) and for every year of age (from 0 to 100), the model follows the number of individuals in each category. Each simulated year the model introduces a birth cohort obtained from the U.S. Census Bureau projections for the period 2010-2050 and ages the population using age- and smoking status- specific death rates. Individuals younger than 18 are consider non-smokers. At age 18 (age 20 for African Americans) a proportion of individuals become menthol smokers, another fraction become non-menthol smokers and the rest remain non-smokers for their remaining life span. After age 18 smokers are given the chance to quit smoking or switch between menthol and non-menthol cigarettes. Those who quit become former smokers and are tracked not just by age but also by years since quit.

The age-specific background cessation rates used in the simulations are the ones estimated by Mendez and Warner (1998)[1]. Those quit rates have been validated since.[5] The quit rates were adjusted to reflect differences between menthol and non-menthol smoking according to the expressions derived on page 6. Age-specific death rates were computed for current (menthol and non-menthol), never, and former smokers by years quit employing smoking relative risks derived from the Cancer Prevention Study II (CPS II) data[8] and the procedure described on pages 5 and 6. Relative risks for current and former smokers specific to the US African American population were derived from CPS II data and supplied by the American Cancer Society (Michael Thun, American Cancer Society, personal communication, March 2011). Background death rates for the general population were obtained from the US Census Bureau. Initial (2010) estimates for overall smoking prevalence for the general and African American populations were obtained from the National Health Interview Survey (NHIS) and the Behavioral Risk Factor Surveillance System (BRFSS) respectively. The initiation rate for the general population was taken to be 21.8%, the smoking prevalence among 18 year-olds reported

by the NHIS in 2009. For African Americans, the initiation rate was taken to be 19.8%, consistent with the smoking prevalence at age 20 reported by the BRFSS 2005 for African Americans. Initial (2010) estimates of menthol prevalence were obtained from the National Survey on Drug Use and Health (NSDUH). All data used to produce this report are publicly available.

Simulation Experiments Settings and Results

The model was used to evaluate the impact of menthol cigarettes on the entire US population and the US African American population. To do this, a simulation covering the period from 2010 to 2050 was performed assuming that current (2010) initiation and cessation rates will remain constant through that period (status-quo scenario). Then the simulation was repeated, now assuming as the counterfactual that menthol cigarettes have never existed in the U.S. The actual 2010 US smoking prevalence was assumed as the 2010 smoking prevalence under the counterfactual, now produced only by non-menthol smoking. For quit rates under the counterfactual, the same non-menthol age-specific quit rates employed in the comparing status-quo scenario were used; the initiation rate on the counterfactual (γ') was computed according to the expression derived on page 6 and 7. The difference in cumulative deaths and cumulative initiation between the status-quo and counterfactual scenarios is reported.

Status quo parameters related to menthol were provided by TPSAC based on literature review findings. An extensive sensitivity analysis of those parameters on the results for the general population was conducted employing parameter ranges also supplied by TPSAC. The results of the analysis for the general population are shown on Tables 1 - 3.

A sensitivity analysis on the African American model was not conducted because of lack of specific data on some parameters and because the rest of the parameters did not show to be sensitive in the general population model. Instead, the results of the African American model were compared to those of a hypothetical population identical to the US African American population in all aspects except menthol prevalence. This hypothetical population was given the same menthol prevalence as the general US population. This comparison highlights the disproportional burden that menthol imposes on the African American population. The results of the analysis for the African American population are shown on Tables 4 – 6.

As the parameters used as input of both models (overall and African American populations) are subject to the statistical uncertainty inherent to their individual estimation process, a Monte Carlo analysis would be required to capture the combined effect of such uncertainty or the results of the analysis. This analysis would not likely change the magnitude and significance of the results, as the model is linear and the simulation settings and parameters chosen were conservative.

Table 1. Input Parameters – General Population:

Parameter	Min	TPSAC Estimate	Max
Proportion of Menthol among Initiators[2] (K_3)	0.35	0.40	0.45
Proportion of Menthol among Experimenters[3] (K_4)	0.38	0.45	0.60
Ratio of "Proportion of Menthol Experimenters that become Established Smokers" / "….Non-menthol….."[4] (K_5)	1.00	1.68	1.85
Cessation Rates Ratio (Menthol/Non-menthol)[5] (K_2)	0.92	0.95	1.10
Mortality Risk Ratio (Menthol/Non-menthol)[6] (K_1)	0.80	1.00	1.20
Switching Rate from Menthol to Non-menthol (among Menthol smokers) (S_{m2n})[7]	0.9%	1.8%	2.7%
Switching Rate from Non-menthol to Menthol (among Non-menthol smokers)[8] (S_{n2m})	0.4%	0.8%	1.2%

[2] Proportion of menthol among those aged 18 to 25. Substance Abuse and Mental Health Services Administration, Office of Applied Studies. (November 19, 2009). The NSDUH Report: Use of Menthol Cigarettes. Rockville, MD.

[3] Provided by TPSAC. 45% was based on the proportion of 12-17 or 14-16 yeor old smokers (from Rock, V. J., Davis, S. P., Thorne, S. L., Asman, K. J., & Caraballo, R. S. (2010). Menthol cigarette use among racial and ethnic groups in the United States, 2004-2008. *Nicotine Tob Res, 12 Suppl 2*, S117-124. doi: ntq204 [pii]10.1093/ntr/ntq204 and Curtin, G. M., Sulsky, S. I., Fuller, W. G., Van Landingham, C., Ogden, M. W., & Swauger, J. E. (2010a). Descriptive epidemiological analysis of menthol use from four national US surveys: I.., respectively); 38% was based on 18-25 year and 17-18 old smokers (from Giovino, G. A. (2010). Patterns and recent trends in the use of mentholated cigarettes in the United States *Submission to the Food and Drug Administration's Tobacco Products Scientific Advisory Committee,*. Rock, V. J., Davis, S. P., Thorne, S. L., Asman, K. J., & Caraballo, R. S. (2010). Menthol cigarette use among racial and ethnic groups in the United States, 2004-2008. *Nicotine Tob Res, 12 Suppl 2*, S117-124. doi: ntq204 [pii]10.1093/ntr/ntq204; Curtin, G. M., Sulsky, S. I., Fuller, W. G., Van Landingham, C., Ogden, M. W., & Swauger, J. E. (2010a). Descriptive epidemiological analysis of menthol use from four national US surveys: I.) and the 60% is based on smoking among middle schoolers or 9-12 yearo olds (from Curtin, G. M., Sulsky, S. I., Fuller, W. G., Van Landingham, C., Ogden, M. W., & Swauger, J. E. (2010a). Descriptive epidemiological analysis of menthol use from four national US surveys: I..; Hersey, J. C., Ng, S. W., Nonnemaker, J. M., Mowery, P., Thomas, K. Y., Vilsaint, M. C.,Haviland, M. L. (2006). Are menthol cigarettes a starter product for youth? *Nicotine Tob Res, 8*(3), 403-413. doi: R32206802V873N68 [pii]10.1080/14622200600670389

[4] Provided by TPSAC. Nonnemaker, J., Hersey, J., Homsi, G., Busey, A., & Vallone, D. (2010). Menthol cigarettes and youth smoking uptake Submission to the Food and Drug Administration's Tobacco Products Scientific Advisory Committee.

[5] Provided by TPSAC. 95 was based on looking at the range of Ors for cessation across a variety of population survey studies and using a conservative estimate (Alexander, L. A., Crawford, T., & Mendiondo, M. S. (2010). Occupational status, work-site cessation programs and policies and menthol smoking on quitting behaviors of US smokers. *Addiction, 105 Suppl 1*, 95-104. doi: 10.1111/j.1360-0443.2010.03227.x; Delnevo, C. D., Gundersen, D. A., & Hrwyna, M. (2010). Examining the relationship between menthol smoking and cessation using data from the 2003 and 2006/7 Tobacco use Supplement: U S Food and Drug Administration commissioned secondary analysis; Fagan, P., Moolchan, E. T., Hart, A., Jr., Rose, A., Lawrence, D., Shavers, V. L., & Gibson, J. T. (2010). Nicotine dependence and quitting behaviors among menthol and non-menthol smokers with similar consumptive patterns. *Addiction, 105 Suppl 1*, 55-74. doi: 10.1111/j.1360-0443.2010.03190.x; Fagan P, Augustson E, Backinger CL, O'Connell ME, Vollinger RE Jr, Kaufman A, Gibson JT (2007). Quit attempts and intention to quit cigarette smoking among young adults in the United States. American Journal of Public Health, 97, 1412-1420; Gundersen, D. A., Delnevo, C. D., & Wackowski, O. (2009). Exploring the relationship between race/ethnicity, menthol smoking, and cessation, in a nationally representative sample of adults. *Prev Med, 49*(6), 553-557. doi: S0091-7435(09)00478-2 [pii]10.1016/j.ypmed.2009.10.003; Trinidad, D. R., Gilpin, E. A., Lee, L., & Pierce, J. P. (2004). Do the majority of Asian-American and African-American smokers start as adults? *Am J Prev Med, 26*(2), 156-158. doi: S0749379703003180 [pii] ; OR 0.92 was obatined from Delnevo, C. D., Gundersen, D. A., & Hrwyna, M. (2010). Examining the relationship between menthol smoking and cessation using data from the 2003 and 2006/7 Tobacco use Supplement: U S Food and Drug Administration commissioned secondary analysis; OR of 1.10 was dervived from Fagan, P., Moolchan, E. T., Hart, A., Jr., Rose, A., Lawrence, D., Shavers, V. L., & Gibson, J. T. (2010). Nicotine dependence and quitting behaviors among menthol and non-menthol smokers with similar consumptive patterns. *Addiction, 105 Suppl 1*, 55-74. doi: 10.1111/j.1360-0443.2010.03190.x

[6] Provided by TPSAC

[7] Switching Book, 1991 – Philip Morris 2500136466-2500137049. 0.6% of all smokers switched from menthol to non-menthol / 0.33- proportion of menthol smokers among smokers. Range +/- 50%

[8] Switching Book, 1991 – Philip Morris 2500136466-2500137049. 0.5% of all smokers switched from non-menthol to menthol / 0.67- proportion of non-menthol smokers among smokers. Range +/-50%

Table 2. Scenario Analysis – General Population

Scenario	Description	Prop of Menthol Initiation	Proportion of Menthol Experimentation	Experimentation to Initiation Yield Ratio Menthol/Non-Menthol	Initiation Rate under Counterfactual	Cessation Ratio Menthol/Non-Menthol	Mortality Ratio Menthol/Non-Menthol	Switching Rate Menthol to Non-Menthol	Switching Rate Non-Menthol to Menthol
1	TPSAC Estimates	0.40	0.45	1.68	16.7%	0.95	1.00	1.8%	0.8%
2	Low Menthol Initiation	0.35	0.45	1.68	16.7%	0.95	1.00	1.8%	0.8%
3	High Menthol Initiation	0.45	0.45	1.68	16.7%	0.95	1.00	1.8%	0.8%
4	Low Menthol Experimentation	0.40	0.38	1.68	17.3%	0.95	1.00	1.8%	0.8%
5	High Menthol Experimentation	0.40	0.60	1.68	15.5%	0.95	1.00	1.8%	0.8%
6	Low Yield from Experimenter to Smoker	0.40	0.45	1.00	21.8%	0.95	1.00	1.8%	0.8%
7	High Yield from Experimenter to Smoker	0.40	0.45	1.85	15.8%	0.95	1.00	1.8%	0.8%
8	Low Menthol Cessation	0.40	0.45	1.68	16.7%	0.92	1.00	1.8%	0.8%
9	High Menthol Cessation	0.40	0.45	1.68	16.7%	1.10	1.00	1.8%	0.8%
10	Low Menthol Mortality Risk	0.40	0.45	1.68	16.7%	0.95	0.80	1.8%	0.8%
11	High Menthol Mortality Risk	0.40	0.45	1.68	16.7%	0.95	1.20	1.8%	0.8%
12	Low Switch Rate Menthol to Non-menthol	0.40	0.45	1.68	16.7%	0.95	1.00	0.9%	0.8%
13	High Switch Rate Menthol to Non-Menthol	0.40	0.45	1.68	16.7%	0.95	1.00	2.7%	0.8%
14	Low Switch Rate Non-menthol to Menthol	0.40	0.45	1.68	16.7%	0.95	1.00	1.8%	0.4%
15	High Switch Rate Non-menthol to Menthol	0.40	0.45	1.68	16.7%	0.95	1.00	1.8%	1.2%

Table 3. Results – General Population

Scenario	Description	Cumulative Excess Deaths				Cumulative Excess Smoking Initiation			
		2020	2030	2040	2050	2020	2030	2040	2050
1	TPSAC Estimates	17,182	67,817	164,590	327,565	2,288,534	4,429,326	6,710,101	9,124,867
2	Low Menthol Initiation	17,181	67,812	164,555	327,396	2,288,534	4,429,326	6,710,101	9,124,867
3	High Menthol Initiation	17,182	67,822	164,625	327,733	2,288,534	4,429,326	6,710,101	9,124,867
4	Low Menthol Experimentation	15,411	61,041	147,794	292,601	2,019,295	3,908,229	5,920,677	8,051,353
5	High Menthol Experimentation	20,723	81,367	198,181	397,489	2,827,013	5,471,520	8,288,948	11,271,894
6	Low Yield from Experimenter to Smoker	2,127	10,220	21,810	30,346	0	0	0	0
7	High Yield from Experimenter to Smoker	19,838	77,980	189,784	380,008	2,692,393	5,210,972	7,894,236	10,735,137
8	Low Menthol Cessation	18,495	74,138	178,061	346,122	2,288,534	4,429,326	6,710,101	9,124,867
9	High Menthol Cessation	11,023	38,336	101,964	241,409	2,288,534	4,429,326	6,710,101	9,124,867
10	Low Menthol Mortality Risk	-239,508	-293,535	-220,657	-41,279	2,288,534	4,429,326	6,710,101	9,124,867
11	High Menthol Mortality Risk	238,551	378,451	494,892	644,022	2,288,534	4,429,326	6,710,101	9,124,867
12	Low Switch Rate Menthol to Non-menthol	17,227	68,265	166,070	330,538	2,288,534	4,429,326	6,710,101	9,124,867
13	High Switch Rate Menthol to Non-Menthol	17,138	67,397	163,252	324,972	2,288,534	4,429,326	6,710,101	9,124,867
14	Low Switch Rate Non-menthol to Menthol	17,139	67,399	163,249	324,993	2,288,534	4,429,326	6,710,101	9,124,867
15	High Switch Rate Non-menthol to Menthol	17,224	68,223	165,874	329,989	2,288,534	4,429,326	6,710,101	9,124,867

Table 4. Input Parameters – African American Population:

Parameter	TPSAC Estimate
Proportion of Menthol among Initiators[9] (K_3)	.80
Proportion of Menthol among Experimenters[10] (K_4)	.80
Ratio of "Proportion of Menthol Experimenters that become Established Smokers" / "….Non-menthol….."[11] (K_5)	1.68
Cessation Rates Ratio (Menthol/Non-menthol)[11] (K_2)	0.95
Mortality Risk Ratio (Menthol/Non-menthol)[11] (K_1)	1
Switching Rate from Menthol to Non-menthol (among Menthol smokers)[12] (S_{m2n})	0.9%
Switching Rate from Non-menthol to Menthol (among Non-menthol smokers)[13] (S_{n2m})	4%
Initiation Rate under Counterfactual (γ')[14]	12.7%

[9] Same as experimenters

[10] Provided by TPSAC. 80% was based on the proportion of 12-17 or 14-16 yeor old smokers (from Appleyard, J., Messeri, P., & Haviland, M. L. (2001). Smoking among Asian American and Hawaiian/Pacific Islander youth: data from the 2000 National Youth Tobacco Survey. *Asian Am Pac Isl J Health, 9*(1), 5-14.; Giovino, G. A. (2010). Patterns and recent trends in the use of mentholated cigarettes in the United States *Submission to the Food and Drug Administration's Tobacco Products Scientific Advisory Committee*; Giovino, G. A., Sidney, S., Gfroerer, J. C., O'Malley, P. M., Allen, J. A., Richter, P. A., & Cummings, K. M. (2004). Epidemiology of menthol cigarette use. *Nicotine Tob Res, 6 Suppl 1*, S67-81. doi: 10.1080/14622203710001649696 14AH8W576MJQ7MCN [pii]; Hersey, J. C., Ng, S. W., Nonnemaker, J. M., et al. (2006). Are menthol cigarettes a starter product for youth? *Nicotine Tob Res, 8*(3), 403-413. doi: R32206802V873N68 [pii]10.1080/14622200600670389; Hersey, J. C., Nonnemaker, J. M., & Homsi, G. (2010). Menthol cigarettes contribute to the appeal and addiction potential of smoking for youth. *Nicotine Tob Res, 12 Suppl 2*, S136-146. doi: ntq173 [pii]10.1093/ntr/ntq173; Rock, V. J., Davis, S. P., Thorne, S. L., Asman, K. J., & Caraballo, R. S. (2010). Menthol cigarette use among racial and ethnic groups in the United States, 2004-2008. *Nicotine Tob Res, 12 Suppl 2*, S117-124. doi: ntq204 [pii]10.1093/ntr/ntq204

[11] Same values as in the general population.

[12] Switching Book, 1991 – Philip Morris 2500136466-2500137049 – 0.7% of all African American smokers switched from menthol to non-menthol / 0.8 – proportion of menthol smokers among African American smokers.

[13] Switching Book, 1991 – Philip Morris 2500136466-2500137049 – 0.8% for all African American smokers switched from non-menthol to menthol / 0.2 – proportion of non-menthol smokers among African American smokers.

[14] Computed using the procedure described on page 7.

Table 5. Input Parameters – Hypothetical Low Menthol African American Population:

Parameter	Estimate
Proportion of Menthol among Initiators[15] (K_3)	.40
Proportion of Menthol among Experimenters[15] (K_4)	.45
Ratio of "Proportion of Menthol Experimenters that become Established Smokers" / "….Non-menthol….."[16] (K_5)	1.68
Cessation Rates Ratio (Menthol/Non-menthol)[16] (K_2)	0.95
Mortality Risk Ratio (Menthol/Non-menthol)[16] (K_1)	1
Switching Rate from Menthol to Non-menthol (among Menthol smokers)[16] (S_{m2n})	0.9%
Switching Rate from Non-menthol to Menthol (among Non-menthol smokers)[16] (S_{n2m})	4%
Initiation Rate under Counterfactual (γ')[17]	15.0%

[15] Same value as in the general population

[16] Same value as in the African American population

[17] Computed using the procedure described on page 7

Table 6. Results – African American Population

Description	Cumulative Excess Deaths				Cumulative Excess Smoking Initiation			
	2020	2030	2040	2050	2020	2030	2040	2050
African American Population – TPSAC Estimates	4,716	16,381	35,250	66,524	461,273	859,101	1,262,086	1,656,005
Low Menthol Prevalence Hypothetical African American Population	2,691	10,244	23,218	44,771	307,515	572,734	841,391	1,104,003

References:

1. Mendez D, Warner KE and Courant PN. "Has Smoking Cessation Ceased? Expected Trends in the Prevalence of Smoking in the United States." *American Journal of Epidemiology,* 1998;148(3):249-58.

2. Mendez D and Warner KE. "Smoking Prevalence in the Year 2010: Why the Healthy People Goal is Unattainable." *American Journal of Public Health,* 2000;90(3):401-403.

3. Mendez D, Warner KE and Courant PN. "Expected Trends in the Prevalence of Cigarette Smoking." Chapter in Lu R, Mackay J, Niu S and Peto R, eds. *The Growing Epidemic,* Singapore: Springer-Verlag, 2000:49-52.

4. Warner KE, Mendez D and Smith DG. "Cost Effectiveness of Smoking Cessation Programs in Managed Care Organizations." *Inquiry,* 2004;41(1):57-69.

5. Mendez D and Warner KE. "Smoking Trends in the US: Declining as Expected if not as Desired." *American Journal of Public Health,* 2004;94:251:252.

6. Mendez D and Warner KE. "Commissioned Simulation Modeling of Smoking Prevalence as an Outcome of Selected Tobacco Control Measures." Chapter in The Institute of Medicine's Committee on Reducing Tobacco Use, eds. *Ending the Tobacco Problem: A Blueprint for the Nation The Institute of Medicine,* 2007.

7. Mendez D and Warner KE. "Setting a challenging, yet realistic smoking prevalence target for Healthy People 2020: Learning from the California experience." *American Journal of Public Health,* 2008;98(3):556-9.

8. Mendez D, Warner KE. "The relative risk of death for former smokers: the influence of age and years-quit." *Unpublished research monograph,* 2001. Available at http://www.umich.edu/~dmendez/tobacco/RRiskmonograph.doc. Accessed March 14, 2011.