
Evaluation of the Economic Impact of California's Tobacco Control Program: A Dynamic Model Approach--Appendix 3 : Parameter Estimates for the Mortality, Morbidity, Health Status and Expenditure Models.

■

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■ Section 1 : The Mortality Model.

See Appendix 2 for the specification of the mortality model and for the method used to estimate the parameters of the model. The order of estimation of the mortality model's parameters is as follows : the never smoker parameters are estimated first; then, the current smoker's parameters are estimated, given the never smoker's parameter estimates; finally, the single former smoker parameter, the standard deviation of the former smoker's variance is estimated, given the never smoker's and the current smoker's parameters. Table 1 presents the full information (for never smokers) and limited information (for current and former smokers) maximum likelihood estimates of the parameter estimates for the mortality model. Figure 1 illustrates the survival model, given its estimates. Figure 1 depicts the probability of survival for men with six different smoking histories : (1, tan) a current - smoker 2 packs per day; (2, lime) a current - smoker 1 pack per day; (3, blue) a former - smoker, 20 years, 1 pack per day; (4, green) a current - smoker, 1/2 pack per day; (5, purple) a former - smoker, 10 years, 1 pack per day; and (6, red) a never - smoker. One of the products of the mortality model is the estimation of the parameters of the tobacco - exposure index which is used to represent the smoking history of individuals. Figure 2 illustrates the model's tobacco - exposure index for current and former smokers with habits of 1/2 and 2 packs a day. Expected index measures summarize an individual's smoking history in the morbidity, health status, and cost models to follow.

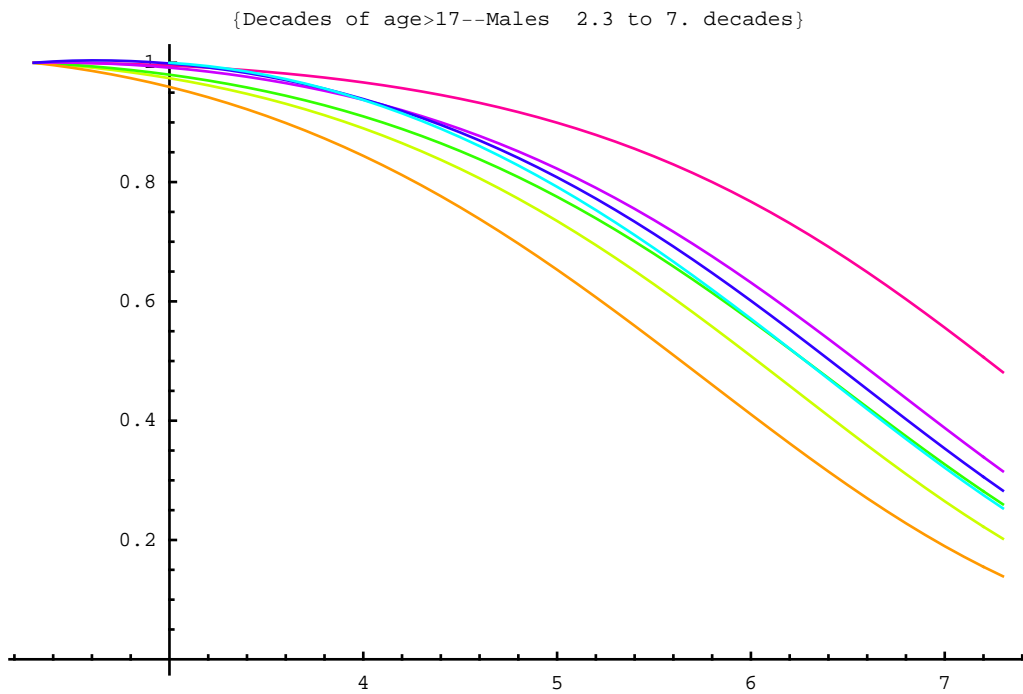
Table 1. Parameter Estimates for Mortality Model

	Parameter	Estimate	Stdev	t - value	Source
Never - Smokers	η_1	1.5681	.0787	19.917	a.
	η_2	0.2205	.0114	19.275	
Current - Smokers	η_3	0.1107	0.0111	9.951	b.
	$\gamma_1 = \text{Exp}[\beta_1]$	-21.5052	0.113	-190.2	
	γ_{c0}	-1.7248	0.183	-9.405	

$\sigma_c = \text{Exp}[\beta_2]$	β_2	- 27.1608	0.182	- 149.3	
Former - Smokers	η_4	0.0394	0.00796	4.950	c.
$\sigma_f = \text{Exp}[\beta_3]$	β_3	- 9.891	10.989.8	- 0.0009	

a.= mathematica files//Twinsnev3.nb ;
 b.= mathematica files//Twinscur61.nb;
 c.= mathematica files//Twinsfor31.nb

■ Figure 1 : Probability of Survival, Given Age and Smoking History

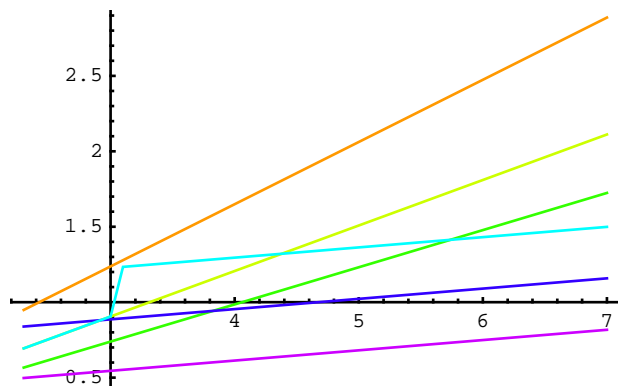


Probability of Survival for Males vs. Decades after age 17
 (Source=Twinsfor31.nb)

The order of the survival curves Figure 1 from bottom to top, evaluated at age 77 (6 decades), is as follows :

- orange = current - smoker 2 packs per day
- lime = current - smoker 1 pack per day
- teal blue = former - smoker, 30 years, 1 pack per day
- green = current - smoker, 1/2 pack per day
- light blue = former - smoker, 30 years, 1 pack per day
- dark blue = former - smoker, 20 years, 1 pack per day
- purple = former - smoker, 10 years, 1 pack per day
- red = never - smoker

Figure 2: Tobacco-Exposure, Current and Former smokers (20 years), 1/2 and 2 packs/day



Tobacco Exposure Index for Males vs. Decades of age after age 17

The order is Figure 2, from bottom to top, is as follows :

Evaluated at age 77 (6 decades), from bottom to top :

purple	= former - smoker, 10 years, 1 pack per day
dark blue	= former - smoker, 20 years, 1 pack per day
light blue	= former - smoker, 30 years, 1 pack per day
green	= current - smoker, 1/2 pack per day
lime	= current - smoker 1 pack per day
orange	= current - smoker 2 packs per day

■ **Section 2. Models of the Probability of being Currently Treated for Two Classes of Smoking Caused Diseases.**

Section 2 presents parameter estimates in the models to predict current treatment status (within a year) for smoking caused diseases. We have separated the smoking caused diseases into groups based on their comparable relative odds ratios. The group labeled LC5 has a relative odds ratio of around ten—the relative odds of a smoker being currently treated for an LCF disease is ten times the relative odds for a never - smoker being treated. The group labeled CHD5 has a relative odds ratio of around two. Table 2 lists the ICD - 9 codes for the two groups.

■ **Table 2 : Smoking Caused Diseases with their ICD - 9 designations.**

Disease Group	Disease Name and ICD - 9
CodeClass 1 : LC5	lung cancer (162), laryngeal cancer (161), chronic obstructive pulmonary disease (491 - 2, 496)
Class 2 : CHD5	atherosclerosis/aortic aneurysm (440 - 441, 444), bladder cancer (188),cerebrovascular disease(430 - 438), with sequelae : hemiplegia and hemiparesis (342), coronary heart disease (410 - 414, 427 - 428), with sequelae : cardiomyopathy and congestive heart failure (425), esophageal cancer (150), kidney cancer (189), oral cancer (140 - 141, 143 - 149), other arterial disease, buerger' s disease (443.1), peripheral vascular disease (443.9), pancreatic cancer (157), and stomach cancer (151)

The probability of being currently treated in any year for each class is specified by the respective equations,

$$\text{ProbLC5} = \text{CDF}[\text{NormalDistribution}[0, (\text{Exp}[\varphi_1 \text{ curr} + \varphi_2 \text{ form}])^{1/2}], (\beta_0 + \beta_1 \text{ Age} + \beta_3 \text{ toxc} + \beta_4 \text{ toxff} + \beta_5 \text{ toxfu})]$$

$$\text{ProbCHD5} = \text{CDF}[\text{NormalDistribution}[0, (\text{Exp}[\varphi_1 \text{ curr} + \varphi_2 \text{ form}])^{1/2}], (\beta_0 + \beta_1 \text{ Age} + \beta_2 \text{ Age}^2 + \beta_3 \text{ toxc} + \beta_4 \text{ toxff} + \beta_5 \text{ toxfu})]$$

where CDF is the normal distribution function;

curr is 1 if a current smoker, 0 otherwise;

form is 1 if a former smoker, 0 otherwise;

age is measured as decades after age 17;

toxc is the expected toxin exposure index level of the current smoker;

toxff is the expected toxin exposure index level of the former smoker at the time he stopped smoking; and

toxfu is the expected toxin exposure index level of the

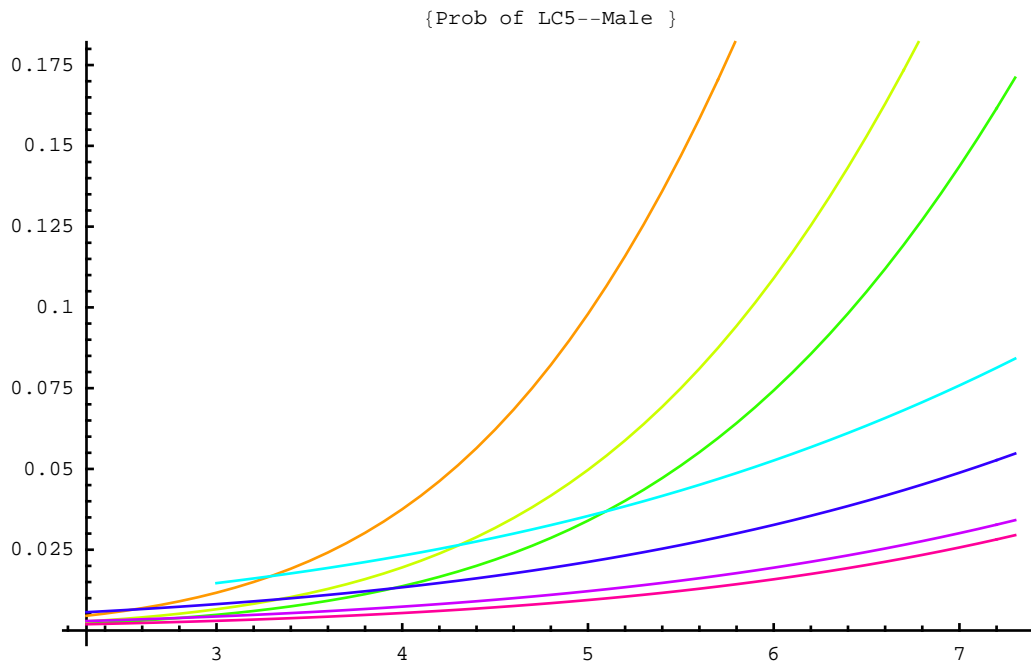
former smoker in decades after quitting. Table 3 presents parameter estimates for the LC5 model and Table 4 presents parameter estimates for the CHD5 model.

■ **Table3: Parameter Estimates for the Current Annual Treatment of LC5 Diseases (Source 719200lc55.nb)**

Variable	Parameter	Estimate	Standard Error	t - value
Current smoker in var	$\varphi1$	- 0.214	0.184	- 1.163
Former smoker in var	$\varphi2$	- 0.034	0.208	- 0.164
Constant	$\beta0$	- 3.349	0.272	- 12.314
Age in decades >17	$\beta1$	0.200	0.0489	4.091
toxc	$\beta3$	0.0637	0.00905	7.040
toxff	$\beta4$	0.0839	0.0345	2.435
toxfu	$\beta5$	- 0.00978	0.0360	- 0.273

(Source 719200lc55.nb)

■ **Figure 3: The probability of annual current treatment (that is, being treated within a year) for LC5, given age and smoking behavior. (Source:/Male Diseases/lc5graphsfinal55.nb)**



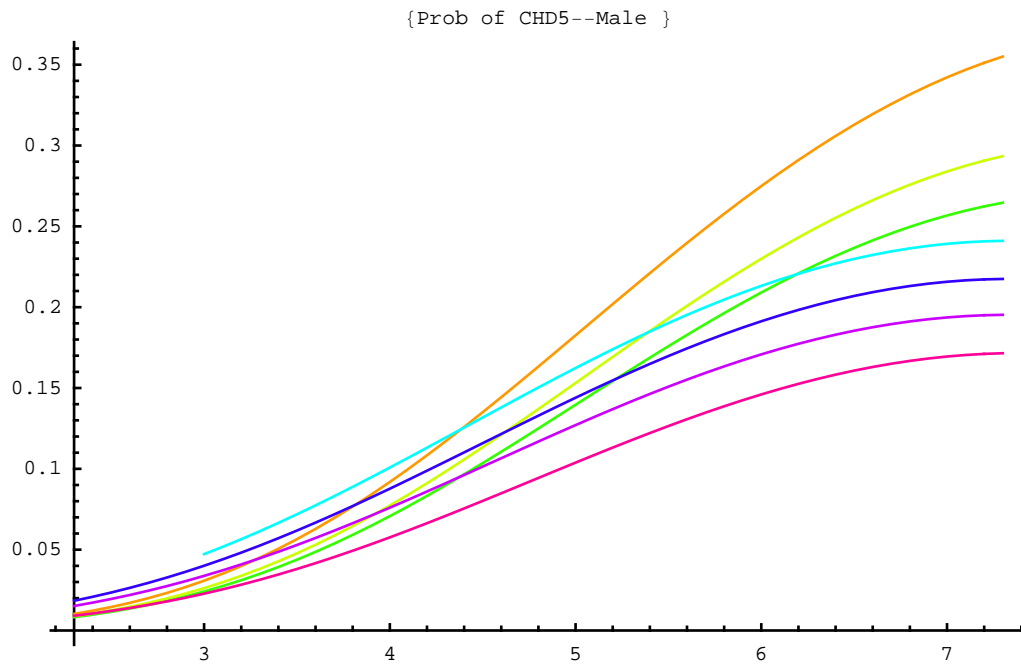
- Bottom to top (evaluated at 6 decades after age 17):
 - never-smoker, (red)
 - former-smoker, 10 yr, 1 pk/day (purple)
 - former-smoker, 20 yr, 1 pk/day (dark blue)
 - former-smoker, 30 yr, 1 pk/day (light blue)
 - current-smoker, 1/2 pk day (green)
 - current-smoker, 1 pk/day (lime)
 - current-smoker, 2 pks/day (tan)

■ **Table4: Parameter Estimates for the Current Annual Treatment of CHD5 Diseases**

Variable	Parameter	Estimate	Standard Error	t - value
Current smoker in var	φ_1	- .128	0.165	- 0.781
Former smoker in var	φ_2	- .113	0.184	- 0.618
Constant	β_0	- 3.925	0.417	- 9.409
Age in decades >17	β_1	0.805	0.172	4.669
Age-squared	β_2	-0.0544	0.0177	
toxc	β_3	0.022	0.00725	7.0402
toxff	β_4	0.0315	0.0208	2.435
toxfu	β_5	-0.0034	0.0215	- 0.273

(Source : 8252004 chd54.nb)

■ **Figure 4: The probability of annual treatment for CHD5, given age and smoking behavior**



Bottom to top (evaluated at 7 decades of smoking history) :

- never - smoker (red)
- former - smoker, 10 yr, 1 pk / day (purple)
- former - smoker, 20 yr, 1 pk / day (blue)
- former - smoker, 30 yr, 1 pk / day (light blue)
- current - smoker, 1 / 2 pack / day, (green)
- current - smoker, 1 pack / day, (lime)
- current - smoker, 2 packs / day, (tan)

■ Section 3: Models of Self-Reported Poor Health Status

Self-Reported poor-health status is modeled as an ordered probability model.

$$\text{Health}^* = (\beta_0 + \beta_1 \text{ age} + \beta_3 \text{ toxc} + \beta_4 \text{ toxff} + \beta_5 \text{ toxfu}) + \varepsilon$$

where $\varepsilon \sim N[0, \text{Exp}(\varphi_1 \text{ curr} + \varphi_2 \text{ form})]$

where Health^* is the latent index of poor health status and (in the discussion below) Health^{\wedge} is the expected value of the latent index of poor health status;

The parameters μ_1 and μ_2 (in Table 4) are boundary values of the latent index of self-reported poor-health status between good and fair and between fair and poor health status, respectively;

The probability of excellent, good, fair, and poor health are given by:

$$\begin{aligned} & \text{CDF}[-\text{Health}^{\wedge}], \\ & \text{CDF}[\mu_1 - \text{Health}^{\wedge}] - \text{CDF}[-\text{Health}^{\wedge}], \\ & \text{CDF}[\mu_2 - \text{Health}^{\wedge}] - \text{CDF}[\mu_1 - \text{Health}^{\wedge}], \\ & \text{and } 1 - \text{CDF}[\mu_2 - \text{Health}^{\wedge}], \text{ respectively.} \end{aligned}$$

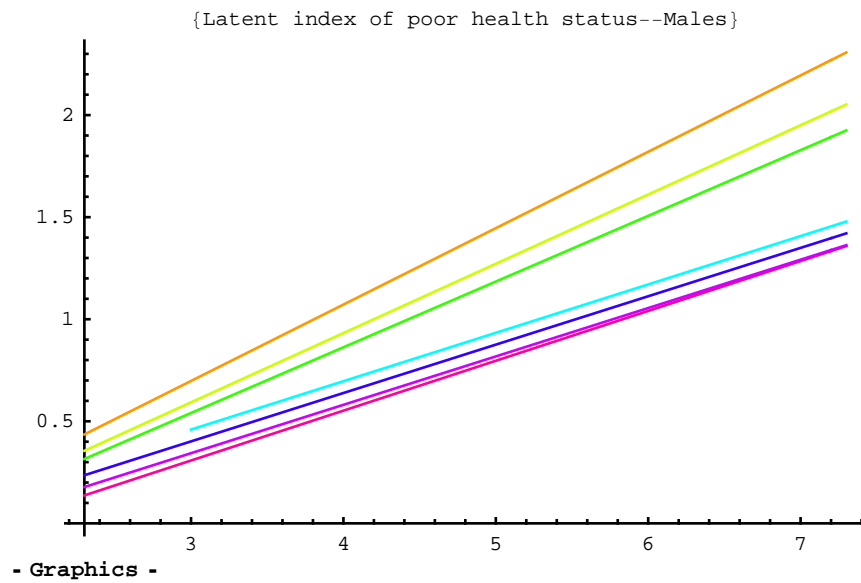
■ Table 5: Parameter Estimates for the Poor Health Status model

Variable	Parameter	Estimate	Standard Error	t-value
Current smoker in variance	φ_1	-0.129	0.0711	-1.81
Former smoker in variance	φ_2	-0.136	0.0755	-1.795
Constant	β_0	-0.425	0.0581	-7.315
Age (in decades >17)	β_1	0.244	0.0165	14.815
Toxc	β_3	0.0349	0.00326	10.688
Toxff	β_4	0.0228	0.0123	1.851
Toxfu	β_5	-0.00425	0.0102	-0.415
Boundary values between good and fair	μ_1	1.438	0.0416	34.542
Boundary values between fair and poor	μ_2	2.452	0.0699	35.068

(Source:/home/len/mathematica files/Male poor health/7232004ph3.nb)

■ **Figure 5: Latent Index of Poor Health Status as a function of age and smoking history**

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Latent Index of Poor Health Status

Bottom to Top (evaluated 7 decades after average onset of smoking age (17)

red = never - smoker

purple = former - smoker, 10 years

dark blue = former - smoker, 20 years

light blue = former - smoker, 30 years

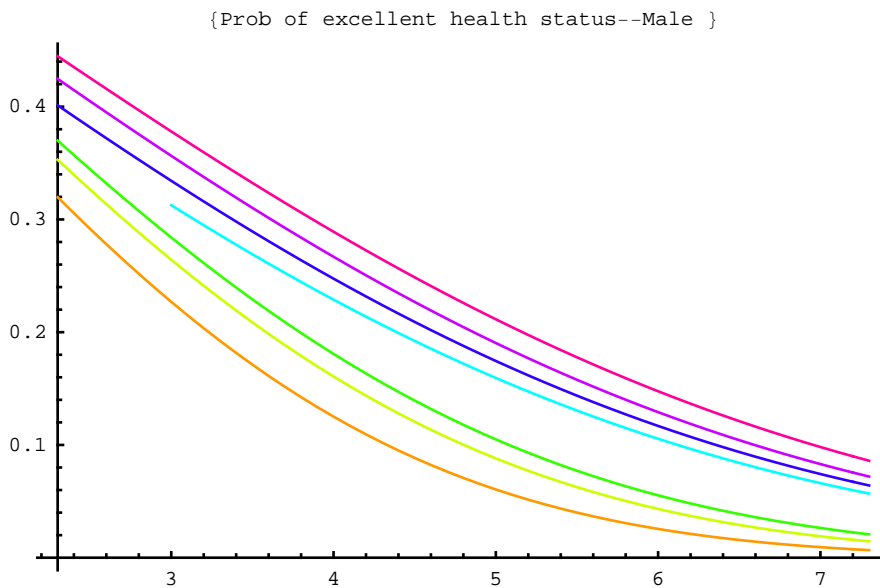
green = current smoker, 1/2 pack/day

lime = current smoker, 1 pack/day

tan = current smoker, 2 packs/day

(Source: poorhealthgraphs3.nb)

■ **Figure 6A: Probability of self-reported excellent health as a function of age and smoking history** (Source: poorhealthgraphs3.nb)



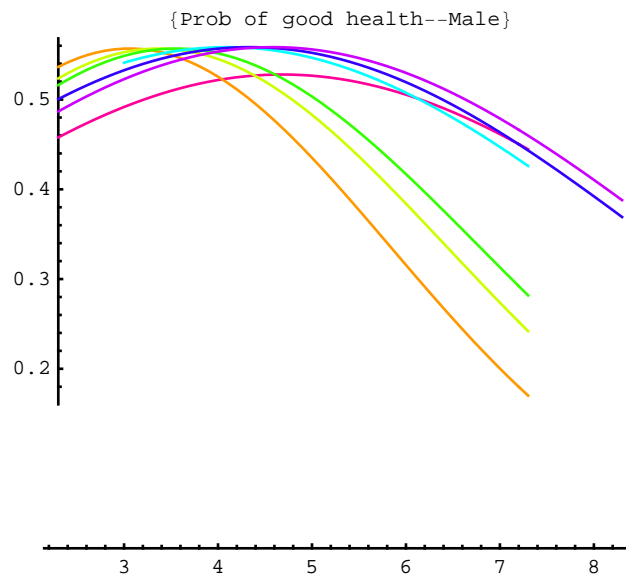
- Graphics -

Probability of self-reported excellent health vs decades after age 17

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red=never-smoker
purple=former-smoker, 10 years
dark blue=former-smoker, 20 years
light blue=former-smoker, 30 years
green=current smoker, 1/2 pack/day
light green=current smoker, 1 pack/day
orange=current smoker, 2 packs/day
    
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■ **Figure 6B: Probability of self-reported good health as a function of age and smoking history** (Source: poorhealthgraphs3.nb)

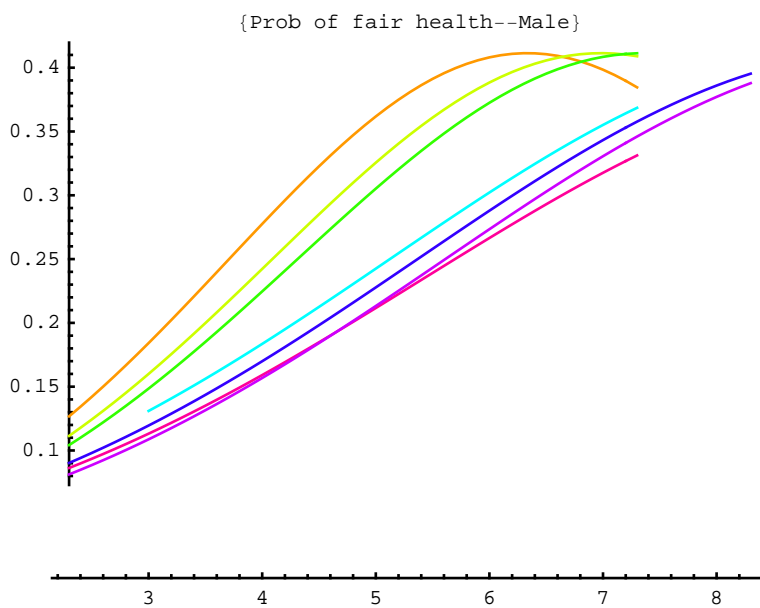


- Graphics -

Probability of self-reported good health vs decades after age 17

red=never-smoker
 purple=former-smoker, 10 years
 dark blue=former-smoker, 20 years
 light blue=former-smoker, 30 years
 green=current smoker, 1/2 pack/day
 light green=current smoker, 1 pack/day
 orange=current smoker, 2 packs/day

■ **Figure 6C: Probability of self-reported fair health as a function of age and smoking history** (Source: poorhealthgraphs3.nb)

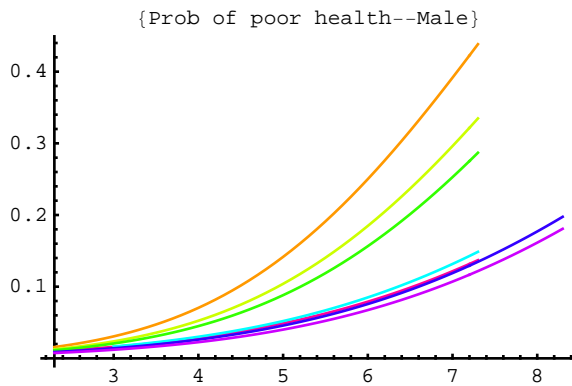


- Graphics -

Probability of self-reported fair health vs decades after age 17

red=never-smoker
 purple=former-smoker, 10 years
 dark blue=former-smoker, 20 years
 light blue=former-smoker, 30 years
 green=current smoker, 1/2 pack/day
 light green=current smoker, 1 pack/day
 orange=current smoker, 2 packs/day

■ **Figure 6D: Probability of self-reported poor health as a function of age and smoking history** (Source: poorhealthgraphs3.nb)



Probability of self-reported poor health vs decades after age 17

red=never-smoker
 purple=former-smoker, 10 years
 dark blue=former-smoker, 20 years
 light blue=former-smoker, 30 years
 green=current smoker, 1/2 pack/day
 light green=current smoker, 1 pack/day
 orange=current smoker, 2 packs/day

■ **Section 4: Annual Health Care cost models as functions of dynamic smoking variables .**

■ **Parameter Estimates for Expected Medical Expenditures for Current LC5 Treatment**

Since current-treatment is determined by hospital ICD-9 codes, and since all currently treated respondents have either hospital stays or have had laboratory work done, currently-treated respondents all have positive expenditures. The cost for LC5 treatment was estimated with the determinants of the logarithm of annual expenditures for respondents with LC5 treatment. Only treatment for LC5 mattered. Log expenditures equaled 7.847. The t value was 62.6. The smearing coefficients for retransformation40, calculated by smoking status, were: never-smokers' smearing coefficient=1.0138; current-smokers' smearing coefficient=3.366; and former-smokers' smearing coefficient=3.326.

$$\text{Log}[\text{expenditure}] = (\beta_0) + \varepsilon$$

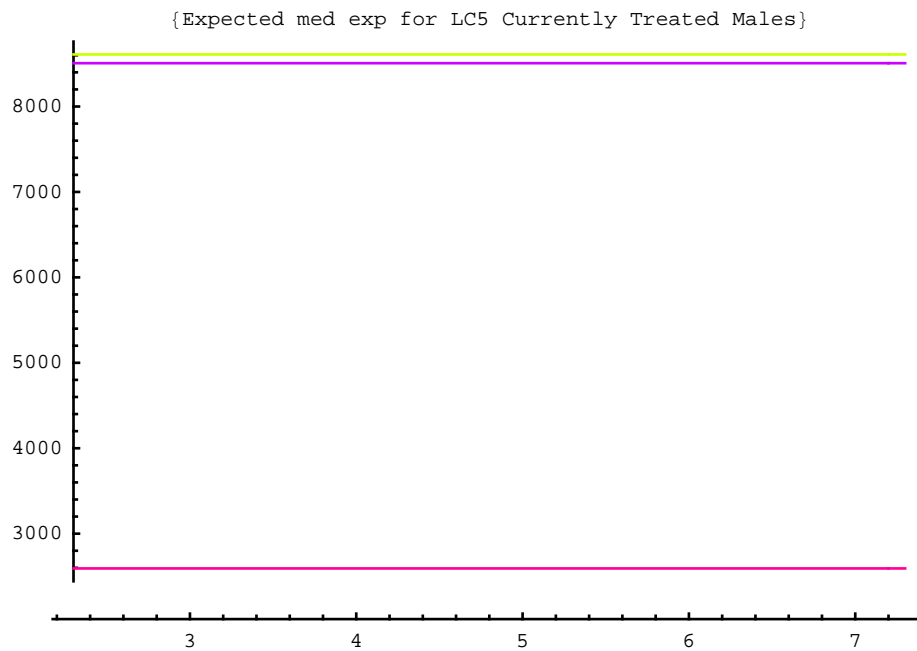
where $\varepsilon \sim N[0, \sigma^2]$

```
{ParameterTable → " " "Estimate" "SE" "TStat" "PValue"
"Constant" 7.84688 0.12542 62.5652 0
RSquared → 0, AdjustedRSquared → 0, EstimatedVariance → 2.7685}
```

■ **Table 6: Parameter Estimates of the Expected Logarithm of Medical Expenditures for Current Treatment of LC5**

Variable	Parameter	Estimate	Sta Error	t - value	Smoking Status	Ψ = Smearing Coefficient
Constant	β_0	7.847	0.125	62.6	Never	1 .0138
					Current	3 .366
					Former	3 .326

■ **Figure7A: Expected medical expenditure on males who were treated within the year for LC5 (Source:/male expenditures/7232004explc52.nb)**



- Graphics -

Bottom to top (at 6.4 decades after mean initiation time (17 years)) :
 never - smoker (red)
 former - smokers, (purple)
 current - smokers, (light green)

■ **Parameter Estimates for Expected Logarithm of Medical Expenditures for CHD5 Treatment**

The CHD5 cost model estimated the determinants of the logarithm of annual expenditures for respondents with CHD5 treatment. Health expenditures were found to be a function of ever-smoker status and the expected latent index of poor health status. Note that the expected poor health status model, which was estimated with persons not currently treated, was here used with the people currently treated for CHD5 to obtain an expected value. As seen above, the expected latent index of poor health status is a function of tobacco exposure. The more exposure the higher the expected poor health status, the higher expected CHD5 expenditures. The never-smoker's smearing coefficient equaled 2.918, the current-smoker's smearing coefficient equaled 3.397, and the former-smoker's smearing coefficient equaled 2.830.

$$\text{Log}[\text{expenditure} \mid \text{expenditure} > 0] = \beta_0 + \beta_1 \text{ ever} + \beta_2 \text{ healthstar} + \epsilon$$

	"	"Estimate"	"SE"	"TStat"	"PValue"
{ParameterTable →	"Constant"	7.81761	0.217024	36.0219	0
	"Eversmoker"	-0.307497	0.1624249	-1.8932	0.059
	"Health*^"	0.42511	0.199207	2.13401	0.033

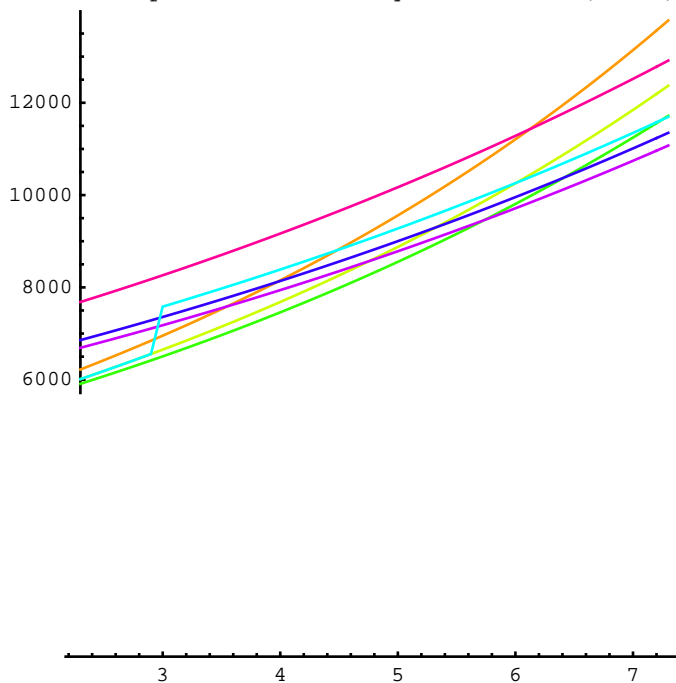
RSquared → 0.0109, AdjustedRSquared → 0.0076, EstimatedVariance → 2.326,

■ **Table7:Parameter Estimates for Expected Medical Expenditures for Current Treatment of CHD5**

Variable	Parameter	Estimate	Sta Error	t - value	Smoking Status	Ψ = Smearing Coefficient
Constant	β_0	7.8176	0.2170	36.02	Never	2.918
Eversmoker Status	β_1	-0.3075	0.1624	-1.893	Current	3.3970
health*^	β_2	0.4251	0.1992	2.134	Former	2.830

■ **Figure 7B: Medical Expenditure of males annually treated for CHD5 (Source:/male expenditures/7232004expCHD52.nb)**

{Expected med exp for CHD5 Currently Treated Males, curr,1/2pk/day}



- Graphics -

Bottom to top (at 7. decades after mean initiation time (17 years)) :

- former - smoker, 10 yr, 1 pk/day (purple)
- former - smoker, 20 yr, 1 pk/day (blue)
- current - smoker, 1/2 pk day (darker green)
- former - smoker, 30 yr, 1 pk/day (light blue)
- current - smoker, 1 pk/day (lime)
- never - smoker (red)
- current - smoker, 2 pks/day (tan)

■ **Parameter Estimates for Expected Medical Expenditures for men who are not currently treated for smoking caused diseases.**

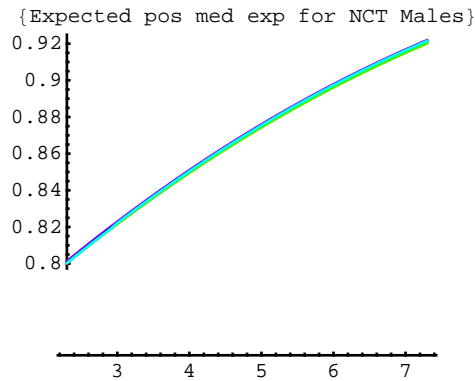
A two part model was used to estimate the health care expenditures for respondents who were not currently treated. The first part, a model of the probability of any health care expenditure, was estimated as a Probit model with exponential heterogeneous variance. The propensity was specified as a function of age, expected poor health status, and indicators of current or former smoking status. Controlling for the expected value of the latent index of poor health status, the smoking status indicators are demand parameters. Only the age and poor health status parameters were significant. The second model of the two part model is a model of the logarithm of the level of positive expenditures. It was specified like the probability model. Former-smoker status, age (measured in decades greater than 17 years of age) and poor health status contributed positively to these expenditures. The never-smoker's smearing coefficient equaled 4.246, the current-smoker's smearing coefficient equaled 3.594, and the former-smoker's smearing coefficient equaled 3.289.

$$E[\text{Medical Expenditures}] = (\text{CDF}[\text{NormalDistribution}[0, \text{Exp}[\varphi_1 \text{ curr} + \varphi_2 \text{ form}], \beta_0 + \beta_1 \text{ Age} + \beta_2 \text{ Health}^* + \beta_3 \text{ curr} + \beta_4 \text{ form}]] * \text{Exp}[\gamma_0 + \gamma_1 \text{ Age} + \gamma_2 \text{ Ehealthstar} + \gamma_3 \text{ curr} + \gamma_4 \text{ form}]) * \Psi$$

■ **Table8a:Parameter Estimates for Probability Medical Expenditures Greater Than Zero for Not Currently Treated (NCT)**

Variable	Parameter	Estimate	Standard Error	t - value
Current smoker				
in variance	φ_1	0.2851	1 .0849	0.263
Former smoker				
in variance	φ_2	- 0.5178	0.851	- 0.609
Constant	β_0	0.5772	0.196	2.952
Age (in decades				
> 17 years)	β_1	0.1184	0.0867	1.366
Health*^	β_2	- 0.01543	0.322	- 0.0479
Current smoker				
status	β_3	- 0.1204	0 .432	- 0.279
Former smoker				
status	β_4	- 0.03287	0 .420	- 0.0783

■ Figure 8: Illustration of Prob. of Medical Expenditure for NCT(Source:7232004probexpNCTtheoryadj.nb)



- Graphics -

Note : The health effects from smoking do not influence the probability of any expenditures for persons who are NCT.

- Graphics -

$$\text{Log}[\text{exp}] = \beta_0 + \beta_1 \text{curr} + \beta_2 \text{form} + \beta_3 \text{aage} + \beta_4 \text{healthstar} + \varepsilon$$

where $\varepsilon \sim N[0, \text{sig}^2]$

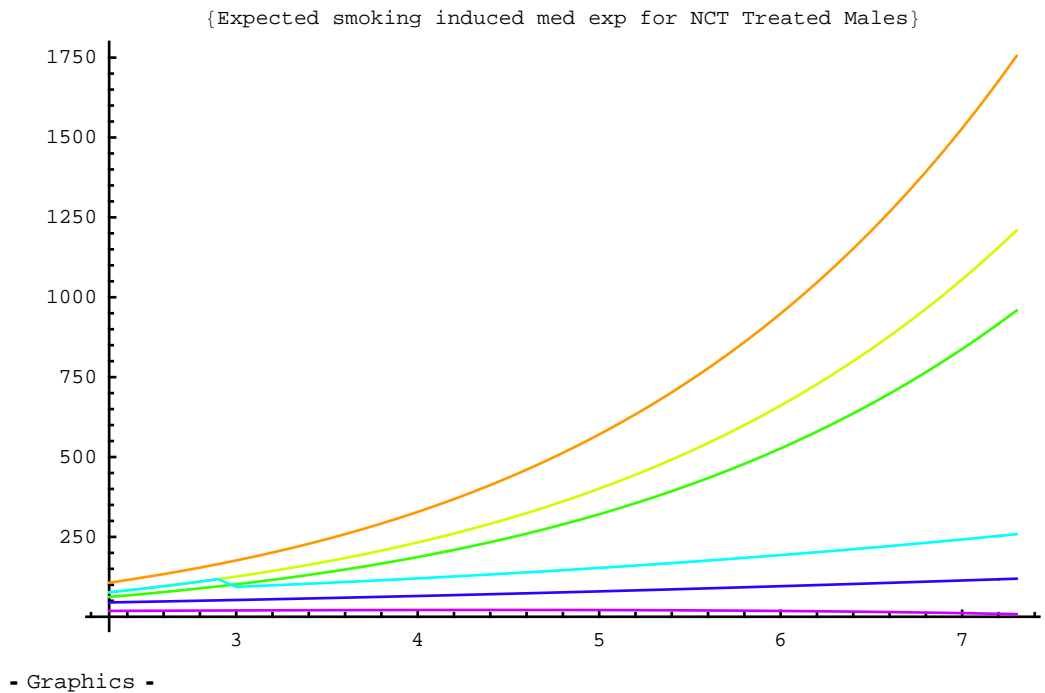
	" "	"Estimate"	"SE"	"TStat"	"PValue"
{ParameterTable →	"Constant"	5.34852	0.18854	28.3682	0
	"Current"	-0.10996	0.13019	-0.8446	0.398
	"Former"	0.11245	0.06081	1.84927	0.064
	"AdjAge"	0.15451	0.08675	1.78122	0.075
	"Healthstar"	0.44798	0.31135	1.43885	0.150

RSquared → 0.0494, AdjustedRSquared → 0.0484, EstimatedVariance → 2.2208

■ **Table8b:Parameter Estimates for Log Medical Expenditures for Not Currently Treated, Given Medical Expenditures Greater Than Zero**

Variable	Parameter	Estimate	Standard Error	t-value	$\Psi =$ Smearing Coefficient
Never					4.246
Current					3.594
Former					3.289
Constant	γ_0	5.3485	0.1885	28.37	
Age (in decades >17)	γ_1	0.1545	0.1302	-0.845	
Health*^	γ_2	0.4480	0.0608	1.849	
Current	γ_3	-0.1100	0.0867	1.781	
Former	γ_4	0.1125	0.3113	1.439	

■ **Illustration of results (Source : male expenditures/expectedsmokinginducedNCTexp2theoryadj.nb)**

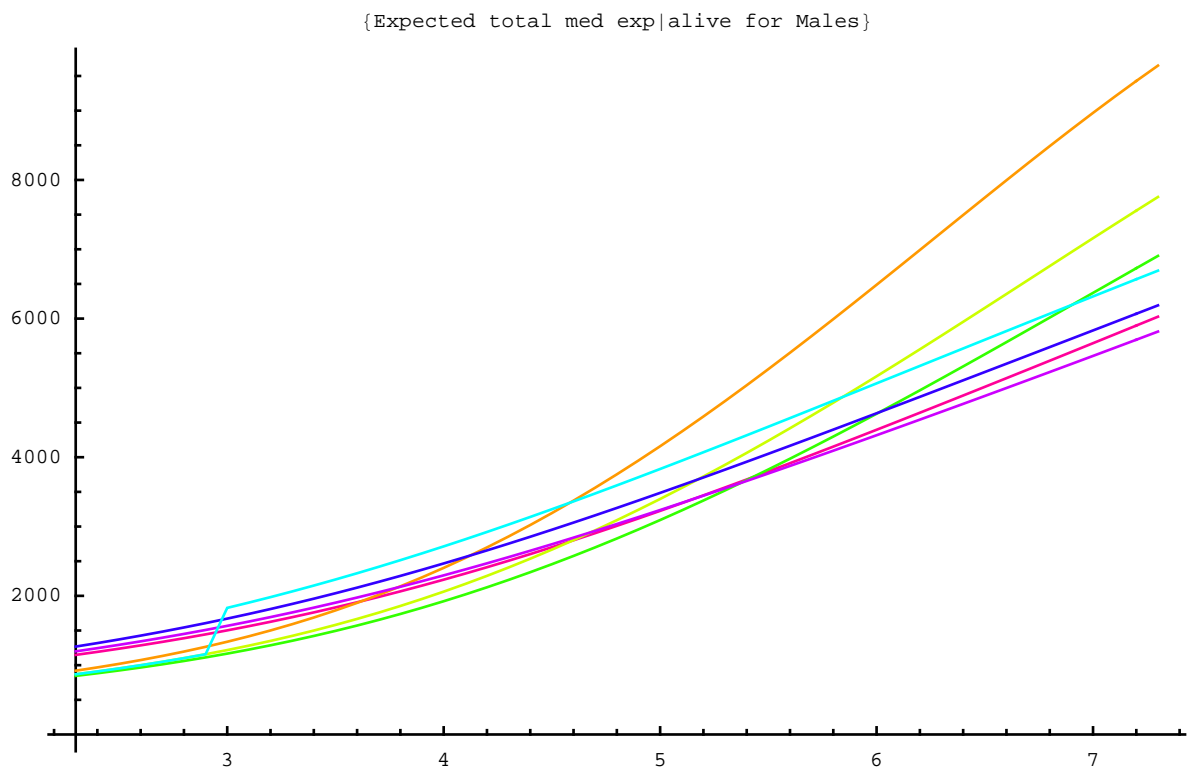


Expected smoking attributable medical expenditures for NCT males in 1987 dollars.

Bottom to top (evaluated at 7 decades of smoking):

- current smoker, 2 pk/day (orange)
- current smoker, 1 pk/day (lime)
- current smoker, 1/2 pk/day (green)
- former smoker, 10yr, 1 pk/day(purple)
- former smokers,20 yr, 1pk/day (blue)
- former smoker, 30yr,1pk/day(light blue),

■ **Expected Total Medical Expenditures, given one is alive**



- Graphics -

(Source:Expected Smoking Induced Med Exp.nb)

Evaluated at 7.2 decades after the mean smoking initiation age (17 years))

Bottom to Top:

- former smoker 10 yr, 1 pk/day (purple)
- never smoker (red)
- former smoker, 20 yr, 1 pk/day (blue)
- former smoker, 30 yr, 1 pk/day (light blue)
- current smoker 1/2 pk/day (green)
- current smoker 1 pk/day (light green)
- current smoker 2 pks/day (orange)