DETERMINANTS OF TRENDS IN US LUNG CANCER MORTALITY RATES
SUPPLEMENTARY REPORT

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1. Introduction

In a detailed report dated 30 June 1994, we examined the analysis published by Swartz (1992). He found that, among white males in the US aged 42-70, a mathematical model based on smoking histories predicted that there should have been a 12% decline in lung cancer mortality between 1970 and 1985, whereas there was in fact a 26% rise. He concluded that "these results strongly suggest that the recent increase in lung cancer among white males in the USA is due entirely or in large part to factors other than cigarette smoking."

In our report, we examined the methods of Swartz and applied them, and other similar models, to a wider range of situations. We also considered aspects of the smoking situation not used in his model. Our results generally supported his conclusions, and showed that they applied also to other age groups, periods and to females, and that they were not heavily dependent on the precise form of the risk model used.

In all the models considered, it was an implicit assumption that the "dose" to which smokers were exposed was constant, i.e. it was the same throughout each smoker's smoking life. In Section 6.1, we considered two elements which might be considered to make up the dose - the number of cigarettes smoked per smoker per day, and the tar delivery per cigarette. Although we agreed with Swartz that taking the well-known decline in tar delivery into account in the modelling could only have strengthened his conclusions, we noted that taking changes in numbers of cigarettes smoked into account would have weakened them. Although we felt that incorporation of both aspects of "dose" into the model would not have a large effect on the results, further work was considered necessary.

This document reports the results of this further work.

2. Multi-stage models

2.1 Error in Section 3.4.1

While extending the definitions of the multistage models to deal with variation of "dose" over time we realized that in section 3.4.1 of our report we had over-simplified the description of the various models. Where the first and penultimate stages are both affected, it is not sufficient, as we had done, merely to state the ratio of their effects, but it is necessary also to define the magnitude of their effects relative to background. As shown in the formulae in Section 2 of Appendix D of the main report, the excess risk for a multistage model (for constant "dose" when smoking) can be expressed in the form $d_1F_1+d_2F_2+d_1d_2F_3$. Here d_1 and d_2 are the excess "doses" relative to background for the first and penultimate stage affected, and F_1, F_2 and F_3 are terms which depend on the number of stages, k, and on differences in time between points at which exposure periods begin or end. Where either $d_1=0$ (penultimate stage only affected), or $d_2=0$ (first stage only affected), ratios of excess risk over time (which is what we are studying) do not depend on "dose", but if both d_1 and d_2 are non zero this is not true, the interaction term $d_1d_2F_3$ taking relatively more importance (for given ratio of d_2/d_1) as d_1 increases.

In our previous report, where we, for example, considered "multistage model 5:1" (with the first stage affected five times as strongly as the penultimate stage) we used values of $d_1=5$ and $d_2=1$ in our calculations, believing wrongly that the absolute values did not matter as long as $d_1/d_2=5$. In fact, setting $d_1=5$ and $d_2=1$ is equivalent to assuming that continuous smoking would increase risk by a factor $(1+5)(1+1)=12$, which makes results not comparable with e.g. "multistage model 1:2" where one is effectively assuming that continuous exposure multiplies risk by $(1+1)(1+2)=6$.

2.2 Choice of Multistage Models

To test the predictions of the multistage model more thoroughly, allowance should be made for variation in absolute effect of smoking as well as in its relative effect on the first and penultimate stage. In the results described here, we decided to use

the same seven ratios of first to penultimate stages (1:0, 5:1, 2:1, 1:1, 1:2, 1:5, 0:1) but for each to choose values of d_1 and d_2 that would imply that smoking a standard number of cigarettes with a standard tar delivery (see Section 2.3) throughout adult life was associated approximately with a 40-fold, 30-fold, 20-fold or 10-fold increase in absolute risk. The derivation of the values of d_1 and d_2 was based on formula (7/3) of Appendix D, where the risk for a smoker who smokes for 3/4 of his life, relative to that of a nonsmoker, can be expressed as

$$R = 1 + d_1 (3/4)^{k-1} + d_2(1 - (1/4)^{k-1}) + d_1 d_2 (3/4)^{k-1}$$

For $d_1 \neq 0$, if we substitute $r=d_1/d_2$, this becomes

$$d_1^2[r (3/4)^{k-1}] + d_1[(3/4)^{k-1} + r(1 - (1/4)^{k-1})] + [1-R] = 0$$

This quadratic in d_1 can be solved for given values of r and R. Similarly for $d_1=0$, the formula becomes

$$R = 1 + d_2 (1 - (1/4)^{k-1})$$

which can be solved for d_2.

The values of d_1 and d_2 for the chosen values of r and R, assuming k-1 = 4.5, are shown in Table S1.

2.3 Multistage models with variable dose

As before, we consider a multistage model with k stages, with the first and penultimate stages affected by exposure. Let a subject's life be divided into T equal annual periods (i=1,..T) and let δ_i be the "dose" (from cigarettes) during period i, and let d_1 and d_2 be the relative effects for the first and penultimate stages respectively. When the subject is not smoking, the doses will be zero. When the subject is smoking, the doses will depend on number of cigarettes smoked per day U_i and tar level P_i according to certain assumptions. One can also make dose depend on the square root of tar to try to take into account "compensation". (Unpublished work by P N Lee suggests tar intake for a smoker may in fact relate

quite closely to the square root of the brand tar yield determined under standard smoking conditions.)

Let U*=20 denote a standard number of cigarettes per smoker per day, and P*=35 denote a standard tar delivery per cigarette. (This is the assumed constant tar delivery of cigarettes before 1956.) Then we have:

(i) Constant dose: $\delta_i = 1$ throughout.

(ii) Dose depends on tar only: $\delta_i = P_i/P^*$

(iii) Dose depends on the square root of tar only: $\delta_i = \sqrt{P_i} / \sqrt{P^*}$

(iv) Dose depends on cigarette consumption only: $\delta_i = U_i/U^*$

(v) Dose depends on tar and cigarette consumption:

$$\delta_i = U_i P_i / U^* P^*$$

(vi) Dose depends on the square root of tar and cigarette consumption: $\delta_i = (U_i\sqrt{P_i})/(U^*\sqrt{P^*})$

The risk at time T can be shown to be the sum of products of terms proportional to $(1+d_1)(1+d_2)$ where $j \geq i$, i being the period during which the first stage occurs and j being the period during which the penultimate stage occurs. When summed, the excess risk can be shown to be

$$d_1 \sum_{i=1}^{T} F_i \delta_i + d_2 \sum_{i=1}^{T} G_i \delta_i + d_1 d_2 \sum_{i=1}^{T} \sum_{j=i}^{T} H_{ij} \delta_i \delta_j$$

where $F_i = (T-i+1)^{k-1} - (T-i)^{k-1}$

$G_i = F_{T-i+1}$

$H_{ij} = 0$ if $i>j$,
$= 1$ if $i=j$, or
$= (j-i+1)^{k-1} - 2(j-i)^{k-1} + (j-i-1)^{k-1}$ if $i>j$

Note that under assumption i, this formula for risk simplifies to the same formula as used in the main report for models with constant dose.

2.4 Absolute rather than relative effect of smoking

In our main report we compared trends in estimated observed excess risk of lung cancer with trends in excess risk estimates predicted by various forms of the multistage model. In this report we compare trends in observed absolute risk of lung cancer with trends in predicted absolute risk estimates.

3. Historical data on "dose"

In Section 6.1, we reviewed the available historical data on tar delivery per cigarette, and on average number of cigarettes smoked per smoker. Sales weighted tar level data were given in Table 8 from 1957 to 1985, and we have followed the commonly-held assumption that tar values were constant in earlier years.

In Section 6.1.2, we summarised the available data on consumption of cigarettes per smoker per day from many disparate sources. The best available estimates were:

	Male	Female
1924	10	(no data)
1934	13	7
1955	20	15
1980	23	20

Taking these as "known data", we used two alternative methods for estimating the consumption in earlier and intermediate years. For method 1, we made assumptions whereby the early consumption was as high as could reasonably be considered compatible with the known data. This would minimise any increase in dose suffered by later cohorts compared with earlier cohorts, and thus minimise any increased risk for the later cohorts. This approach is therefore least likely to undermine the main conclusion. For method 2 we took the opposite approach, making the assumptions for early consumption as low as possible, thus maximising the increase in dose and having the best chance of refuting our conclusion. These methods are now described in more detail.

Method 1. Males : The consumption per smoker was assumed to be constant at 10 cigarettes per day before 1924, and constant at 20 cigarettes per day from 1945-1955. The periods 1925-33, 1935-44 and

1956-1979 were estimated by linear interpolation. Note that this includes the assumption that all the rise in consumption between 1934 and 1955 had actually occurred by 1945.

Females : The assumptions were similar, except that consumption was assumed to be constant at 7 cigarettes per day before 1934, the first known data point.

Method 2. Males : The consumption for the period 1925-33 was estimated by linear interpolation, and the same slope (an increase of 3 cigarettes per 10 years) was used to give estimates by linear extrapolation before 1924. This would have given estimates less than 0 within the time period of interest and a constant value of 1 cigarettes per day was assumed before 1894. The periods 1935-54 and 1956-79 were estimated by linear interpolation.

Females : Consumption before 1934 was estimated by linear extrapolation using the same slope as had been calculated from the male data for 1924-34, and by a constant value of 1 before 1914. The periods 1935-54 and 1956-79 were estimated by linear interpolation.

The estimates at selected years are shown in Table S2.

(These two methods are the same as those described in the footnote to Table 9B in the main report, except that treatment of the earliest years under method 2 is somewhat different.)

An aspect of cigarettes per smoker not previously discussed is the consumption of hand-rolled (HR) cigarettes. Virtually none of the surveys shown in International Smoking Statistics (IntSS) specified the type of cigarettes. Nor did the 1924 and 1934 sources used here. Estimates of HR consumption were made in IntSS only from 1949 and were non-sex-specific, but some evidence was quoted suggesting that HR cigarettes had been a larger proportion of total cigarette consumption in the 1930s. This could affect our estimates of "dose" in two ways.

Firstly, if the pre-war data were in fact for manufactured cigarettes only, then estimates of consumption including HR would be higher and therefore closer (at least for males) to the constant consumption assumed by Swartz.

Secondly, although there is little epidemiological evidence on the subject, virtually all shows that the risk from HR cigarettes

is higher than from manufactured cigarettes. The higher pre-war proportion of HR among total cigarettes could be represented in the models by a higher dose per cigarette.

We have not attempted to fit models with dose estimates incorporating either of these ideas, but either or both would clearly tend to strengthen the main conclusion.

4. Methods

4.1 The Basic Model

The basic model, as described in section 3.5.1 of the main report has been used. This used the assumptions:

1. Earliest age of starting to smoke = 15
2. Lag = 5 years
3. k-1 = 4.5 (where k is the number of stages in the cancer process)
4. No drift. (See section 3.2 of the main report.)

Only the Swartz smoking sub-model has been used. Smoking prevalence data are from Harris.

The same combinations of age group, period and sex have been used as in the main report, namely

Both sexes

Age groups 45-54, 55-64, 65-74

Periods 1956-65, 1966-75, 1976-85,

except that age 65-74 for 1956-65 is omitted.

4.2 Variants to the model

The six assumptions on dose described in Section 2.3 were used. For assumptions iv - vi, estimates of cigarettes per smoker by both Methods 1 and 2 (described in Section 3) were used, giving 9 model variants in all.

4.3 Presentation of results

The tables give the predicted 10 year percentage change in risk for each sex/age group combination and for each 10 year period. The 10 year percentage changes in the observed rate are repeated at the head of each table.

In addition, graphs are presented showing the predicted risks over the full 30 year period 1956-85 (the 27 year period 1959-85 for the 65-74 age group), relative to the 1970 rate. Thus the section of the graph from 1970 to 1985 is comparable to the original Figure 2 of Swartz.

5. Results

5.1 Constant dose

We first review the results for the revised multistage models. Table S3 compares observed 10 year changes in lung cancer risk, by age, sex and period, with those predicted using the 28 multistage predictors described in Section 2.2. The conclusions reached in Section 5.2 of the main report are largely upheld by the revised analysis. The predicted changes are higher for those models which depend most heavily on smoking early in life than for those that depend most heavily on recent smoking. However, with the exception of the model depending only on early smoking (1:0), the difference between models is small compared to the difference between observed and predicted rates. This can be clearly seen in Figure 1M and Figure 1F, which show the trends in observed and predicted risk with differing ratios of early to late stage effects, for males and for females aged 45-54 with a smoking relative risk of 20.

The predicted 10 year change is greater for those models with a higher value for the relative risk of smoking. For males, the choice of value of makes relatively little difference compared with the difference between observed and predicted rates, as illustrated in Figure 2M. For females (see Figures 2Fa, 2Fb and 2Fc for the three age groups), the difference between the predictions for different relative risk values is more substantial, but even here does not affect the conclusion that observed rates rise faster than predicted rates.

We noted in the main report that, using arguably the most appropriate predictors, those with an early to penultimate stage ratio of 1:2, the change in predicted rate was always less than the

observed change. This is still true in the revised analysis, except for females age 55-64 in the earliest period, where it is only true at the lowest value, 10, for the smoking relative risk.

5.2 Variable dose without tar correction

Table S4 compares results for the three estimates of cigarettes per smoker, for selected models. Other models are shown in the Appendix. As expected, the predicted changes are generally higher with the Method 2 estimates than with the Method 1 estimates (with the exception of some results for models with the first stage more heavily affected than the penultimate stage) so that the discrepancy between observed and predicted is eroded or reversed more with the Method 2 estimates than with Method 1. However this difference is never large.

For males, a much larger difference is seen between the results with constant cigarettes per day and the results with either variable estimate than between the results for the two variable estimates. This difference is large even for the youngest age group at the latest 10-year period, despite the fact that most of their smoking took place during the period when cigarettes per day was only rising slowly. (Persons age 45-54 in 1976-85 were born in 1922-1940, so started smoking (age 15) in 1937-1955.) The discrepancy is eliminated or reversed in most cases, particularly for the models with the first stage more heavily affected than the penultimate stage. The discrepancy is still clearly seen only for age 45-54, 1966-75.

For females, the effects of using prediction models with variable doses are more complex. For some age/periods, the predicted change with the variable dose model is smaller than with the constant dose model, while in some cases the change is larger only with the higher values of the smoking relative risk. However, the discrepancy between observed and predicted is still clearly seen in all cases, except for age 55-64 in 1956-65. It can also be noted that this revised analysis has avoided the difficulty of the inadequacy of estimates of background risk in females, since the models presented here are of absolute, not excess, risk.

5.3 Variable dose with tar correction

Results for selected models are shown in Table S5, those for other models being given in the Appendix. Compared with the results for the equivalent cigarettes per smoker estimates, tar correction has, as expected, predicted lower changes in risk; results with square root tar correction are intermediate between no correction and full correction. The difference is greater for models with the penultimate stage more heavily affected than the first stage. The difference is small in the first period when the tar level decline was just starting, but is substantial in the later periods.

Thus where the discrepancy between observed and predicted was seen, full tar correction (or square root tar correction) has increased it. However of greater interest is whether the discrepancy exists in those cases where it did not exist without tar correction.

With full tar correction, the discrepancy is seen for females for virtually all models and for all age / period combinations except for age 55-64 in 1956-65. For males, the discrepancy is not seen for models with only the first stage affected (1:0). For the other models, the discrepancy is seen in the two later periods, but not generally in the first period. With method 1 estimates, the predicted changes in the first period for 55-64 year olds are of the same order as those observed, but with the more exacting Method 2 estimates, the predicted changes in that age group are larger than observed, while the predicted changes for the youngest age group are now of the same order as those observed.

With square root tar correction, the overall pattern is quite similar, but the discrepancies are smaller and seen slightly less often. In particular, the discrepancy for males age 65-74, 1976-85 is not now seen in the models with the first stage more heavily affected (5:1 and 2:1)

These results are illustrated in Figures 3M and 3F (a, b and c for the three age groups). The model 1:2(20) has been selected, and each plot shows a single age group/ sex combination. Trends for the nine dose/tar analyses are shown, with the colour representing the cigarettes per smoker estimate (red=constant, blue=method 1,

green=method 2), and the line style representing tar correction (solid=none, short dashes=square root tar, dash/dot=full tar correction). The observed trends are also shown (black).

These graphs particularly help to clarify the patterns where discrepancies over the three successive 10 year periods are due to peaks occurring at different times. This is seen for males for the two younger age groups. Models with tar correction predict the peak risks to have occurred earlier than the models without tar correction, and models with constant cigarettes per smoker predict the peak earlier than either of the models with variable cigarettes per smoker. For age 45-54, a peak in the observed rate occurred around 1978, and the variable cigarettes per smoker without tar correction reflected this most closely; all other models predicted an earlier peak. However the observed rates then fell quite quickly, which was better reflected by the tar corrected models. For age 55-64, all the prediction models had peaked by 1985 (or, for the variable cigarettes per smoker without tar correction models, at least levelled), whereas the observed rates were still rising, albeit slowly.

The trends already discussed in terms of the 10 year changes are also seen here:

- the fairly good fit throughout for the models with variable dose and no tar correction.

- the steeper rises at the early years for the models with variable dose and full (or square root) tar correction.

- the greater discrepancy in recent years between the observed and the full tar corrected model compared with its equivalent constant tar model, with the square root tar model intermediate.

For females, the graphs give a very clear picture of observed rates rising more steeply than predicted rates. Some other points to be seen are:

- the early slow increase in observed rates, accelerating about 1965, particularly for age 55-64, compared with predicted rises for all models right from the start.

- the quite small difference between models based on the two

cigarettes per smoker estimates, (or even models based on constant cigarettes per smoker, at the oldest age group), presumably due to the very low prevalences of smoking in early years.

The results are also illustrated in Figures 4M, 4F and Figures 5M, 5F. The variable dose is based on method 2 estimates of cigarettes per smoker and square root tar correction. Figure 4 illustrates the effects of varying the ratio between stages and Figure 5 illustrates the effects of varying the relative risk of smoking (cf Figures 1, 2 for constant dose). For males, Figure 4M shows the lack of any discrepancy in early years for the 45-54 and 55-64 age groups, and the lack of discrepancy with heavier first stage ratios for the 55-64 and 65-74 age groups. The discrepancy is always clear in Figure 4F. Figure 5 confirms the relatively minor differences due to choice of the relative risk of smoking.

5.4 Relative risk of smoking

The predicted rates considered so far have been the predictions for the whole population. These calculations are based on proportions of the population who have either never smoked, or who started and stopped smoking at various ages, as estimated by the smoking sub-model. It is also possible to calculate the risk within each of the three main smoking groups (never smoked, current smoker and former smoker), and thus to calculate the relative risk for current smokers, and for former smokers, relative to never smokers.

Although the models selected were chosen with a fixed value R (10, 20, 30, 40) for the relative risk of a "smoker" to a never smoker, this was based on a hypothetical smoker who smoked a standard dose for 3/4 of his life. In practice, the number of years smoked varies according to the age of starting smoking (determined by the smoking sub-model) and the current age, and the dose has often been less than standard, particularly when using tar (or square root tar) corrected doses. Therefore the value of the relative risk for current smokers is generally less than the value of R for the model. Trends in the relative risks can also be studied.

Tables S6 and S7 show results for model 1:2(20) and model 1:2(40) respectively, with variable dose (method 2 estimates of

cigarettes per smoker, and square root tar correction). This shows the relative risk rising steeply during the early years for both sexes and all age groups, but then slowing down, even falling for the youngest male age group. Models with full tar correction show a greater and earlier fall, including some fall for females. Conversely, models with no tar correction show a continuing rise with little slowing, except for the youngest male age group. The constant dose model (where changes in the relative risk depend only on changing age of starting smoking in the smoking sub-model) show only a small steady increase for males; for females the increases are larger, although slowing down in later years for the youngest age group.

In nearly all models, relative risks for former smokers showed rises in the early years, similar to the rises in the relative risk for current smokers in the equivalent model. However subsequent falls were then much greater.

Tables S6 and S7 also show the sex ratios (female/male) for the relative risks. For current smoking it has risen from approximately 0.5 to 0.7 in each of the three age groups, with values slightly lower for the higher value of R. The sex ratio for former smokers has also risen by a similar amount.

Sex ratios for other models and with variable cigarettes per smoker (not shown) are also slightly lower for models with the first stage more heavily affected, but the rise is generally of a similar magnitude. For the constant dose model, the sex ratio has also risen and was between 0.9 and 1 by 1985 for virtually all models.

6. Summary and conclusions

Swartz reported that, in US males aged 42-70, there was a discrepancy between observed and smoking-predicted lung cancer trends over the period 1970-85. In our first report we showed clearly that this discrepancy existed over a wider time period (1956-1985), that it existed for females as well as males, and that it was evident within 10 year age groups over the range 45-74. The discrepancy was not contingent on the exact form of the mathematical model used to predict lung cancer trends based on trends in smoking habits, and did not appear to be due to inappropriate smoking

prevalence data being used. We did, however, point out that the work carried out by both Swartz and ourselves may be limited by failure to take into account variations over time in number of cigarettes smoked per smoker and in the tar level of cigarettes smoked.

In this report we attempt to take such variations over time into account in our predictions. We restrict attention to the multistage model and extend the formulae to allow for single year changes in number of cigarettes smoked and in tar level. We also correct an error made in the earlier report and present revised predictions assuming smokers smoke a constant "dose".

As expected, the effect of taking into account the lower number of cigarettes per smoker in earlier years, particularly pre-war, has been to reduce the discrepancy between the trends to observed and predicted lung cancer rates.

For females, however, the discrepancy remains clearly evident for all the model variants studied (see Figures 3F-5F).

For males also the discrepancy is clear if full tar correction is used and if models are used in which a first to penultimate stage ratio of effects of 1:1, 1:2 or 1:5 is used. (As noted in Appendix D of the main report, model-fitting work by Brown and Chen supports 1:2 as being a reasonable choice of ratio.)

Because smokers may "compensate" when smoking lower delivery brands, we have also presented results in which "dose" is proportional to number of cigarettes smoked times the square root of the tar yield. Though the discrepancy is relatively small for some models, it is generally present and, in the case of the more appropriate models, reasonably clear (see Figures 3M-5M).

7. Future plans

We intend to write up all the US work into a paper for publication highlighting the major findings. Before we do that we will continue with work on other countries, as this may cast light on the overall interpretation. We will report this additional work at convenient points. We have yet to receive any comments from Swartz or Forastiere on the first report they were sent.

Table S1

Values of d_1 and d_2 used to define Multistage models with chosen values of ratio between stages (r) and smoking risk (R).

R	10		20		30		40	
	d_1	d_2	d_1	d_2	d_1	d_2	d_1	d_2
r								
1:0	32.85	0.00	69.34	0.00	105.83	0.00	142.33	0.00
5:1	9.20	1.84	14.79	2.96	19.09	3.82	22.70	4.54
2:1	5.76	2.88	9.29	4.64	12.00	6.00	14.29	7.14
1:1	3.86	3.86	6.32	6.32	8.23	8.23	9.83	9.83
1:2	2.48	4.96	4.17	8.34	5.49	10.99	6.62	13.23
1:5	1.28	6.41	2.27	11.35	3.07	15.32	3.75	18.75
0:1	0.00	9.02	0.00	19.04	0.00	29.06	0.00	39.08

Notes: R is the risk of a smoker smoking for 3/4 of his life relative to a nonsmoker.

k-1 = 4.5

Table S2

Estimates of cigarette consumption per smoker per day, by two methods at selected years

	Method 1		Method 2	
	Male	Female	Male	Female
1894	10.0	7.0	1.0	1.0
1904	10.0	7.0	4.0	1.0
1914	10.0	7.0	7.0	1.0
1924	10.0	7.0	10.0	4.0
1934	13.0	7.0	13.0	7.0
1940	16.8	11.4	15.0	9.3
1945	20.0	15.0	16.7	11.2
1950	20.0	15.0	18.3	13.1
1955	20.0	15.0	20.0	15.0
1960	20.6	16.0	20.6	16.0
1965	21.2	17.0	21.2	17.0
1970	21.8	18.0	21.8	18.0
1975	22.4	19.0	22.4	19.0
1980	23.0	20.0	23.0	20.0

Note: Figures underlined are original data points.

Table S3
10 year percentage change in US Observed Lung Cancer risk
and in Predicted risk estimates using different multistage models.

Basic model, with constant cigarettes per smoker and constant tar level.

Sex	Male								Female							
Age	45-54			55-64			65-74		45-54			55-64			65-74	
Period	1956 1965	1966 1975	1976 1985	1956 1965	1966 1975	1976 1985	1966 1975	1976 1985	1956 1965	1966 1975	1976 1985	1956 1965	1966 1975	1976 1985	1966 1975	1976 1985
Lung cancer rate																
Observed	27.0	22.5	-9.3	31.5	19.8	7.2	30.1	9.4	93.4	87.4	23.5	50.2	124.4	56.1	95.1	97.8
Multistage model																
1:0(10)	10.2	4.2	-3.0	22.7	10.7	3.6	22.5	10.6	34.2	14.1	8.9	31.1	44.2	16.0	42.0	48.7
1:0(20)	12.3	4.9	-3.5	26.8	12.2	4.0	25.5	11.7	55.8	19.7	11.8	54.0	64.1	20.3	67.3	65.2
1:0(30)	13.1	5.2	-3.7	28.4	12.8	4.2	26.6	12.1	69.4	22.4	13.1	69.9	74.5	22.1	82.8	72.8
1:0(40)	13.6	5.4	-3.9	29.2	13.1	4.3	27.2	12.3	78.7	24.0	13.9	81.6	80.8	23.1	93.2	77.2
5:1(10)	8.8	0.0	-9.4	19.2	6.8	-2.9	17.5	4.0	36.2	11.8	3.6	37.4	39.6	9.6	43.1	38.1
5:1(20)	10.3	0.0	-11.1	22.8	7.5	-3.7	20.1	3.9	53.3	15.6	4.8	59.3	55.2	11.9	66.2	50.5
5:1(30)	11.0	0.0	-11.9	24.3	7.8	-4.0	21.1	3.7	63.6	17.5	5.5	73.6	63.5	12.9	80.2	56.4
5:1(40)	11.4	0.0	-12.4	25.2	7.9	-4.3	21.7	3.5	70.8	18.7	5.8	84.1	68.9	13.5	89.8	60.0
2:1(10)	8.5	-0.8	-10.4	18.1	6.1	-4.1	16.1	2.8	37.1	11.3	2.4	40.3	38.2	8.3	44.0	35.4
2:1(20)	9.9	-0.8	-12.0	21.6	6.8	-4.7	18.8	2.8	52.4	14.6	3.5	61.4	52.4	10.4	66.0	47.0
2:1(30)	10.6	-0.7	-12.7	23.2	7.1	-5.0	19.9	2.8	61.5	16.4	4.1	74.8	60.1	11.5	79.3	52.9
2:1(40)	11.0	-0.7	-13.1	24.1	7.3	-5.1	20.6	2.7	67.7	17.5	4.5	84.4	65.1	12.1	88.3	56.5
1:1(10)	8.3	-1.4	-11.1	17.3	5.6	-4.8	15.0	2.1	37.7	10.9	1.5	42.7	37.1	7.3	44.8	33.4
1:1(20)	9.6	-1.3	-12.5	20.7	6.4	-5.3	17.7	2.2	51.7	13.9	2.5	63.1	50.1	9.4	65.9	44.4
1:1(30)	10.2	-1.2	-13.1	22.2	6.7	-5.5	19.0	2.2	59.7	15.5	3.1	75.8	57.2	10.4	78.4	50.0
1:1(40)	10.6	-1.2	-13.4	23.1	6.9	-5.6	19.7	2.2	65.3	16.5	3.5	84.7	61.9	11.0	87.0	53.5
1:2(10)	8.1	-1.8	-11.6	16.5	5.2	-5.4	14.0	1.5	38.4	10.6	0.8	45.1	36.1	6.5	45.6	31.6
1:2(20)	9.3	-1.7	-12.9	19.7	6.0	-5.9	16.7	1.7	51.0	13.3	1.6	65.0	47.8	8.4	65.8	41.7
1:2(30)	9.9	-1.7	-13.4	21.1	6.3	-6.0	17.9	1.7	58.0	14.7	2.1	76.8	54.2	9.3	77.5	46.9
1:2(40)	10.3	-1.6	-13.7	22.1	6.5	-6.1	18.7	1.8	62.9	15.6	2.5	85.0	58.5	10.0	85.5	50.3
1:5(10)	8.0	-2.2	-12.1	15.7	4.8	-6.0	12.8	1.0	39.1	10.3	0.1	47.9	35.0	5.7	46.6	29.6
1:5(20)	9.0	-2.2	-13.2	18.4	5.5	-6.5	15.3	1.2	50.2	12.6	0.6	67.2	45.1	7.2	65.7	38.4
1:5(30)	9.5	-2.2	-13.7	19.7	5.9	-6.6	16.5	1.3	56.1	13.7	1.0	78.1	50.5	8.1	76.3	43.0
1:5(40)	9.8	-2.1	-13.9	20.6	6.1	-6.6	17.2	1.3	60.0	14.5	1.3	85.3	54.1	8.6	83.4	46.1
0:1(10)	7.8	-2.7	-12.6	14.4	4.4	-6.7	11.1	0.3	40.0	10.0	-0.9	52.1	33.5	4.6	48.3	26.7
0:1(20)	8.5	-3.0	-13.7	16.0	4.8	-7.3	12.4	0.4	48.9	11.4	-1.0	71.4	40.4	5.2	65.5	32.2
0:1(30)	8.7	-3.0	-14.1	16.6	4.9	-7.6	12.9	0.4	52.5	11.9	-1.0	80.6	43.1	5.5	73.6	34.4
0:1(40)	8.9	-3.1	-14.3	16.9	5.0	-7.7	13.1	0.4	54.5	12.2	-1.0	86.1	44.6	5.6	78.4	35.6

Table S4

10 year percentage change in US Observed Lung Cancer risk and in Predicted risk estimates using different estimates of cigarettes per smoker per day.

Selected Multistage models. Basic model, with constant tar level.

Sex		Male								Female							
Age		45-54			55-64			65-74		45-54			55-64			65-74	
Period		1956 1965	1966 1975	1976 1985	1956 1965	1966 1975	1976 1985	1966 1975	1976 1985	1956 1965	1966 1975	1976 1985	1956 1965	1966 1975	1976 1985	1966 1975	1976 1985
Lung cancer rate Observed		27.0	22.5	-9.3	31.5	19.8	7.2	30.1	9.4	93.4	87.4	23.5	50.2	124.4	56.1	95.1	97.8
Multistage Model	Cigs/smkr estimate																
1:0(20)	Constant	12.3	4.9	-3.5	26.8	12.2	4.0	25.5	11.7	55.8	19.7	11.8	54.0	64.1	20.3	67.3	65.2
	Method 1	34.5	26.4	0.8	37.1	37.5	22.3	40.9	36.3	44.5	38.6	16.8	30.4	65.9	39.9	47.3	75.9
	Method 2	31.0	21.6	7.8	48.6	32.9	20.6	49.3	32.4	41.7	34.9	26.2	29.8	62.2	40.6	46.8	73.8
5:1(20)	Constant	10.3	0.0	-11.1	22.8	7.5	-3.7	20.1	3.9	53.3	15.6	4.8	59.3	55.2	11.9	66.2	50.5
	Method 1	29.7	17.1	-5.5	36.6	28.8	12.3	35.2	24.8	46.3	31.5	13.9	40.3	57.9	30.4	50.9	61.0
	Method 2	33.9	16.0	-0.7	48.7	28.1	11.6	43.1	22.8	49.3	31.5	19.7	40.8	57.6	31.0	51.1	59.7
2:1(20)	Constant	9.9	-0.8	-12.0	21.6	6.8	-4.7	18.8	2.8	52.4	14.6	3.5	61.4	52.4	10.4	66.0	47.0
	Method 1	27.3	13.9	-6.6	35.2	25.4	9.5	32.6	21.4	48.7	28.9	12.6	46.3	56.1	27.0	54.2	56.9
	Method 2	32.4	13.7	-2.6	46.1	25.6	9.0	39.6	19.9	53.9	30.1	17.2	47.8	57.0	27.8	55.1	56.2
1:1(20)	Constant	9.6	-1.3	-12.5	20.7	6.4	-5.3	17.7	2.2	51.7	13.9	2.5	63.1	50.1	9.4	65.9	44.4
	Method 1	25.4	11.3	-7.4	33.9	22.7	7.2	30.4	18.6	50.8	27.0	11.5	51.6	54.8	24.4	57.2	53.7
	Method 2	31.0	11.9	-4.1	43.8	23.5	6.9	36.6	17.6	57.7	29.1	15.3	54.1	56.6	25.2	58.8	53.5
1:2(20)	Constant	9.3	-1.7	-12.9	19.7	6.0	-5.9	16.7	1.7	51.0	13.3	1.6	65.0	47.8	8.4	65.8	41.7
	Method 1	23.5	8.9	-8.1	32.6	20.0	4.8	28.1	15.7	52.8	25.2	10.5	57.3	53.6	21.8	60.4	50.7
	Method 2	29.6	10.1	-5.4	41.5	21.3	4.9	33.6	15.2	61.4	28.1	13.5	60.9	56.4	22.8	62.6	51.1
1:5(20)	Constant	9.0	-2.2	-13.2	18.4	5.5	-6.5	15.3	1.2	50.2	12.6	0.6	67.2	45.1	7.2	65.7	38.4
	Method 1	21.5	6.2	-8.8	31.0	16.7	2.0	25.3	12.1	55.2	23.3	9.3	64.3	52.2	18.8	64.4	47.3
	Method 2	28.0	8.1	-6.9	38.7	18.8	2.4	29.9	12.3	65.7	27.1	11.5	69.4	56.1	20.0	67.5	48.3
0:1(20)	Constant	8.5	-3.0	-13.7	16.0	4.8	-7.3	12.4	0.4	48.9	11.4	-1.0	71.4	40.4	5.2	65.5	32.2
	Method 1	18.3	1.7	-10.0	28.4	11.2	-3.2	20.4	5.5	59.1	20.3	7.5	77.3	50.2	13.9	71.9	41.6
	Method 2	25.3	4.9	-9.3	34.1	14.4	-1.9	23.4	6.9	72.9	25.4	8.4	85.6	55.7	15.6	76.4	43.8

Table S5

10 year percentage change in US Observed Lung Cancer risk and in Predicted risk estimates using different estimates of cigarettes per smoker and different tar correction.

Selected multistage models. Basic model.

Sex			Male								Female							
Age			45-54			55-64			65-74		45-54			55-64			65-74	
Period			1956 1965	1966 1975	1976 1985	1956 1965	1966 1975	1976 1985	1966 1975	1976 1985	1956 1965	1966 1975	1976 1985	1956 1965	1966 1975	1976 1985	1966 1975	1976 1985
Lung cancer rate Observed			27.0	22.5	-9.3	31.5	19.8	7.2	30.1	9.4	93.4	87.4	23.5	50.2	124.4	56.1	95.1	97.8
Multistage Model	Cigs/smkr estimate	Tar level																
5:1(20)	Method 1	const	29.7	17.1	-5.5	36.6	28.8	12.3	35.2	24.8	46.3	31.5	13.9	40.3	57.9	30.4	50.9	61.0
		sqrt	27.9	7.1	-14.6	35.1	19.2	3.1	26.7	15.7	44.8	21.9	3.4	39.3	47.6	20.0	43.5	48.3
		actual	26.3	-1.1	-21.3	33.8	11.3	-3.9	19.8	8.8	43.4	14.1	-4.1	38.4	39.2	12.2	37.4	38.7
5:1(20)	Method 2	const	33.9	16.0	-0.7	48.7	28.1	11.6	43.1	22.8	49.3	31.5	19.7	40.8	57.6	31.0	51.1	59.7
		sqrt	32.0	6.2	-10.3	47.1	18.6	2.4	34.1	13.9	47.8	22.1	8.5	39.8	47.5	20.5	43.8	47.2
		actual	30.3	-1.9	-17.4	45.6	10.8	-4.6	26.7	7.1	46.4	14.4	0.5	39.0	39.2	12.7	37.9	37.8
2:1(20)	Method 1	const	27.3	13.9	-6.6	35.2	25.4	9.5	32.6	21.4	48.7	28.9	12.6	46.3	56.1	27.0	54.2	56.9
		sqrt	25.4	3.4	-16.2	33.6	15.3	-0.4	23.5	11.5	47.0	18.5	1.6	45.1	44.8	15.9	45.6	43.3
		actual	23.7	-5.4	-23.5	32.2	6.9	-8.2	16.0	3.7	45.4	9.9	-6.5	44.1	35.5	7.4	38.5	32.9
2:1(20)	Method 2	const	32.4	13.7	-2.6	46.1	25.6	9.0	39.6	19.9	53.9	30.1	17.2	47.8	57.0	27.8	55.1	56.2
		sqrt	30.4	3.3	-12.7	44.4	15.5	-0.9	30.0	10.3	52.0	19.7	5.7	46.6	45.8	16.6	46.6	42.8
		actual	28.6	-5.4	-20.3	42.8	7.1	-8.6	22.1	2.6	50.4	11.2	-2.9	45.6	36.5	8.1	39.6	32.5
1:2(20)	Method 1	const	23.5	8.9	-8.1	32.6	20.0	4.8	28.1	15.7	52.8	25.2	10.5	57.3	53.6	21.8	60.4	50.7
		sqrt	21.7	-1.7	-17.9	31.0	9.8	-5.4	18.9	5.5	50.8	14.1	-0.7	55.8	41.4	10.3	50.3	36.9
		actual	20.0	-10.5	-25.7	29.6	1.3	-13.6	11.2	-2.7	49.0	4.8	-9.5	54.4	31.4	1.3	42.0	26.1
1:2(20)	Method 2	const	29.6	10.1	-5.4	41.5	21.3	4.9	33.6	15.2	61.4	28.1	13.5	60.9	56.4	22.8	62.6	51.1
		sqrt	27.6	-0.5	-15.5	39.7	11.0	-5.3	23.9	5.2	59.2	16.8	2.0	59.3	44.0	11.3	52.3	37.3
		actual	25.8	-9.4	-23.5	38.1	2.4	-13.4	15.8	-2.9	57.2	7.4	-7.0	57.9	33.8	2.3	43.9	26.5
1:5(20)	Method 1	const	21.5	6.2	-8.8	31.0	16.7	2.0	25.3	12.1	55.2	23.3	9.3	64.3	52.2	18.8	64.4	47.3
		sqrt	19.7	-4.2	-18.6	29.5	6.8	-8.1	16.3	2.1	53.1	11.9	-1.9	62.6	39.8	7.4	53.5	33.7
		actual	18.0	-12.9	-26.5	28.1	-1.5	-16.3	8.7	-6.0	51.2	2.4	-10.8	61.1	29.6	-1.7	44.5	22.8
1:5(20)	Method 2	const	28.0	8.1	-6.9	38.7	18.8	2.4	29.9	12.3	65.7	27.1	11.5	69.4	56.1	20.0	67.5	48.3
		sqrt	26.0	-2.4	-16.8	37.0	8.6	-7.6	20.4	2.3	63.4	15.4	0.1	67.7	43.3	8.7	56.2	34.7
		actual	24.2	-11.3	-24.9	35.4	0.1	-15.8	12.5	-5.8	61.2	5.6	-9.0	66.0	32.7	-0.4	47.0	23.8

Table S6

10 year percentage change in Predicted Relative risk of Current Smoking and Former Smoking (vs Never smoking); Predicted Relative risk and Sex Ratio of Predicted Relative risk at selected years.

Multistage model 1:2(20). Basic model, with cigarettes per smoker estimated by method 2, and square root tar correction.

Sex	Male											
Age	45-54				55-64				65-74			
Period		1956 1965	1966 1975	1976 1985		1956 1965	1966 1975	1976 1985			1966 1975	1976 1985
RR(current)		19.9	2.3	-3.8		27.2	6.2	1.5			12.3	4.3
RR(former)		19.1	-6.0	-19.3		23.4	2.9	-11.1			13.8	-2.0
Year	1956	1965	1975	1985	1956	1965	1975	1985	1959	1965	1975	1985
RR(current)	9.23	11.07	11.39	10.94	9.18	11.68	12.54	12.76	9.81	11.36	12.98	13.62
RR(former)	7.58	9.02	8.52	6.76	6.88	8.50	8.85	7.82	6.16	7.37	8.59	8.46

Sex	Female											
Age	45-54				55-64				65-74			
Period		1956 1965	1966 1975	1976 1985		1956 1965	1966 1975	1976 1985			1966 1975	1976 1985
RR(current)		36.5	10.2	4.0		38.3	16.9	8.6			18.4	14.4
RR(former)		27.3	0.1	-8.5		63.4	7.8	-10.4			37.3	-0.5
Year	1956	1965	1975	1985	1956	1965	1975	1985	1959	1965	1975	1985
RR(current)	5.18	7.07	7.92	8.29	4.96	6.85	8.18	8.99	5.32	6.44	7.80	9.07
RR(former)	5.24	6.67	6.71	6.13	3.94	6.43	7.08	6.32	3.50	4.51	6.51	6.53

Sex Ratio F/M

Age	45-54				55-64				65-74			
Year	1956	1965	1975	1985	1956	1965	1975	1985	1959	1965	1975	1985
RR(current)	0.56	0.64	0.70	0.76	0.54	0.59	0.65	0.70	0.54	0.57	0.60	0.67
RR(former)	0.69	0.74	0.79	0.91	0.57	0.76	0.80	0.81	0.57	0.62	0.76	0.77

Table S7

10 year percentage change in Predicted Relative risk of Current Smoking and Former Smoking (vs Never smoking); Predicted Relative risk and Sex Ratio of Predicted Relative risk at selected years.

Multistage model 1:2(40). Basic model, with cigarettes per smoker estimated by method 2, and square root tar correction.

Sex	Male											
Age	45-54				55-64				65-74			
Period	1956	1966	1976		1956	1966	1976		1966	1976		
	1965	1975	1985		1965	1975	1985		1975	1985		
RR(current)	23.2	4.0	-3.2		32.3	8.5	3.2		16.0	6.5		
RR(former)	22.4	-5.3	-20.4		28.3	4.6	-11.0		17.5	-0.8		
Year	1956	1965	1975	1985	1956	1965	1975	1985	1959	1965	1975	1985
RR(current)	15.51	19.11	20.04	19.39	15.63	20.68	22.75	23.59	16.89	20.12	23.82	25.60
RR(former)	12.50	15.31	14.57	11.41	11.43	14.66	15.56	13.78	10.18	12.60	15.22	15.22

Sex	Female											
Age	45-54				55-64				65-74			
Period	1956	1966	1976		1956	1966	1976		1966	1976		
	1965	1975	1985		1965	1975	1985		1975	1985		
RR(current)	43.2	13.3	6.0		45.3	22.2	12.1		23.8	20.0		
RR(former)	31.7	1.8	-8.0		75.1	11.7	-9.6		45.3	2.7		
Year	1956	1965	1975	1985	1956	1965	1975	1985	1959	1965	1975	1985
RR(current)	7.88	11.28	13.04	13.95	7.49	10.88	13.65	15.54	8.10	10.09	12.84	15.73
RR(former)	8.04	10.59	10.87	10.00	5.80	10.16	11.66	10.53	5.08	6.84	10.53	10.95

	Sex Ratio F/M											
Age	45-54				55-64				65-74			
Year	1956	1965	1975	1985	1956	1965	1975	1985	1959	1965	1975	1985
RR(current)	0.51	0.59	0.64	0.72	0.48	0.53	0.60	0.66	0.48	0.50	0.54	0.61
RR(former)	0.64	0.69	0.75	0.88	0.51	0.69	0.75	0.76	0.50	0.54	0.69	0.72

Appendix

10 year percentage change in US Observed Lung Cancer risk
and in Predicted risk estimates using different multistage models,
and different estimates of dose from cigarettes.

Sex	Male								Female							
Age	45-54			55-64			65-74		45-54			55-64			65-74	
Period	1956 1965	1966 1975	1976 1985	1956 1965	1966 1975	1976 1985	1966 1975	1976 1985	1956 1965	1966 1975	1976 1985	1956 1965	1966 1975	1976 1985	1966 1975	1976 1985
Lung cancer rate																
Observed	27.0	22.5	-9.3	31.5	19.8	7.2	30.1	9.4	93.4	87.4	23.5	50.2	124.4	56.1	95.1	97.8
Dose Cigarettes per smoker Constant, Tar level Actual (full tar correction)																
Multistage model																
1:0(10)	10.2	3.8	-8.2	22.7	10.6	1.9	22.4	9.9	34.2	13.7	3.3	31.1	44.0	14.0	41.9	47.7
1:0(20)	12.3	4.5	-9.6	26.8	12.1	2.2	25.5	11.0	55.8	19.1	4.4	54.0	63.8	17.7	67.2	63.9
1:0(30)	13.1	4.8	-10.2	28.4	12.7	2.3	26.6	11.4	69.4	21.8	4.9	69.9	74.2	19.3	82.6	71.3
1:0(40)	13.6	5.0	-10.5	29.2	13.0	2.3	27.2	11.5	78.7	23.3	5.1	81.6	80.6	20.2	93.1	75.7
5:1(10)	6.5	-12.1	-20.2	17.3	-4.5	-13.1	7.2	-5.6	33.8	-0.2	-8.6	35.7	25.8	-1.7	32.2	23.7
5:1(20)	7.4	-15.1	-25.0	20.3	-6.6	-16.6	6.9	-8.5	49.6	-0.8	-11.8	56.5	35.1	-3.4	48.5	30.5
5:1(30)	7.8	-16.5	-27.4	21.5	-7.7	-18.4	6.6	-10.1	59.1	-1.2	-13.5	70.0	39.9	-4.4	58.2	33.6
5:1(40)	8.0	-17.4	-28.9	22.2	-8.4	-19.6	6.2	-11.1	65.6	-1.5	-14.6	79.8	42.9	-5.1	64.8	35.4
2:1(10)	6.0	-14.5	-22.5	16.0	-6.7	-16.0	4.4	-8.6	34.3	-2.6	-11.1	38.3	22.7	-4.7	31.5	19.1
2:1(20)	6.8	-17.1	-27.1	19.0	-8.5	-19.3	4.4	-11.2	48.4	-3.2	-14.2	58.3	30.9	-6.4	46.7	25.3
2:1(30)	7.2	-18.3	-29.2	20.3	-9.4	-20.8	4.3	-12.5	56.8	-3.5	-15.7	71.0	35.3	-7.2	55.8	28.4
2:1(40)	7.4	-19.0	-30.5	21.0	-10.0	-21.8	4.2	-13.4	62.5	-3.7	-16.7	80.0	38.2	-7.8	62.0	30.3
1:1(10)	5.7	-15.8	-24.0	15.1	-7.9	-17.7	2.8	-10.3	34.8	-3.9	-12.7	40.5	20.7	-6.6	31.3	16.2
1:1(20)	6.5	-18.1	-28.2	18.0	-9.5	-20.7	2.9	-12.7	47.6	-4.6	-15.6	59.9	28.1	-8.2	45.9	22.0
1:1(30)	6.9	-19.2	-30.1	19.3	-10.2	-22.1	2.9	-13.9	55.0	-4.8	-17.0	71.8	32.2	-8.9	54.4	25.0
1:1(40)	7.1	-19.8	-31.3	20.1	-10.7	-22.9	2.9	-14.6	60.1	-5.0	-17.9	80.2	34.9	-9.3	60.3	26.9
1:2(10)	5.5	-16.8	-25.0	14.3	-8.7	-18.9	1.4	-11.6	35.3	-5.0	-14.0	42.8	19.2	-8.0	31.4	13.9
1:2(20)	6.2	-18.8	-28.9	17.0	-10.1	-21.8	1.7	-13.8	46.9	-5.7	-16.8	61.6	25.7	-9.6	45.3	19.1
1:2(30)	6.6	-19.7	-30.7	18.2	-10.8	-23.0	1.8	-14.8	53.4	-5.9	-18.1	72.8	29.4	-10.2	53.3	21.9
1:2(40)	6.8	-20.3	-31.7	19.0	-11.2	-23.7	1.9	-15.4	57.8	-6.0	-18.8	80.5	31.9	-10.6	58.8	23.8
1:5(10)	5.3	-17.6	-26.0	13.5	-9.3	-20.0	0.2	-12.6	35.9	-5.9	-15.2	45.5	17.7	-9.4	31.8	11.6
1:5(20)	6.0	-19.4	-29.5	15.8	-10.5	-22.7	0.5	-14.6	46.1	-6.7	-17.9	63.8	23.2	-11.0	44.9	16.0
1:5(30)	6.3	-20.2	-31.0	17.0	-11.1	-23.7	0.6	-15.5	51.5	-7.0	-19.1	74.0	26.3	-11.6	52.2	18.4
1:5(40)	6.5	-20.6	-31.9	17.7	-11.4	-24.4	0.8	-16.0	55.1	-7.1	-19.7	80.9	28.4	-11.9	57.1	20.1
0:1(10)	5.1	-18.4	-27.0	12.3	-9.8	-21.2	-1.3	-13.6	36.7	-7.1	-16.7	49.5	15.8	-11.0	32.7	8.8
0:1(20)	5.6	-20.0	-30.1	13.6	-10.8	-23.6	-1.5	-15.3	44.8	-8.1	-19.5	67.8	19.2	-13.0	44.7	10.9
0:1(30)	5.8	-20.6	-31.2	14.1	-11.1	-24.5	-1.6	-15.9	48.2	-8.5	-20.6	76.6	20.6	-13.7	50.4	11.8
0:1(40)	5.9	-20.8	-31.8	14.4	-11.3	-24.9	-1.6	-16.3	50.0	-8.8	-21.1	81.8	21.3	-14.1	53.8	12.3
Dose Cigarettes per smoker Constant, Tar level Square Root																
Multistage model																
1:0(10)	10.2	4.0	-5.8	22.7	10.7	2.7	22.4	10.2	34.2	13.9	5.9	31.1	44.1	14.9	42.0	48.2
1:0(20)	12.3	4.7	-6.8	26.8	12.2	3.0	25.5	11.3	55.8	19.4	7.8	54.0	63.9	18.9	67.2	64.5
1:0(30)	13.1	5.0	-7.2	28.4	12.7	3.1	26.6	11.7	69.4	22.1	8.7	69.9	74.3	20.6	82.7	72.0
1:0(40)	13.6	5.2	-7.4	29.2	13.0	3.2	27.2	11.9	78.7	23.7	9.2	81.6	80.7	21.5	93.1	76.4
5:1(10)	7.6	-6.6	-15.7	18.2	0.6	-8.8	11.8	-1.5	35.0	5.2	-3.6	36.5	32.0	3.0	37.1	29.9
5:1(20)	8.8	-8.3	-19.2	21.5	-0.2	-11.0	12.9	-3.1	51.4	6.6	-4.8	57.8	44.2	3.2	56.5	39.2
5:1(30)	9.3	-9.0	-20.8	22.9	-0.7	-12.2	13.2	-4.0	61.3	7.3	-5.4	71.7	50.6	3.1	68.2	43.6
5:1(40)	9.6	-9.5	-21.8	23.7	-1.0	-12.9	13.2	-4.6	68.1	7.7	-5.9	81.8	54.7	3.0	76.1	46.2
2:1(10)	7.2	-8.3	-17.4	17.0	-0.9	-10.9	9.7	-3.7	35.6	3.7	-5.4	39.2	29.7	0.8	37.1	26.1
2:1(20)	8.3	-9.7	-20.6	20.2	-1.5	-12.9	10.9	-5.1	50.3	4.9	-6.6	59.7	40.6	0.9	55.4	34.8
2:1(30)	8.8	-10.3	-22.0	21.7	-1.9	-13.8	11.4	-5.8	59.0	5.5	-7.2	72.8	46.5	1.0	66.4	39.2
2:1(40)	9.1	-10.7	-22.9	22.5	-2.1	-14.4	11.6	-6.2	65.0	5.9	-7.5	82.1	50.4	1.0	73.9	42.0
1:1(10)	6.9	-9.3	-18.4	16.2	-1.8	-12.1	8.3	-4.9	36.2	2.8	-6.6	41.6	28.1	-0.6	37.4	23.7
1:1(20)	8.0	-10.5	-21.3	19.2	-2.3	-13.9	9.7	-6.1	49.5	3.8	-7.8	61.4	38.1	-0.5	54.9	31.8
1:1(30)	8.5	-11.0	-22.6	20.7	-2.5	-14.7	10.2	-6.7	57.3	4.4	-8.3	73.7	43.6	-0.4	65.3	36.1
1:1(40)	8.8	-11.3	-23.4	21.5	-2.7	-15.2	10.5	-7.1	62.6	4.8	-8.5	82.4	47.2	-0.3	72.4	38.8
1:2(10)	6.7	-10.0	-19.2	15.4	-2.4	-13.0	7.1	-5.8	36.8	2.1	-7.6	43.9	26.8	-1.7	37.8	21.6
1:2(20)	7.7	-11.1	-21.8	18.3	-2.8	-14.7	8.5	-6.9	48.8	2.9	-8.7	63.2	35.8	-1.6	54.6	29.1
1:2(30)	8.2	-11.5	-23.0	19.6	-3.0	-15.4	9.1	-7.4	55.6	3.5	-9.2	74.7	40.7	-1.5	64.3	33.1
1:2(40)	8.4	-11.7	-23.7	20.5	-3.1	-15.8	9.5	-7.7	60.2	3.8	-9.4	82.6	44.0	-1.4	70.9	35.7
1:5(10)	6.6	-10.6	-19.8	14.5	-2.9	-13.8	5.9	-6.6	37.4	1.4	-8.5	46.6	25.5	-2.8	38.5	19.5
1:5(20)	7.4	-11.6	-22.2	17.0	-3.2	-15.4	7.2	-7.6	48.0	2.0	-9.7	65.4	33.1	-2.9	54.3	25.9
1:5(30)	7.8	-12.0	-23.2	18.3	-3.4	-16.0	7.8	-8.0	53.7	2.5	-10.1	75.9	37.3	-2.8	63.1	29.4
1:5(40)	8.1	-12.2	-23.8	19.1	-3.5	-16.3	8.2	-8.2	57.4	2.8	-10.3	83.0	40.1	-2.7	69.0	31.8
0:1(10)	6.4	-11.3	-20.5	13.3	-3.4	-14.7	4.3	-7.4	38.3	0.7	-9.6	50.7	23.8	-4.1	39.8	16.7
0:1(20)	7.0	-12.2	-22.6	14.8	-3.7	-16.2	4.8	-8.3	46.8	0.8	-11.1	69.5	28.8	-4.8	54.1	20.5
0:1(30)	7.2	-12.6	-23.3	15.3	-3.8	-16.8	5.0	-8.6	50.2	0.8	-11.6	78.5	30.8	-5.0	61.0	22.0
0:1(40)	7.3	-12.7	-23.7	15.6	-3.9	-17.0	5.1	-8.7	52.1	0.8	-11.9	83.8	31.9	-5.1	64.9	22.8

Appendix (continued/1)

Sex	Male								Female							
Age	45-54			55-64			65-74		45-54			55-64			65-74	
Period	1956 1965	1966 1975	1976 1985	1956 1965	1966 1975	1976 1985	1966 1975	1976 1985	1956 1965	1966 1975	1976 1985	1956 1965	1966 1975	1976 1985	1966 1975	1976 1985
Lung cancer rate Observed	27.0	22.5	-9.3	31.5	19.8	7.2	30.1	9.4	93.4	87.4	23.5	50.2	124.4	56.1	95.1	97.8
Dose Cigarettes per smoker Variable Method 1, Tar level Constant (no tar correction)																
Multistage model																
1:0(10)	26.0	21.4	0.7	28.5	30.9	19.4	33.3	31.5	23.8	24.6	12.0	15.7	39.0	28.6	25.7	49.4
1:0(20)	34.5	26.4	0.8	37.1	37.5	22.3	40.9	36.3	44.5	38.6	16.8	30.4	65.9	39.9	47.3	75.9
1:0(30)	38.4	28.4	0.8	40.9	40.1	23.4	43.9	38.1	60.8	46.9	19.2	42.9	83.8	45.5	64.0	91.2
1:0(40)	40.6	29.6	0.9	43.1	41.6	23.9	45.6	39.1	74.0	52.5	20.6	53.6	96.5	48.8	77.4	101.1
5:1(10)	22.9	13.1	-4.9	28.3	23.0	10.0	27.9	20.7	29.3	21.2	10.0	24.3	37.3	21.7	30.6	40.9
5:1(20)	29.7	17.1	-5.5	36.6	28.8	12.3	35.2	24.8	46.3	31.5	13.9	40.3	57.9	30.4	50.9	61.0
5:1(30)	33.4	19.2	-5.8	40.7	31.6	13.4	38.6	26.7	58.3	37.9	16.1	52.4	71.5	35.3	65.8	73.1
5:1(40)	35.7	20.6	-5.9	43.3	33.4	14.0	40.7	27.8	67.6	42.4	17.6	62.3	81.6	38.5	77.6	81.5
2:1(10)	21.4	10.2	-6.1	27.7	20.0	7.1	25.8	17.2	32.6	20.1	9.1	29.3	37.6	19.3	34.0	38.9
2:1(20)	27.3	13.9	-6.6	35.2	25.4	9.5	32.6	21.4	48.7	28.9	12.6	46.3	56.1	27.0	54.2	56.9
2:1(30)	30.5	15.9	-6.8	39.0	28.3	10.7	36.0	23.5	59.5	34.4	14.5	58.5	68.0	31.5	68.4	67.8
2:1(40)	32.7	17.3	-6.8	41.4	30.1	11.6	38.1	24.8	67.6	38.3	15.9	68.2	76.8	34.5	79.4	75.4
1:1(10)	20.2	8.1	-6.9	27.2	17.7	4.8	24.1	14.5	35.4	19.4	8.5	33.7	38.0	17.6	37.1	37.5
1:1(20)	25.4	11.3	-7.4	33.9	22.7	7.2	30.4	18.6	50.8	27.0	11.5	51.6	54.8	24.4	57.2	53.7
1:1(30)	28.2	13.3	-7.5	37.4	25.4	8.5	33.6	20.7	60.5	31.7	13.2	63.9	65.3	28.4	70.8	63.5
1:1(40)	30.2	14.7	-7.5	39.6	27.2	9.4	35.7	22.2	67.7	35.1	14.5	73.3	73.0	31.2	81.2	70.5
1:2(10)	19.1	6.2	-7.6	26.6	15.6	2.7	22.4	11.9	38.1	18.7	7.9	38.2	38.4	15.9	40.2	36.3
1:2(20)	23.5	8.9	-8.1	32.6	20.0	4.8	28.1	15.7	52.8	25.2	10.5	57.3	53.6	21.8	60.4	50.7
1:2(30)	26.0	10.7	-8.1	35.7	22.5	6.2	31.1	17.9	61.6	29.1	12.0	69.6	62.7	25.3	73.4	59.4
1:2(40)	27.7	11.9	-8.1	37.7	24.2	7.2	33.1	19.3	67.9	32.0	13.1	78.7	69.3	27.8	83.0	65.5
1:5(10)	18.1	4.2	-8.3	26.0	13.3	0.4	20.6	9.0	41.1	18.0	7.3	43.5	38.9	14.2	44.0	35.0
1:5(20)	21.5	6.2	-8.8	31.0	16.7	2.0	25.3	12.1	55.2	23.3	9.3	64.3	52.2	18.8	64.4	47.3
1:5(30)	23.4	7.5	-8.9	33.6	18.8	3.2	27.9	14.1	63.0	26.3	10.5	76.8	59.8	21.6	76.8	54.4
1:5(40)	24.8	8.6	-8.9	35.3	20.3	4.1	29.7	15.4	68.2	28.5	11.4	85.6	65.1	23.6	85.4	59.3
0:1(10)	16.6	1.6	-9.3	25.1	10.2	-2.9	18.1	5.0	45.3	17.2	6.5	51.7	39.7	11.9	49.7	33.4
0:1(20)	18.3	1.7	-10.0	28.4	11.2	-3.2	20.4	5.5	59.1	20.3	7.5	77.3	50.2	13.9	71.9	41.6
0:1(30)	18.9	1.8	-10.3	29.6	11.5	-3.3	21.2	5.7	65.3	21.6	7.8	91.3	54.7	14.7	83.5	45.1
0:1(40)	19.2	1.8	-10.5	30.2	11.7	-3.3	21.7	5.8	68.8	22.3	8.0	100.2	57.1	15.1	90.6	47.0
Dose Cigarettes per smoker Variable Method 1, Tar level Actual (full tar correction)																
Multistage model																
1:0(10)	26.0	20.9	-4.9	28.5	30.7	17.4	33.3	30.5	23.8	24.1	6.5	15.7	38.9	26.4	25.6	48.2
1:0(20)	34.5	25.8	-5.8	37.1	37.3	20.0	40.8	35.3	44.5	38.0	9.1	30.4	65.6	36.8	47.2	74.2
1:0(30)	38.4	27.9	-6.1	40.9	39.9	20.9	43.9	37.0	60.8	46.2	10.4	42.9	83.4	42.0	63.9	89.1
1:0(40)	40.6	29.0	-6.3	43.1	41.4	21.5	45.5	38.0	74.0	51.6	11.2	53.6	96.1	45.0	77.2	98.8
5:1(10)	20.3	-1.1	-17.2	26.3	9.5	-2.6	16.4	8.3	27.5	9.4	-3.0	23.3	25.5	8.8	22.8	26.1
5:1(20)	26.3	-1.1	-21.3	33.8	11.3	-3.9	19.8	8.8	43.4	14.1	-4.1	38.4	39.2	12.2	37.4	38.7
5:1(30)	29.4	-1.0	-23.3	37.5	12.0	-4.6	21.2	8.8	54.6	17.1	-4.8	49.9	48.2	14.1	48.0	46.4
5:1(40)	31.4	-1.0	-24.5	39.8	12.4	-5.1	22.0	8.6	63.3	19.3	-5.2	59.3	54.8	15.3	56.4	51.8
2:1(10)	18.5	-5.5	-19.8	25.4	5.1	-7.2	12.8	3.0	30.4	6.3	-5.2	27.9	23.7	4.8	24.3	22.1
2:1(20)	23.7	-5.4	-23.5	32.2	6.9	-8.2	16.0	3.7	45.4	9.9	-6.5	44.1	35.5	7.4	38.5	32.9
2:1(30)	26.5	-5.1	-25.2	35.6	7.8	-8.6	17.6	4.0	55.4	12.3	-7.2	55.6	43.2	9.0	48.5	39.7
2:1(40)	28.4	-4.8	-26.3	37.8	8.5	-8.8	18.6	4.2	62.9	14.2	-7.6	64.8	48.9	10.2	56.3	44.6
1:1(10)	17.3	-8.2	-21.3	24.8	2.2	-10.3	10.5	-0.5	32.9	4.3	-6.7	32.0	22.7	2.1	26.0	19.6
1:1(20)	21.7	-8.1	-24.7	30.9	3.9	-11.1	13.5	0.3	47.2	7.1	-8.1	49.1	33.2	4.1	40.1	29.2
1:1(30)	24.2	-7.8	-26.3	34.0	4.9	-11.3	15.1	0.8	56.2	9.1	-8.7	60.7	39.9	5.6	49.6	35.3
1:1(40)	26.0	-7.4	-27.2	36.0	5.7	-11.3	16.1	1.2	62.9	10.7	-9.1	69.6	44.9	6.7	56.9	39.6
1:2(10)	16.2	-10.5	-22.5	24.2	-0.1	-12.8	8.6	-3.4	35.3	2.7	-7.9	36.3	22.1	-0.1	27.9	17.7
1:2(20)	20.0	-10.5	-25.7	29.6	1.3	-13.6	11.2	-2.7	49.0	4.8	-9.5	54.4	31.4	1.3	42.0	26.1
1:2(30)	22.1	-10.1	-27.0	32.4	2.3	-13.7	12.7	-2.1	57.2	6.4	-10.1	66.1	37.1	2.5	51.1	31.3
1:2(40)	23.6	-9.8	-27.8	34.2	3.1	-13.6	13.7	-1.6	63.0	7.6	-10.4	74.8	41.4	3.5	57.8	35.2
1:5(10)	15.1	-12.6	-23.5	23.5	-2.4	-15.3	6.6	-6.4	38.1	1.1	-9.1	41.4	21.6	-2.3	30.2	16.0
1:5(20)	18.0	-12.9	-26.5	28.1	-1.5	-16.3	8.7	-6.0	51.2	2.4	-10.8	61.1	29.6	-1.7	44.5	22.8
1:5(30)	19.7	-12.7	-27.7	30.4	-0.7	-16.4	10.0	-5.5	58.3	3.5	-11.4	73.0	34.2	-0.9	53.2	27.0
1:5(40)	20.9	-12.4	-28.4	31.9	0.0	-16.3	10.9	-5.0	63.2	4.4	-11.8	81.4	37.5	-0.2	59.3	30.1
0:1(10)	13.7	-15.1	-24.8	22.6	-5.3	-18.5	4.2	-10.1	41.9	-0.8	-10.7	49.2	21.2	-5.1	34.1	13.9
0:1(20)	15.1	-16.5	-27.5	25.6	-5.8	-20.6	4.8	-11.4	54.7	-0.9	-12.8	73.6	27.0	-6.2	49.7	18.0
0:1(30)	15.5	-17.0	-28.5	26.6	-6.0	-21.3	5.0	-11.9	60.4	-1.0	-13.6	86.9	29.5	-6.6	57.9	19.8
0:1(40)	15.8	-17.2	-29.0	27.2	-6.1	-21.7	5.1	-12.1	63.7	-1.0	-14.1	95.3	30.9	-6.8	63.0	20.8

Appendix (continued/2)

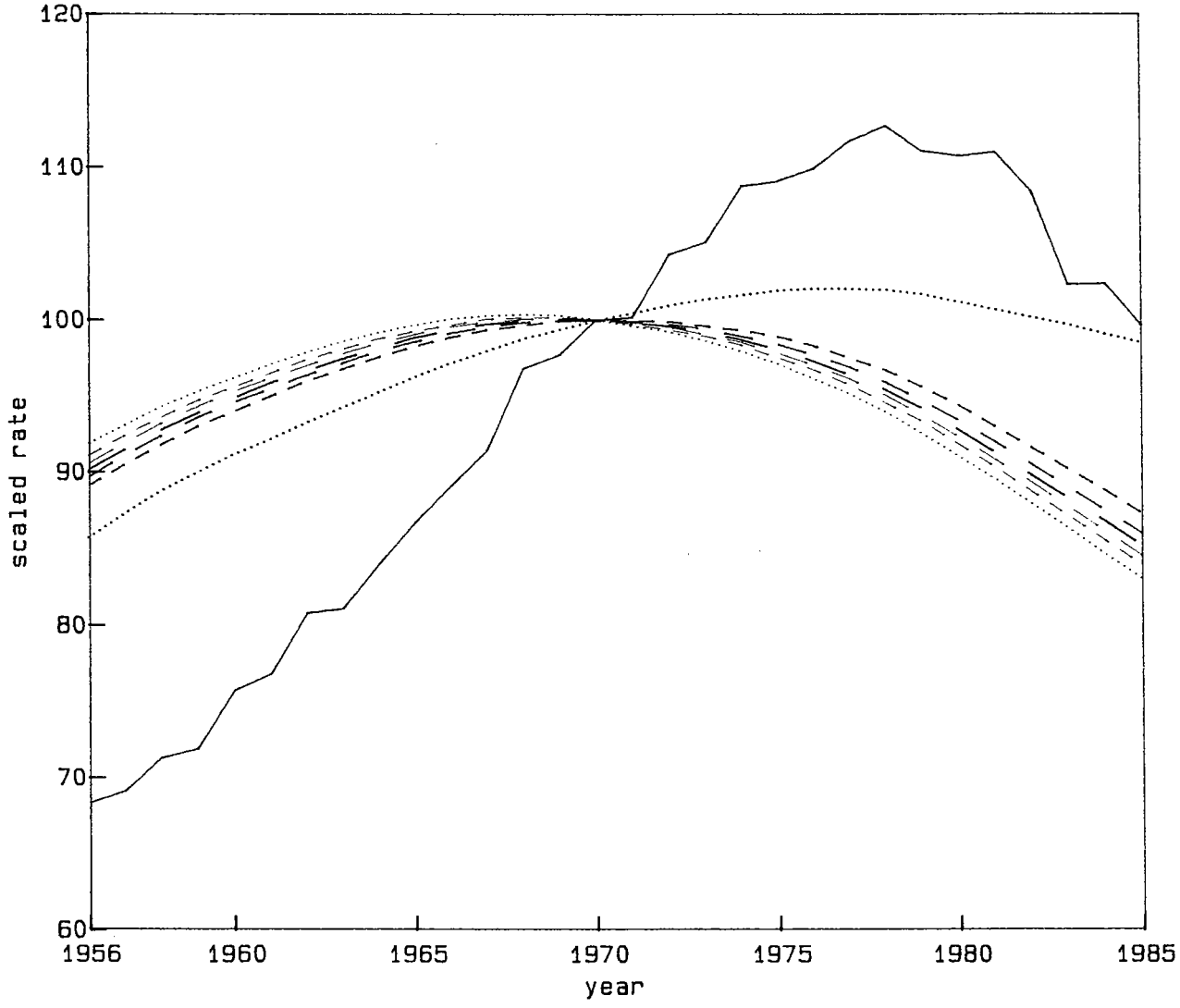
Sex	Male								Female							
Age	45-54			55-64			65-74		45-54			55-64			65-74	
Period	1956 1965	1966 1975	1976 1985	1956 1965	1966 1975	1976 1985	1966 1975	1976 1985	1956 1965	1966 1975	1976 1985	1956 1965	1966 1975	1976 1985	1966 1975	1976 1985
Lung cancer rate Observed	27.0	22.5	-9.3	31.5	19.8	7.2	30.1	9.4	93.4	87.4	23.5	50.2	124.4	56.1	95.1	97.8
Dose Cigarettes per smoker Variable Method 1, Tar level Square Root																
Multistage model																
1:0(10)	26.0	21.1	-2.3	28.5	30.8	18.3	33.3	31.0	23.8	24.3	9.0	15.7	39.0	27.4	25.7	48.7
1:0(20)	34.5	26.1	-2.8	37.1	37.4	21.0	40.8	35.7	44.5	38.3	12.7	30.4	65.8	38.2	47.3	75.0
1:0(30)	38.4	28.1	-2.9	40.9	40.0	22.1	43.9	37.6	60.8	46.5	14.5	42.9	83.6	43.6	64.0	90.1
1:0(40)	40.6	29.2	-3.0	43.1	41.5	22.6	45.6	38.5	74.0	52.0	15.6	53.6	96.3	46.7	77.3	99.8
5:1(10)	21.5	5.3	-12.1	27.3	15.6	2.8	21.6	13.6	28.4	14.7	2.4	23.8	30.8	14.2	26.3	32.4
5:1(20)	27.9	7.1	-14.6	35.1	19.2	3.1	26.7	15.7	44.8	21.9	3.4	39.3	47.6	20.0	43.5	48.3
5:1(30)	31.3	8.1	-15.8	39.0	20.9	3.3	29.1	16.6	56.3	26.5	4.0	51.1	58.7	23.2	56.0	58.0
5:1(40)	33.4	8.8	-16.5	41.5	21.9	3.3	30.5	17.1	65.3	29.7	4.5	60.8	66.9	25.3	66.0	64.8
2:1(10)	19.9	1.6	-13.9	26.5	11.8	-1.1	18.7	9.2	31.5	12.5	0.8	28.6	29.9	11.0	28.7	29.3
2:1(20)	25.4	3.4	-16.2	33.6	15.3	-0.4	23.5	11.5	47.0	18.5	1.6	45.1	44.8	15.9	45.6	43.3
2:1(30)	28.4	4.5	-17.2	37.2	17.1	0.0	25.9	12.7	57.3	22.3	2.1	57.0	54.4	18.8	57.5	52.0
2:1(40)	30.4	5.3	-17.8	39.5	18.3	0.3	27.4	13.4	65.2	25.1	2.6	66.4	61.5	20.9	66.7	58.2
1:1(10)	18.7	-0.8	-15.1	25.9	9.3	-3.7	16.6	6.1	34.1	11.1	-0.2	32.8	29.6	8.7	31.0	27.3
1:1(20)	23.5	0.7	-17.1	32.3	12.4	-3.0	21.1	8.4	48.9	16.1	0.4	50.3	43.0	13.0	47.8	39.9
1:1(30)	26.1	1.8	-18.0	35.6	14.2	-2.4	23.5	9.7	58.3	19.3	0.8	62.3	51.4	15.6	59.2	47.7
1:1(40)	28.0	2.6	-18.5	37.7	15.5	-2.0	25.0	10.6	65.2	21.8	1.2	71.4	57.6	17.5	67.8	53.3
1:2(10)	17.6	-2.9	-16.0	25.3	7.0	-6.0	14.8	3.3	36.6	9.9	-1.1	37.2	29.5	6.8	33.4	25.8
1:2(20)	21.7	-1.7	-17.9	31.0	9.8	-5.4	18.9	5.5	50.8	14.1	-0.7	55.8	41.4	10.3	50.3	36.9
1:2(30)	24.0	-0.7	-18.6	33.9	11.5	-4.8	21.1	6.8	59.3	16.7	-0.3	67.8	48.7	12.6	61.2	43.8
1:2(40)	25.6	0.1	-19.0	35.9	12.7	-4.2	22.6	7.8	65.3	18.7	0.0	76.7	54.0	14.3	69.2	48.7
1:5(10)	16.5	-5.0	-16.8	24.7	4.7	-8.4	13.0	0.4	39.5	8.8	-2.0	42.4	29.4	4.9	36.4	24.3
1:5(20)	19.7	-4.2	-18.6	29.5	6.8	-8.1	16.3	2.1	53.1	11.9	-1.9	62.6	39.8	7.4	53.5	33.7
1:5(30)	21.5	-3.5	-19.2	31.9	8.2	-7.5	18.1	3.3	60.5	13.9	-1.6	74.8	45.8	9.2	63.8	39.2
1:5(40)	22.8	-2.8	-19.6	33.5	9.2	-7.0	19.4	4.2	65.6	15.4	-1.4	83.4	50.0	10.5	71.1	43.2
0:1(10)	15.1	-7.5	-17.8	23.8	1.7	-11.5	10.5	-3.4	43.5	7.4	-3.0	50.4	29.6	2.4	41.1	22.4
0:1(20)	16.6	-8.2	-19.5	26.9	1.9	-12.7	11.9	-3.8	56.8	8.8	-3.6	75.4	37.5	2.9	59.8	28.6
0:1(30)	17.2	-8.4	-20.1	28.0	2.0	-13.1	12.4	-4.0	62.8	9.3	-3.8	89.0	41.0	3.1	69.5	31.2
0:1(40)	17.4	-8.5	-20.4	28.6	2.0	-13.3	12.6	-4.0	66.1	9.6	-3.9	97.7	42.9	3.2	75.5	32.7
Dose Cigarettes per smoker Variable Method 2, Tar level Constant (no tar correction)																
Multistage model																
1:0(10)	23.2	17.3	6.5	36.3	27.0	17.8	39.5	27.9	21.8	21.5	18.1	14.8	35.6	28.3	24.3	46.3
1:0(20)	31.0	21.6	7.8	48.6	32.9	20.6	49.3	32.4	41.7	34.9	26.2	29.8	62.2	40.6	46.8	73.8
1:0(30)	34.5	23.4	8.3	54.3	35.3	21.7	53.4	34.1	58.1	43.2	30.4	43.3	80.8	47.0	65.6	90.5
1:0(40)	36.6	24.4	8.6	57.6	36.6	22.3	55.7	35.0	72.0	48.8	33.0	55.7	94.7	50.9	81.6	101.7
5:1(10)	25.8	12.4	-1.1	36.2	22.4	9.4	33.3	19.0	30.6	21.2	13.7	24.1	36.6	21.8	30.1	39.4
5:1(20)	33.9	16.0	-0.7	48.7	28.1	11.6	43.1	22.8	49.3	31.5	19.7	40.8	57.6	31.0	51.1	59.7
5:1(30)	38.3	17.9	-0.5	55.5	30.9	12.6	47.9	24.5	63.1	38.1	23.1	54.1	71.9	36.3	67.3	72.5
5:1(40)	41.1	19.1	-0.3	59.9	32.6	13.2	51.0	25.6	74.1	42.8	25.5	65.5	82.7	39.9	80.7	81.5
2:1(10)	25.3	10.5	-3.1	34.9	20.3	6.7	30.6	16.1	35.4	21.2	12.1	29.6	37.9	19.7	34.0	38.0
2:1(20)	32.4	13.7	-2.6	46.1	25.6	9.0	39.6	19.9	53.9	30.1	17.2	47.8	57.0	27.8	55.1	56.2
2:1(30)	36.3	15.5	-2.3	52.3	28.3	10.2	44.3	21.8	66.6	35.7	20.2	61.6	69.6	32.5	70.7	67.5
2:1(40)	38.9	16.7	-2.0	56.3	30.1	11.0	47.3	23.0	76.6	39.7	22.4	72.9	78.9	35.8	83.2	75.6
1:1(10)	24.8	9.0	-4.5	33.8	18.7	4.8	28.4	13.9	39.4	21.2	10.9	34.5	39.1	18.1	37.5	37.2
1:1(20)	31.0	11.9	-4.1	43.8	23.5	6.9	36.6	17.6	57.7	29.1	15.3	54.1	56.6	25.2	58.8	53.5
1:1(30)	34.4	13.6	-3.7	49.3	26.1	8.2	41.0	19.6	69.6	33.9	17.9	68.3	67.8	29.4	73.7	63.6
1:1(40)	36.8	14.7	-3.3	53.1	27.8	9.0	44.0	20.8	78.6	37.3	19.8	79.5	76.0	32.4	85.4	70.8
1:2(10)	24.3	7.7	-5.7	32.8	17.1	2.9	26.2	11.8	43.3	21.2	9.8	39.5	40.3	16.7	41.1	36.5
1:2(20)	29.6	10.1	-5.4	41.5	21.3	4.9	33.6	15.2	61.4	28.1	13.5	60.9	56.4	22.8	62.6	51.1
1:2(30)	32.6	11.6	-5.0	46.3	23.7	6.1	37.6	17.1	72.5	32.2	15.7	75.4	66.1	26.4	77.0	59.8
1:2(40)	34.6	12.7	-4.6	49.6	25.3	7.0	40.4	18.4	80.5	35.1	17.4	86.6	73.2	29.0	87.9	66.1
1:5(10)	23.6	6.3	-7.0	31.5	15.4	1.0	23.9	9.5	47.7	21.2	8.7	45.6	41.7	15.3	45.4	35.8
1:5(20)	28.0	8.1	-6.9	38.7	18.8	2.4	29.9	12.3	65.7	27.1	11.5	69.4	56.1	20.0	67.5	48.3
1:5(30)	30.3	9.3	-6.6	42.6	20.7	3.5	33.3	14.0	75.9	30.3	13.2	84.6	64.2	22.9	81.2	55.5
1:5(40)	31.9	10.2	-6.3	45.3	22.1	4.3	35.6	15.2	82.8	32.5	14.5	95.6	69.9	24.9	91.0	60.5
0:1(10)	22.7	4.5	-8.6	29.9	13.0	-1.8	20.7	6.2	53.9	21.3	7.3	55.2	43.6	13.3	51.9	34.9
0:1(20)	25.3	4.9	-9.3	34.1	14.4	-1.9	23.4	6.9	72.9	25.4	8.4	85.6	55.7	15.6	76.4	43.8
0:1(30)	26.2	5.0	-9.6	35.6	14.8	-2.0	24.5	7.2	81.9	27.1	8.8	103.3	61.0	16.5	89.5	47.5
0:1(40)	26.7	5.1	-9.7	36.5	15.1	-2.0	25.0	7.3	87.1	28.0	9.0	114.9	64.0	17.0	97.6	49.6

Sex	Male								Female							
Age	45-54			55-64			65-74		45-54			55-64			65-74	
Period	1956 1965	1966 1975	1976 1985	1956 1965	1966 1975	1976 1985	1966 1975	1976 1985	1956 1965	1966 1975	1976 1985	1956 1965	1966 1975	1976 1985	1966 1975	1976 1985
Lung cancer rate																
Observed	27.0	22.5	-9.3	31.5	19.8	7.2	30.1	9.4	93.4	87.4	23.5	50.2	124.4	56.1	95.1	97.8
Dose Cigarettes per smoker Variable Method 2, Tar level Actual (full tar correction)																
Multistage model																
1:0(10)	23.2	16.9	0.5	36.3	26.8	15.6	39.4	26.9	21.8	21.1	12.3	14.8	35.5	25.9	24.3	45.1
1:0(20)	31.0	21.1	0.7	48.6	32.7	18.2	49.2	31.3	41.7	34.2	17.8	29.8	61.9	37.2	46.7	71.9
1:0(30)	34.5	22.8	0.7	54.3	35.1	19.1	53.4	32.9	58.1	42.3	20.6	43.3	80.4	43.0	65.5	88.1
1:0(40)	36.6	23.8	0.7	57.6	36.4	19.6	55.6	33.8	72.0	47.9	22.4	55.7	94.2	46.6	81.4	99.0
5:1(10)	23.1	-1.6	-14.0	33.9	9.1	-3.2	21.3	6.9	28.8	9.6	0.2	23.1	25.1	9.0	22.6	25.0
5:1(20)	30.3	-1.9	-17.4	45.6	10.8	-4.6	26.7	7.1	46.4	14.4	0.5	39.0	39.2	12.7	37.9	37.8
5:1(30)	34.1	-2.0	-19.1	51.8	11.5	-5.3	29.3	7.0	59.2	17.6	0.7	51.7	48.8	14.8	49.8	45.9
5:1(40)	36.6	-2.1	-20.1	55.9	11.9	-5.8	30.9	6.9	69.6	19.8	0.9	62.5	56.1	16.3	59.5	51.8
2:1(10)	22.3	-5.2	-17.2	32.4	5.4	-7.5	17.1	2.2	33.1	7.4	-2.7	28.2	24.1	5.2	24.5	21.5
2:1(20)	28.6	-5.4	-20.3	42.8	7.1	-8.6	22.1	2.6	50.4	11.2	-2.9	45.6	36.5	8.1	39.6	32.5
2:1(30)	32.0	-5.3	-21.7	48.5	7.9	-9.1	24.7	2.8	62.3	13.7	-2.8	58.6	44.8	9.9	50.7	39.6
2:1(40)	34.3	-5.2	-22.5	52.2	8.5	-9.3	26.4	2.9	71.5	15.6	-2.6	69.4	51.0	11.3	59.7	44.8
1:1(10)	21.7	-7.4	-19.2	31.2	3.1	-10.2	14.2	-0.8	36.8	6.0	-4.7	32.8	23.8	2.8	26.4	19.5
1:1(20)	27.2	-7.6	-22.1	40.5	4.6	-11.2	18.8	-0.3	53.8	9.1	-5.1	51.5	35.0	5.0	41.5	29.3
1:1(30)	30.2	-7.5	-23.3	45.5	5.5	-11.5	21.3	0.0	64.9	11.2	-5.1	64.9	42.2	6.6	52.2	35.5
1:1(40)	32.2	-7.3	-24.0	49.0	6.2	-11.6	23.0	0.3	73.3	12.7	-4.9	75.6	47.6	7.8	60.6	40.1
1:2(10)	21.1	-9.2	-20.8	30.1	1.1	-12.5	11.8	-3.4	40.3	4.9	-6.3	37.6	23.8	0.7	28.6	18.1
1:2(20)	25.8	-9.4	-23.5	38.1	2.4	-13.4	15.8	-2.9	57.2	7.4	-7.0	57.9	33.8	2.3	43.9	26.5
1:2(30)	28.4	-9.3	-24.5	42.6	3.3	-13.6	18.1	-2.5	67.5	9.0	-7.1	71.7	40.0	3.6	54.1	32.0
1:2(40)	30.1	-9.1	-25.1	45.6	4.0	-13.6	19.7	-2.2	75.0	10.3	-7.0	82.3	44.6	4.6	61.9	36.0
1:5(10)	20.4	-10.8	-22.3	28.8	-0.7	-14.7	9.4	-5.9	44.4	3.9	-7.9	43.4	23.9	-1.2	31.4	16.7
1:5(20)	24.2	-11.3	-24.9	35.4	0.1	-15.8	12.5	-5.8	61.2	5.6	-9.0	66.0	32.7	-0.4	47.0	23.8
1:5(30)	26.2	-11.2	-25.8	39.0	0.9	-16.0	14.4	-5.4	70.6	6.8	-9.2	80.4	37.8	0.4	56.7	28.2
1:5(40)	27.6	-11.1	-26.3	41.5	1.4	-16.0	15.8	-5.0	77.1	7.7	-9.2	90.8	41.5	1.2	63.8	31.3
0:1(10)	19.5	-12.8	-24.1	27.1	-3.1	-17.4	6.2	-9.0	50.1	2.6	-9.8	52.5	24.3	-3.7	35.7	15.2
0:1(20)	21.7	-13.9	-26.8	31.0	-3.4	-19.4	7.1	-10.2	67.8	3.2	-11.8	81.4	31.3	-4.5	53.0	19.9
0:1(30)	22.5	-14.4	-27.7	32.4	-3.5	-20.1	7.4	-10.6	76.2	3.4	-12.6	98.2	34.4	-4.8	62.4	21.9
0:1(40)	22.9	-14.6	-28.2	33.1	-3.6	-20.5	7.6	-10.8	81.0	3.5	-13.0	109.2	36.2	-5.0	68.2	23.1
Dose Cigarettes per smoker Variable Method 2, Tar level Square Root																
Multistage model																
1:0(10)	23.2	17.1	3.3	36.3	26.9	16.6	39.4	27.4	21.8	21.3	14.9	14.8	35.6	27.0	24.3	45.7
1:0(20)	31.0	21.3	3.9	48.6	32.8	19.3	49.3	31.8	41.7	34.5	21.6	29.8	62.0	38.8	46.8	72.8
1:0(30)	34.5	23.1	4.2	54.3	35.2	20.3	53.4	33.5	58.1	42.7	25.1	43.3	80.6	44.9	65.6	89.2
1:0(40)	36.6	24.1	4.3	57.6	36.5	20.8	55.7	34.3	72.0	48.3	27.3	55.7	94.4	48.6	81.5	100.2
5:1(10)	24.4	4.7	-8.6	35.0	15.1	2.1	26.7	12.0	29.7	14.8	5.7	23.5	30.3	14.3	26.0	31.1
5:1(20)	32.0	6.2	-10.3	47.1	18.6	2.4	34.1	13.9	47.8	22.1	8.5	39.8	47.5	20.5	43.8	47.2
5:1(30)	36.1	7.0	-11.1	53.5	20.3	2.5	37.7	14.7	61.1	26.8	10.2	52.8	59.2	24.1	57.7	57.4
5:1(40)	38.8	7.6	-11.6	57.8	21.3	2.5	40.0	15.1	71.8	30.2	11.4	63.9	68.1	26.5	69.1	64.8
2:1(10)	23.8	1.9	-11.2	33.6	12.2	-1.3	23.2	8.2	34.2	13.6	3.5	28.9	30.3	11.3	28.8	28.6
2:1(20)	30.4	3.3	-12.7	44.4	15.5	-0.9	30.0	10.3	52.0	19.7	5.7	46.6	45.8	16.6	46.6	42.8
2:1(30)	34.0	4.2	-13.2	50.3	17.2	-0.5	33.6	11.3	64.4	23.7	7.1	60.0	56.0	19.8	59.7	51.8
2:1(40)	36.4	4.8	-13.5	54.2	18.3	-0.3	35.9	11.9	73.9	26.5	8.2	71.1	63.6	22.0	70.3	58.4
1:1(10)	23.2	0.0	-12.8	32.5	10.1	-3.7	20.6	5.6	38.0	12.9	2.0	33.6	30.7	9.4	31.4	27.1
1:1(20)	29.0	1.3	-14.2	42.1	13.2	-3.2	26.9	7.6	55.6	18.1	3.7	52.8	44.8	13.8	49.3	39.9
1:1(30)	32.2	2.1	-14.6	47.4	14.9	-2.7	30.3	8.7	67.1	21.5	4.9	66.5	53.8	16.6	61.9	47.9
1:1(40)	34.4	2.8	-14.8	50.9	16.0	-2.4	32.5	9.5	75.8	23.9	5.9	77.5	60.4	18.7	71.8	53.7
1:2(10)	22.6	-1.5	-14.2	31.4	8.4	-5.7	18.3	3.3	41.7	12.3	0.7	38.5	31.2	7.7	34.2	26.0
1:2(20)	27.6	-0.5	-15.5	39.7	11.0	-5.3	23.9	5.2	59.2	16.8	2.0	59.3	44.0	11.3	52.3	37.3
1:2(30)	30.4	0.2	-15.8	44.4	12.6	-4.8	27.0	6.3	69.9	19.5	3.0	73.5	51.9	13.7	64.4	44.3
1:2(40)	32.2	0.8	-16.0	47.5	13.7	-4.3	29.1	7.1	77.6	21.6	3.8	84.3	57.6	15.5	73.6	49.4
1:5(10)	21.9	-3.0	-15.5	30.1	6.6	-7.7	16.0	0.9	45.9	11.7	-0.6	44.5	31.9	6.0	37.7	25.0
1:5(20)	26.0	-2.4	-16.8	37.0	8.6	-7.6	20.4	2.3	63.4	15.4	0.1	67.7	43.3	8.7	56.2	34.7
1:5(30)	28.2	-1.9	-17.1	40.7	9.9	-7.2	23.0	3.3	73.1	17.5	0.8	82.4	49.8	10.5	67.8	40.3
1:5(40)	29.7	-1.4	-17.3	43.3	10.9	-6.8	24.8	4.1	79.8	19.0	1.4	93.1	54.4	11.8	76.1	44.4
0:1(10)	21.0	-4.9	-17.1	28.4	4.3	-10.4	12.8	-2.2	51.9	11.1	-2.2	53.7	33.0	3.8	43.0	23.9
0:1(20)	23.4	-5.3	-18.8	32.5	4.7	-11.5	14.5	-2.5	70.3	13.3	-2.6	83.4	42.4	4.6	63.6	30.6
0:1(30)	24.2	-5.5	-19.3	33.9	4.9	-11.8	15.2	-2.6	78.9	14.2	-2.8	100.7	46.6	4.9	74.7	33.5
0:1(40)	24.7	-5.6	-19.6	34.7	4.9	-12.0	15.5	-2.6	83.9	14.7	-2.9	111.9	48.9	5.0	81.6	35.1

Figure 1M

Observed and predicted trends in lung cancer rate
Effects of various assumptions on ratio between stages

Multistage model, cigs/smoker and tar level constant
Males, 45-54



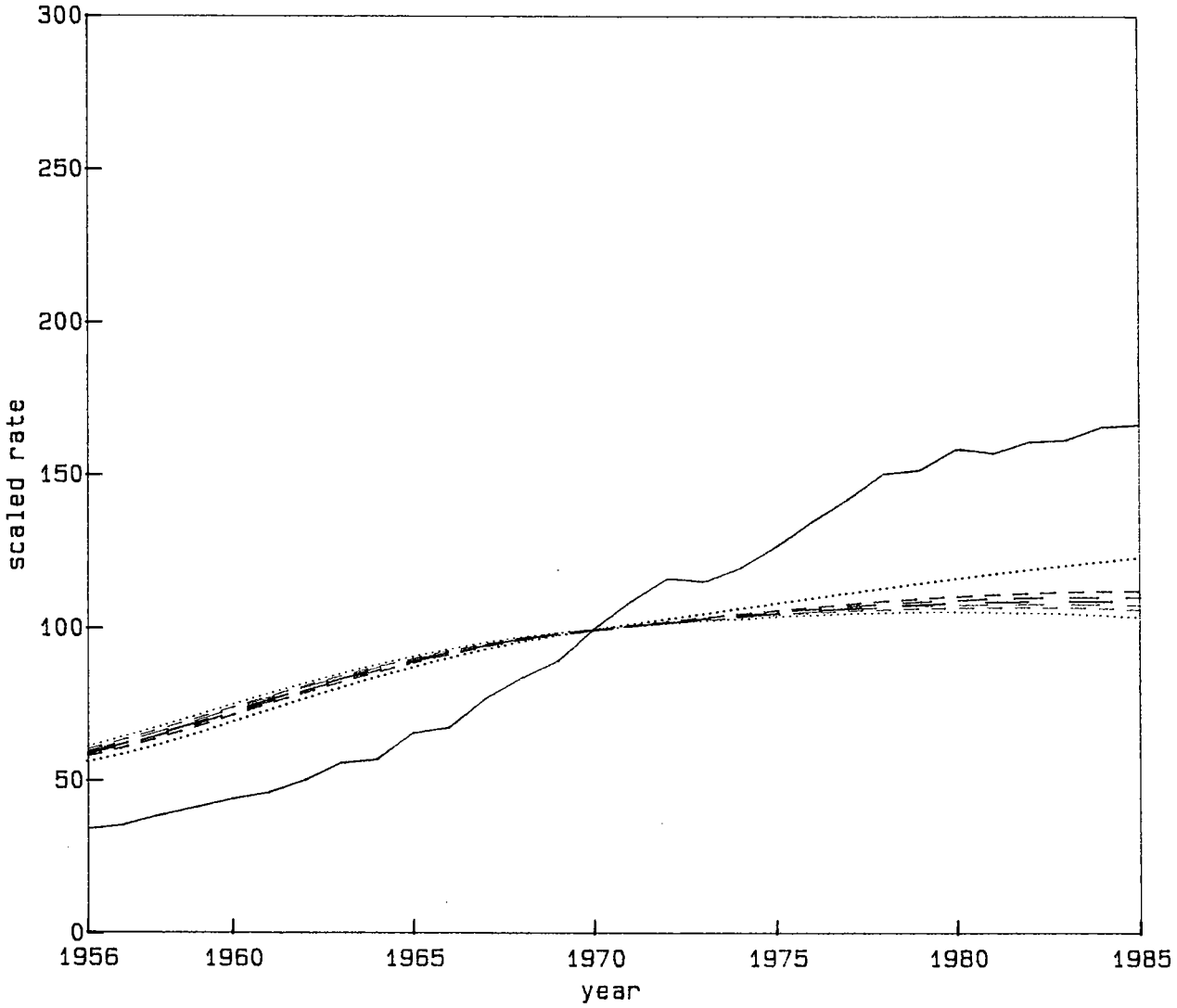
Model
1: 0 (20)
5: 1 (20)
2: 1 (20)
1: 1 (20)
1: 2 (20)
1: 5 (20)
0: 1 (20)

Observed rate

Figure 1F

Observed and predicted trends in lung cancer rate
Effects of various assumptions on ratio between stages

Multistage model, cigs/smoker and tar level constant
Females, 45-54



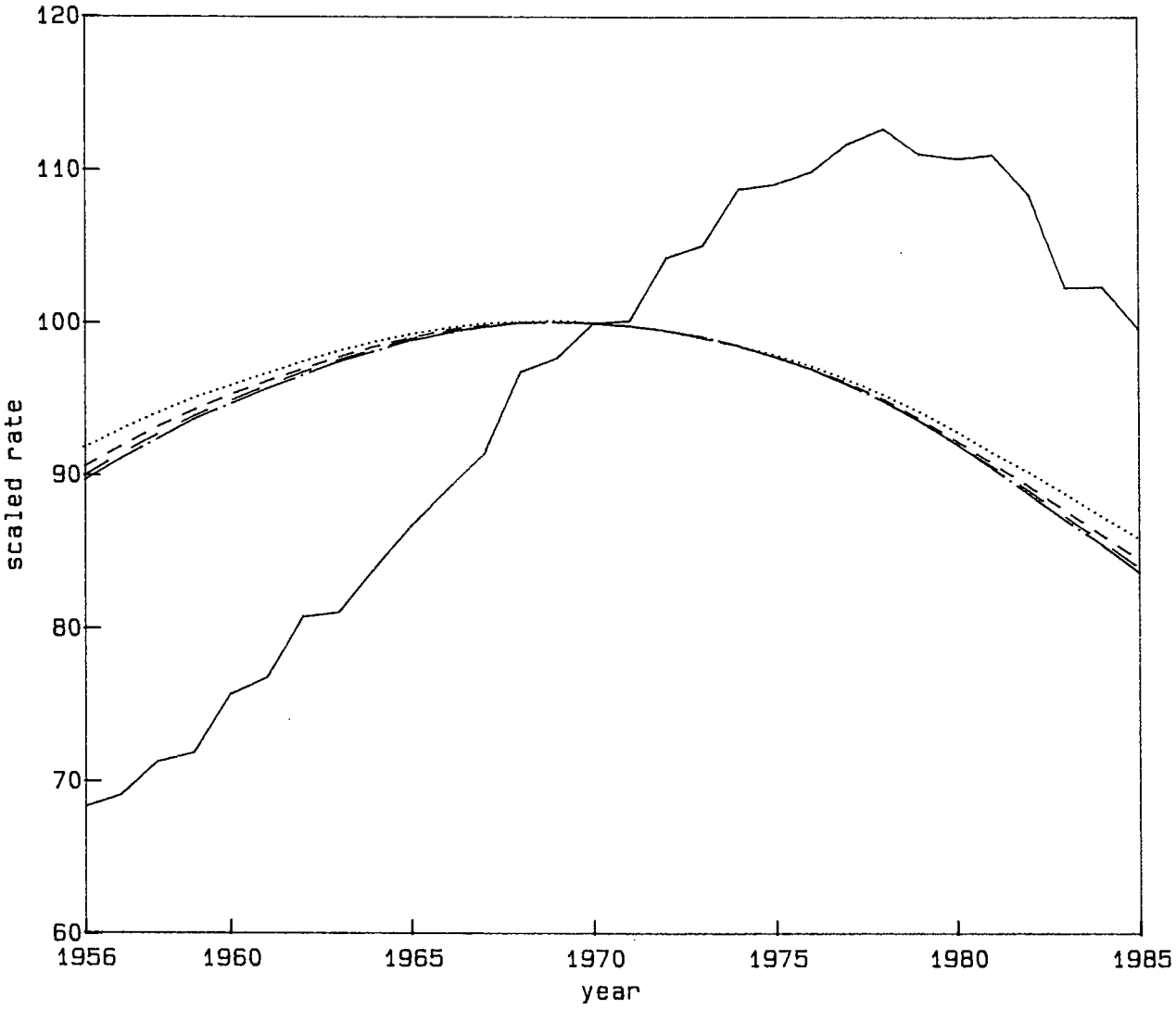
Model
1: 0 (20)
5: 1 (20)
2: 1 (20)
1: 1 (20)
1: 2 (20)
1: 5 (20)
0: 1 (20)

Observed rate

Figure 2M

Observed and predicted trends in lung cancer rate
Effects of various assumptions on relative risk of smoking

Multistage model, cigs/smoker and tar level constant
Males, 45-54



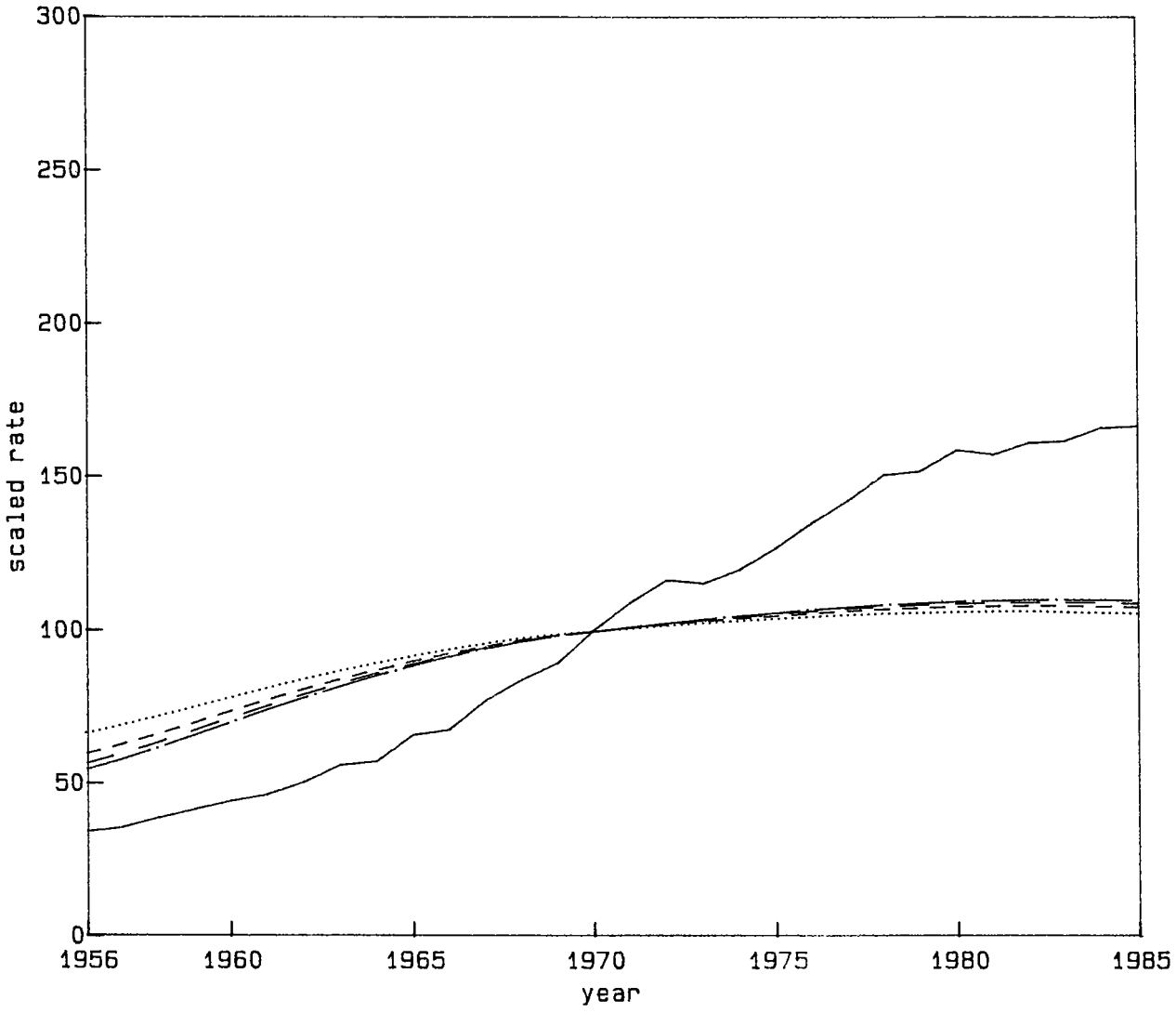
Model
1: 2 (10)
1: 2 (20)
1: 2 (30)
1: 2 (40)

Observed rate

Figure 2Fa

Observed and predicted trends in lung cancer rate
Effects of various assumptions on relative risk of smoking

Multistage model, cigs/smoker and tar level constant
Females, 45-54



Model
1: 2 (10)
1: 2 (20)
1: 2 (30)
1: 2 (40)

Observed rate

Figure 2Fb

Observed and predicted trends in lung cancer rate
Effects of various assumptions on relative risk of smoking

Multistage model, cigs/smoker and tar level constant
Females, 55-64

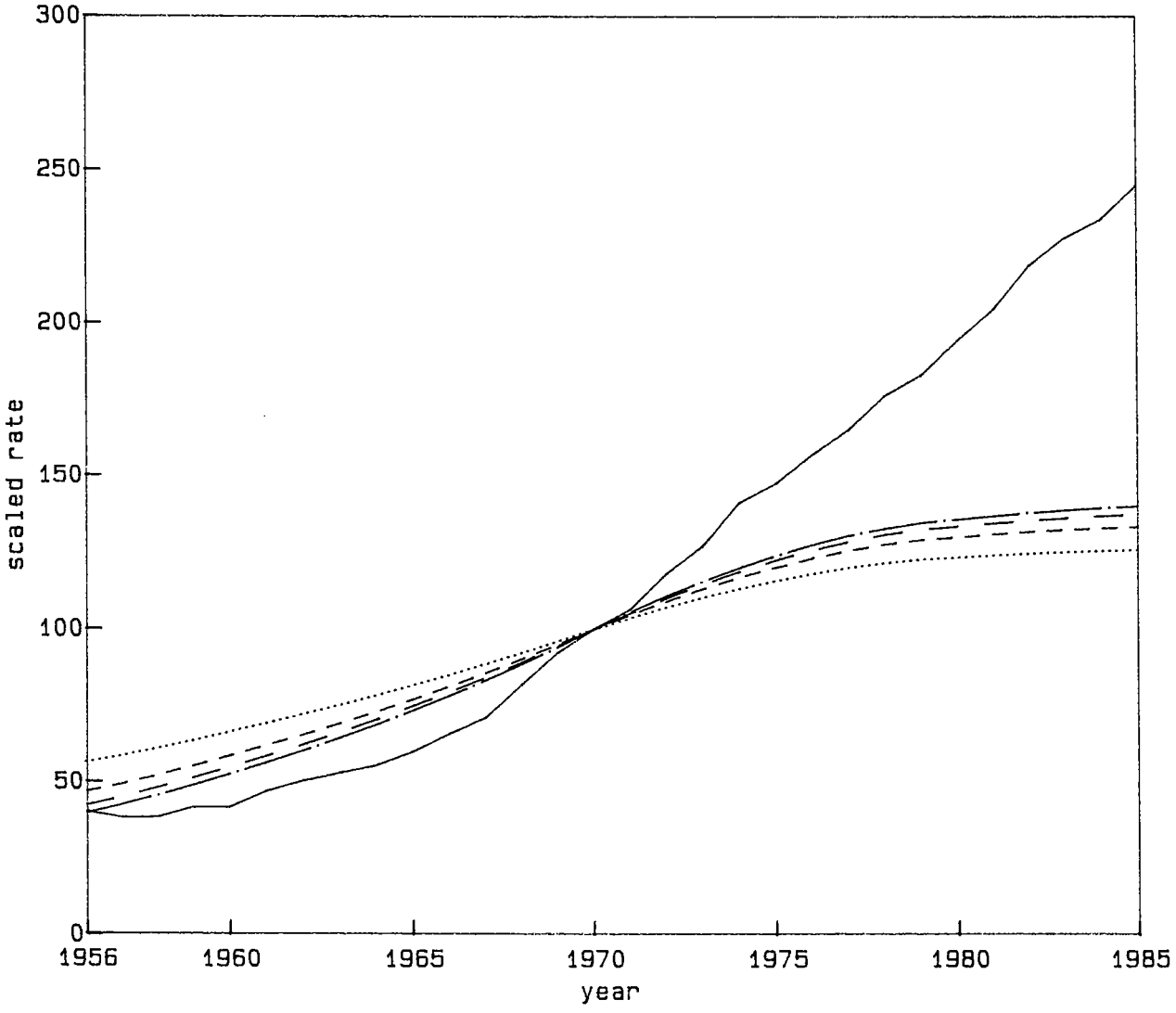
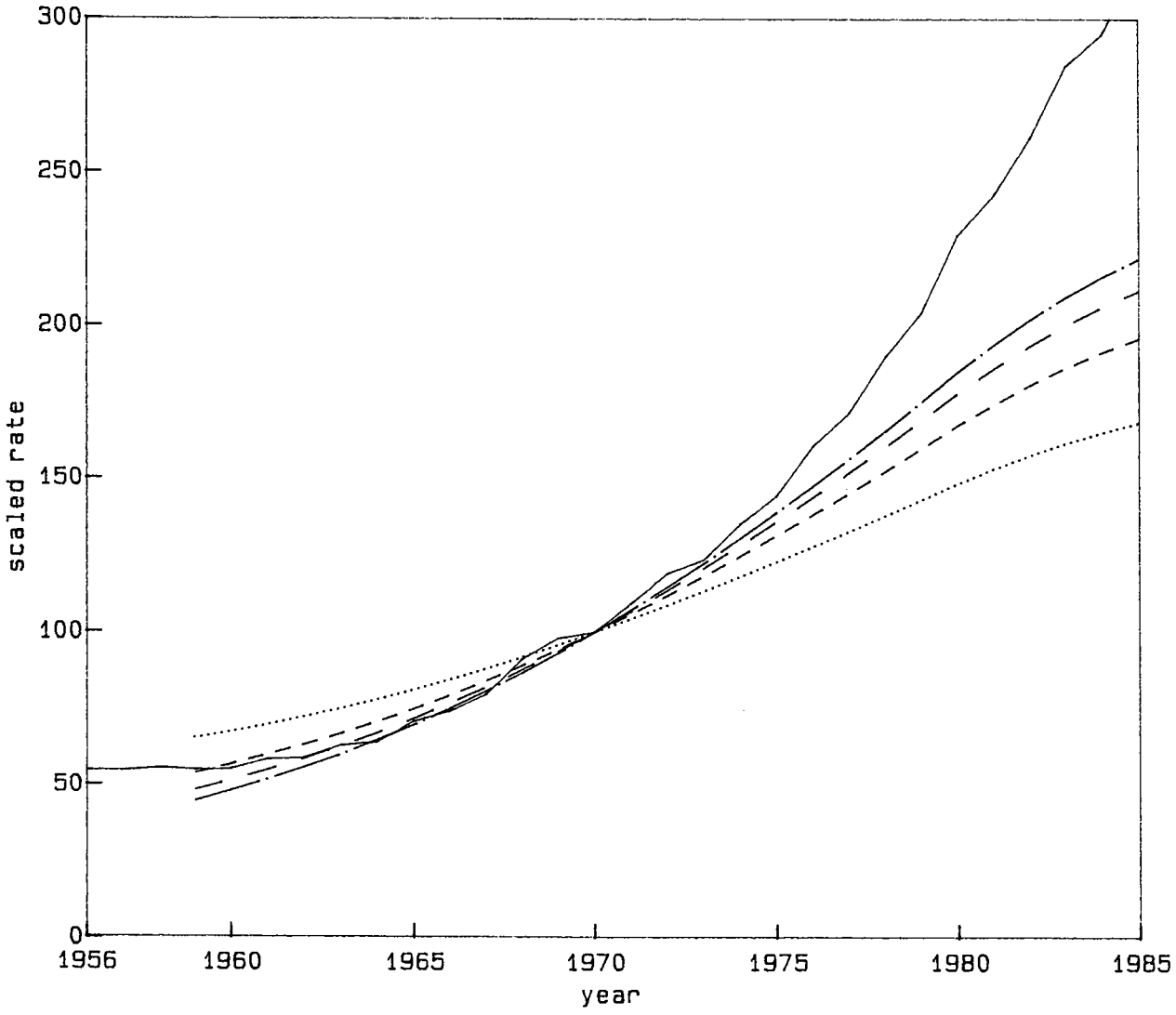


Figure 2Fc

Observed and predicted trends in lung cancer rate
Effects of various assumptions on relative risk of smoking

Multistage model, cigs/smoker and tar level constant
Females, 65-74



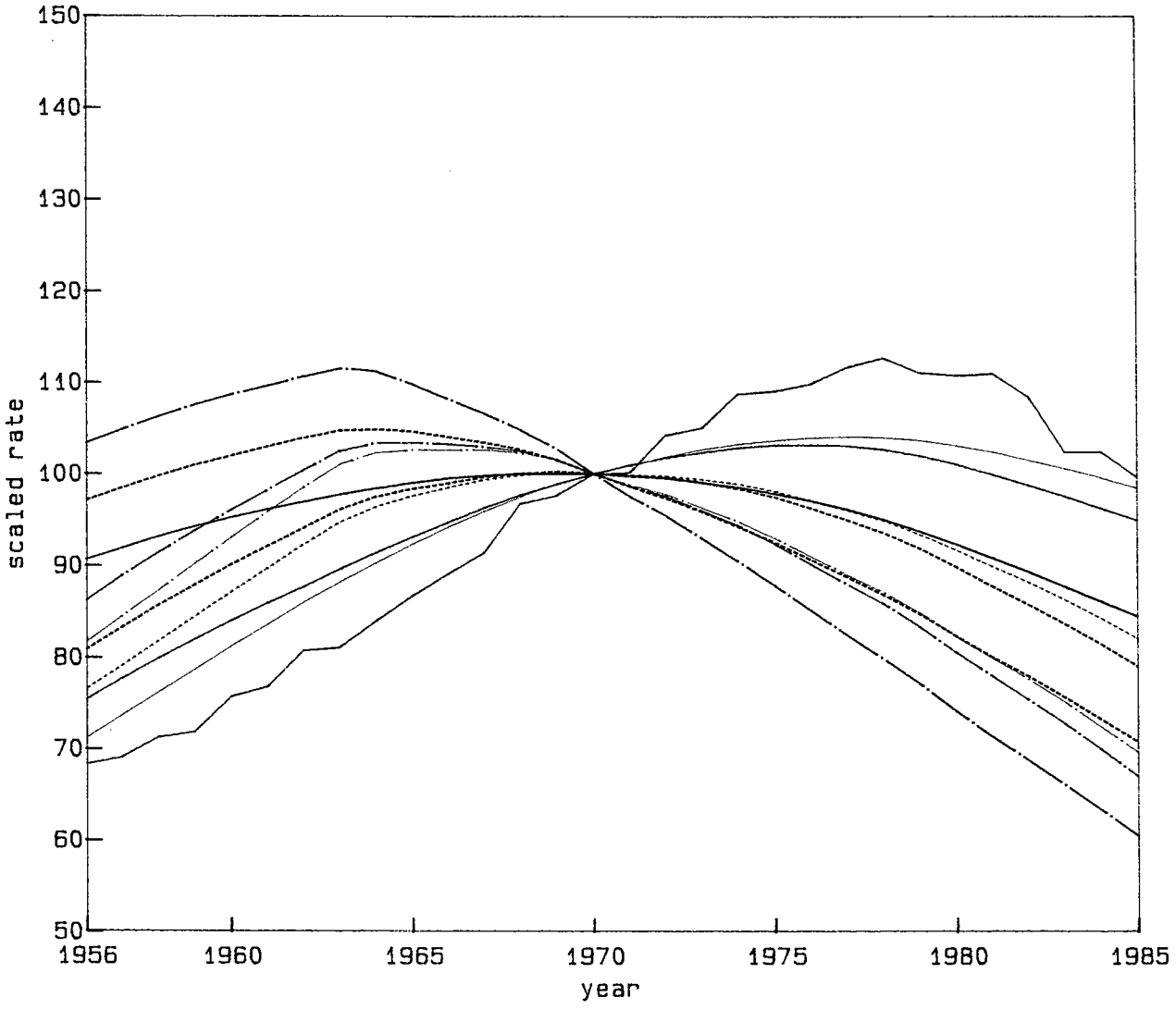
Model
1: 2 (10)
1: 2 (20)
1: 2 (30)
1: 2 (40)

Observed rate

Figure 3Ma

Observed and predicted trends in lung cancer rate
Effects of various assumptions on cigs/smoker and tar level

Multistage model 1: 2 (20)
Males, 45-54

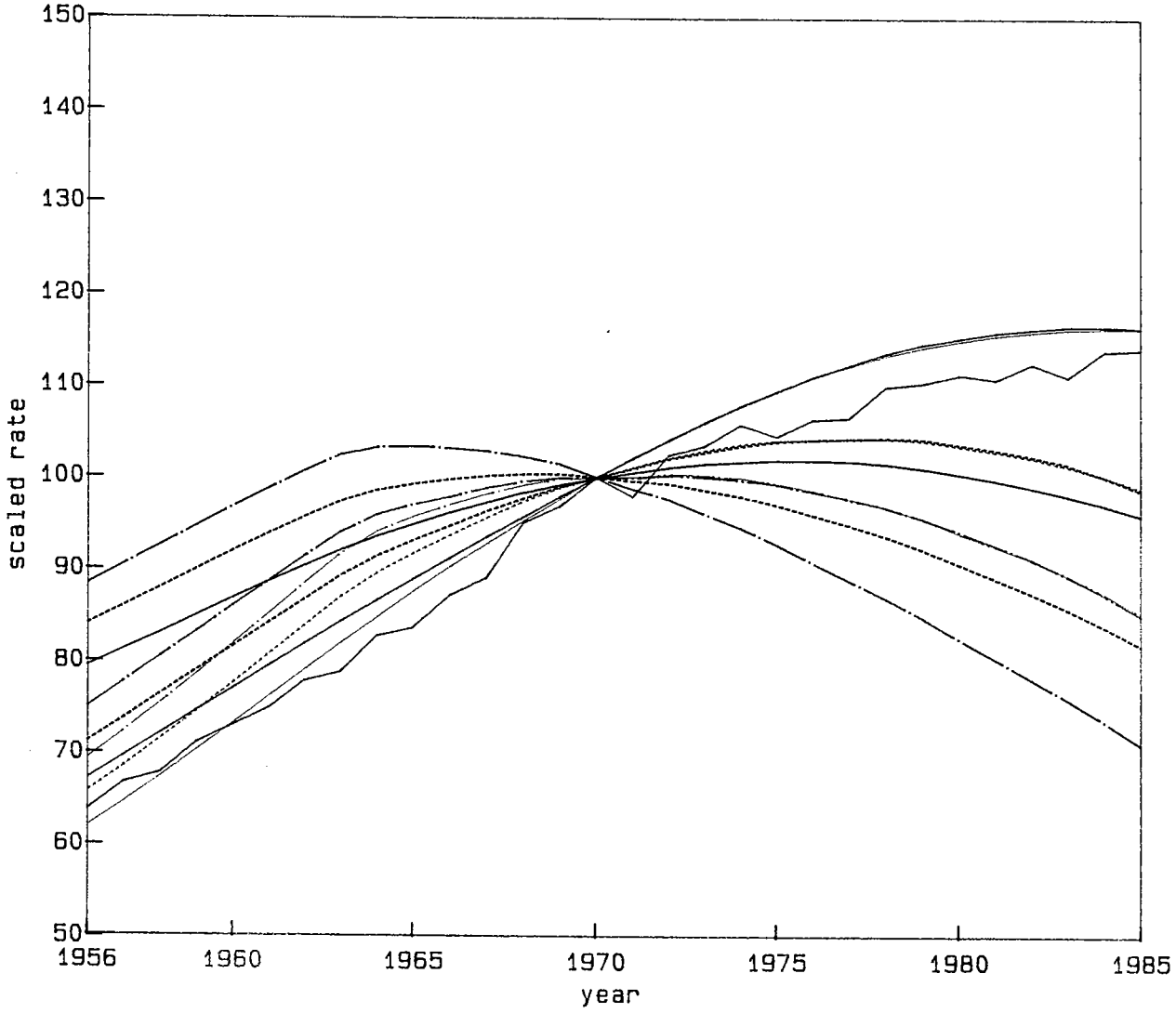


		Tar level: Constant (no correction)	Square root	Actual (full correction)
Cigs/smoker	Constant	———	.....	——·——·——
	Variable, method 1	———	.....	——·——·——
	Variable, method 2	———	.....	——·——·——
	Observed rate	———		

Figure 3Mb

Observed and predicted trends in lung cancer rate
Effects of various assumptions on cigs/smoker and tar level

Multistage model 1: 2 (20)
Males, 55-64

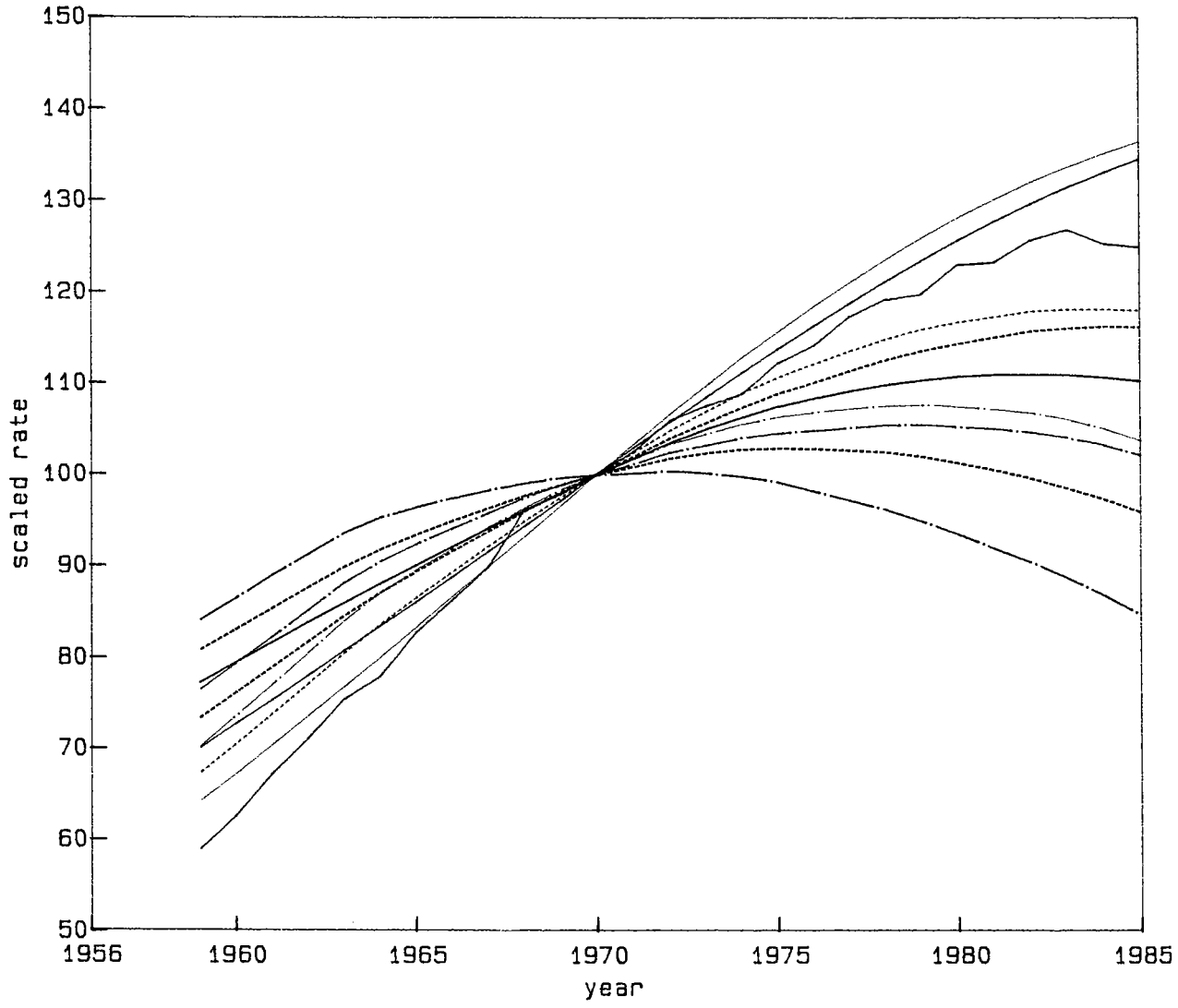


Cigs/smoker		Tar level: Constant (no correction)	Square root	Actual (full correction)
	Constant	———	-------	——·——·——
	Variable, method 1	———	-------	——·——·——
	Variable, method 2	———	-------	——·——·——
	Observed rate	———		

Figure 3Mc

Observed and predicted trends in lung cancer rate
Effects of various assumptions on cigs/smoker and tar level

Multistage model 1: 2(20)
Males, 65-74

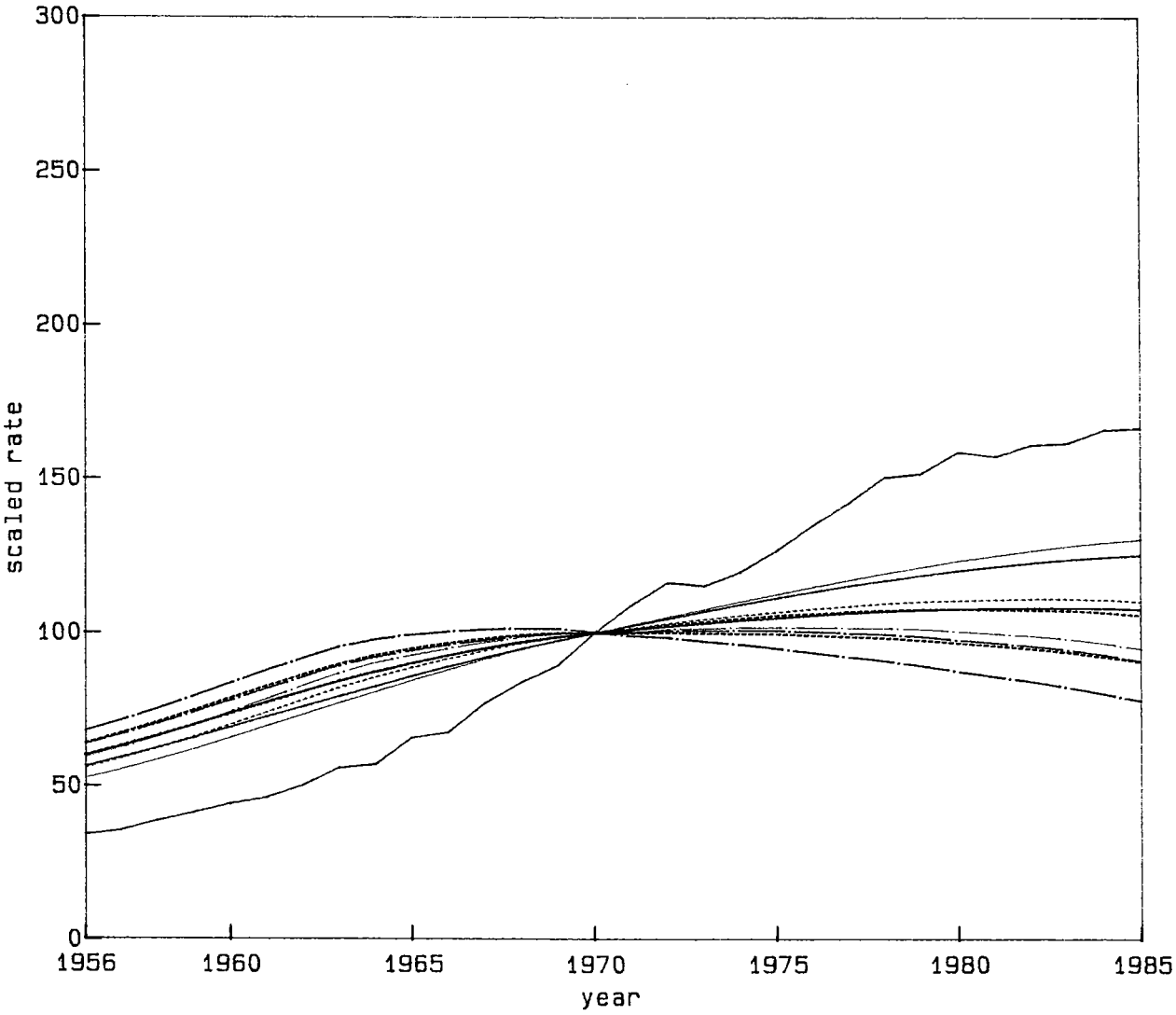


Cigs/smoker		Tar level: Constant (no correction)	Square root	Actual (full correction)
	Constant	———	.....	——·——·——
	Variable, method 1	———	.....	——·——·——
	Variable, method 2	———	.....	——·——·——
	Observed rate	———		

Figure 3Fa

Observed and predicted trends in lung cancer rate
Effects of various assumptions on cigs/smoker and tar level

Multistage model 1: 2 (20)
Females, 45-54

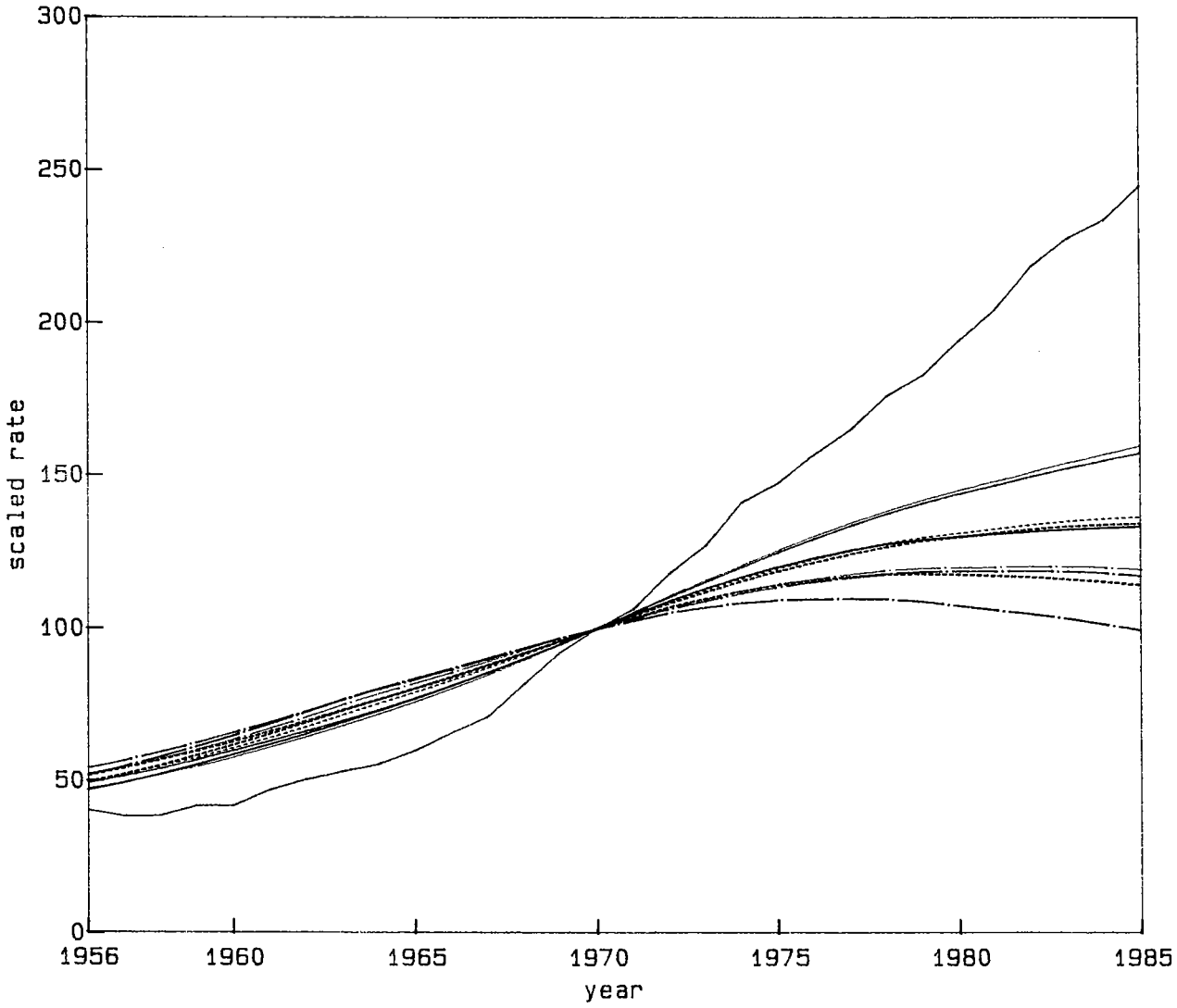


Cigs/smoker		Tar level: Constant (no correction)	Square root	Actual (full correction)
	Constant	———	.....	——·——·——
	Variable, method 1	———	.....	——·——·——
	Variable, method 2	———	.....	——·——·——
	Observed rate	———		

Figure 3Fb

Observed and predicted trends in lung cancer rate
Effects of various assumptions on cigs/smoker and tar level

Multistage model 1: 2 (20)
Females, 55-64

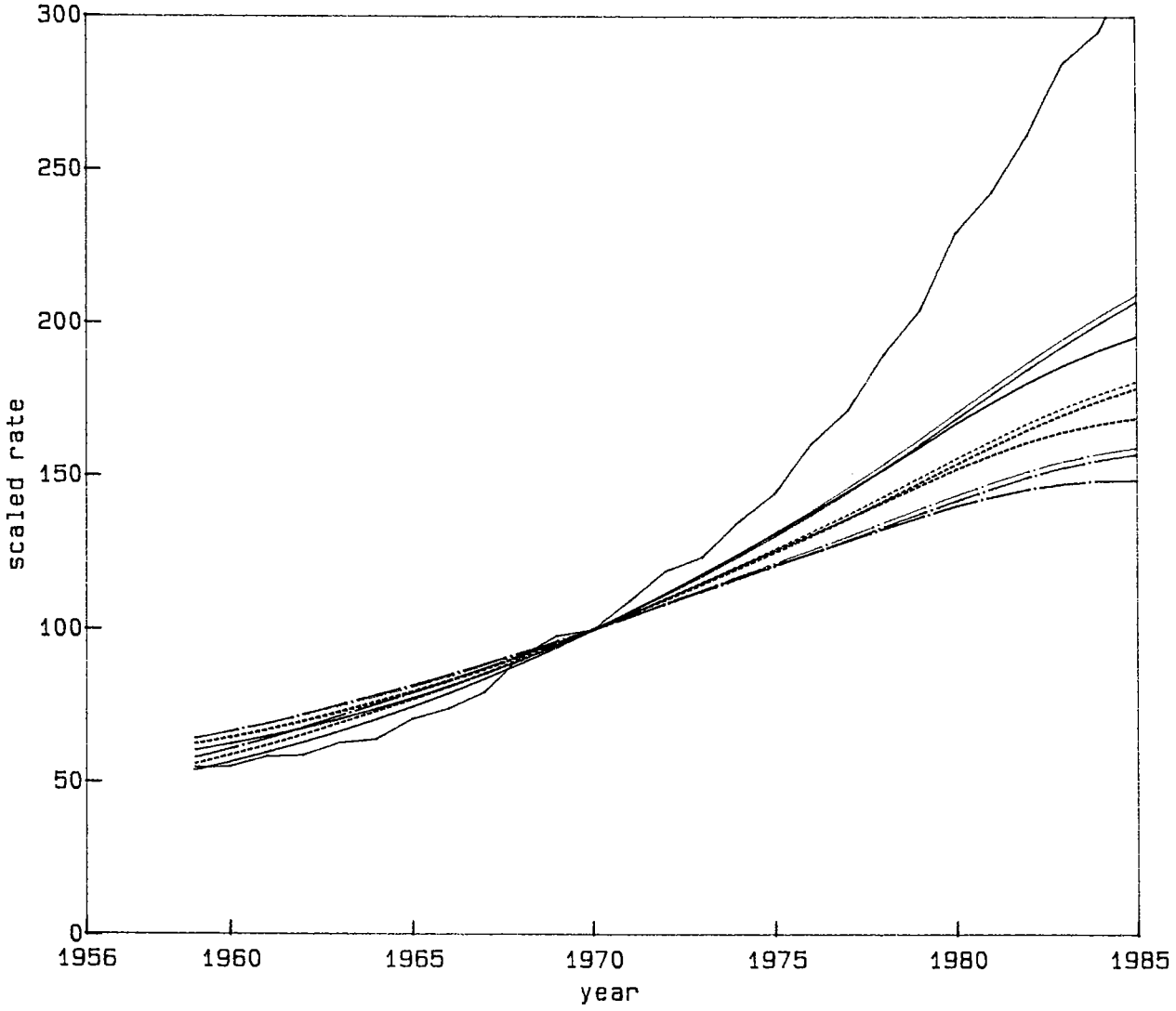


		Tar level: Constant (no correction)	Square root	Actual (full correction)
Cigs/smoker	Constant	———	-----	——·——·——
	Variable, method 1	———	-----	——·——·——
	Variable, method 2	———	-----	——·——·——
	Observed rate	———		

Figure 3Fc

Observed and predicted trends in lung cancer rate
Effects of various assumptions on cigs/smoker and tar level

Multistage model 1: 2(20)
Females, 65-74

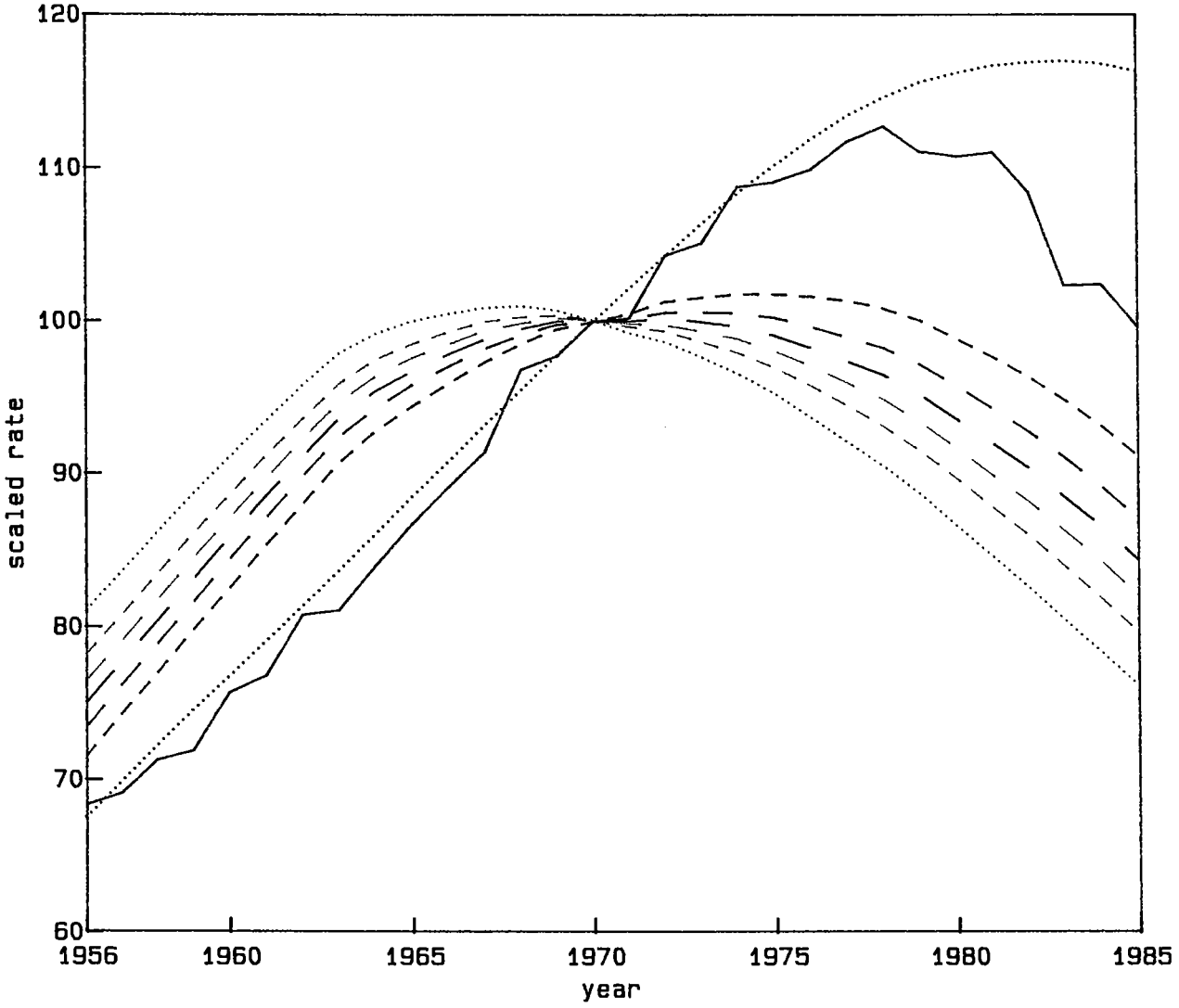


		Tar level: Constant (no correction)	Square root	Actual (full correction)
Cigs/smoker	Constant	———	·····	——·——·——
	Variable, method 1	———	·····	——·——·——
	Variable, method 2	——·——·——	·····	——·——·——
	Observed rate	———		

Figure 4Ma

Observed and predicted trends in lung cancer rate
Effects of various assumptions on ratio between stages

Multistage model, cigs/smoker Method 2, square root tar level
Males, 45-54



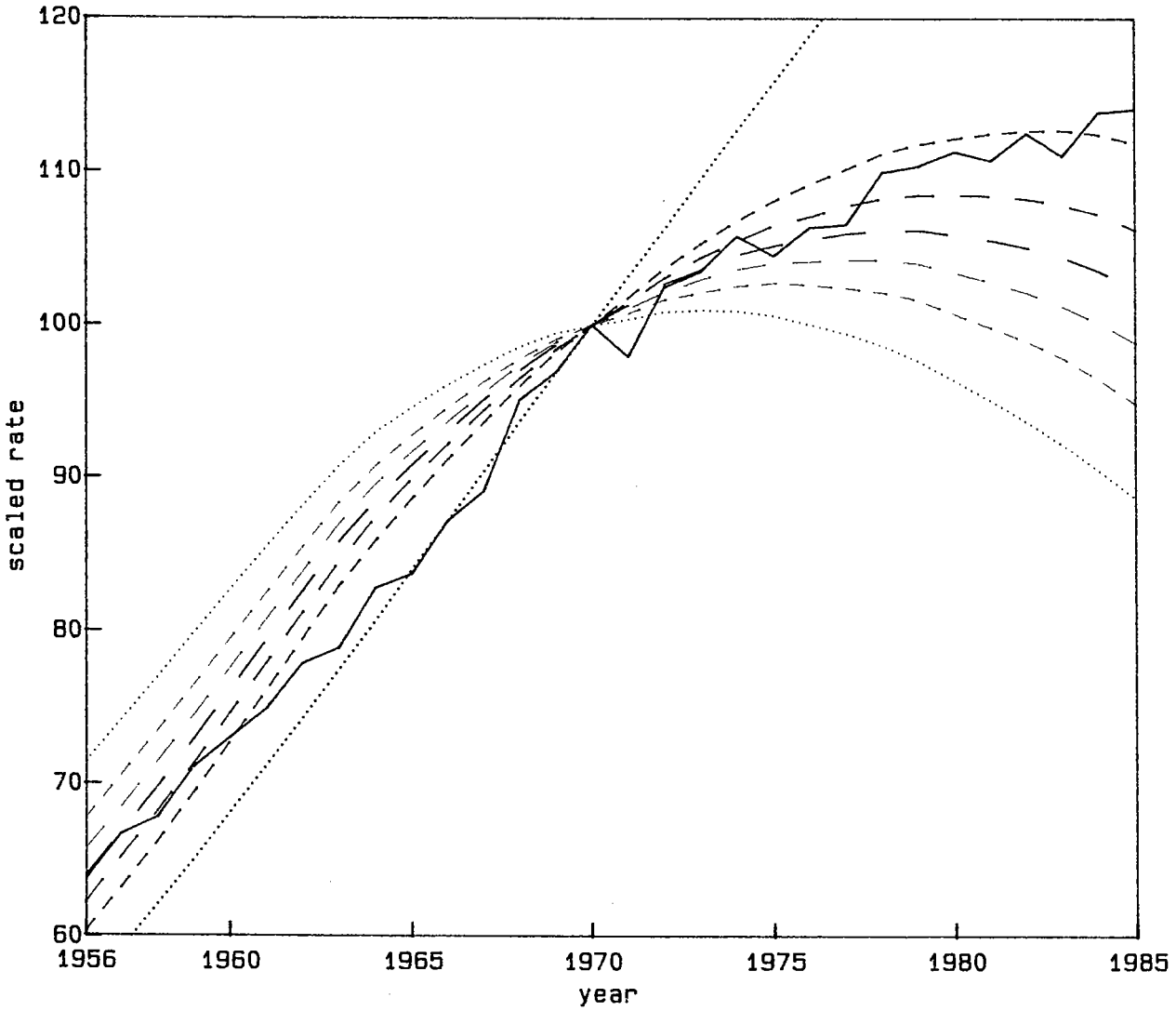
Model
1: 0 (20)
5: 1 (20)
2: 1 (20)
1: 1 (20)
1: 2 (20)
1: 5 (20)
0: 1 (20)

Observed rate

Figure 4Mb

Observed and predicted trends in lung cancer rate
Effects of various assumptions on ratio between stages

Multistage model, cigs/smoker Method 2, square root tar level
Males, 55-64



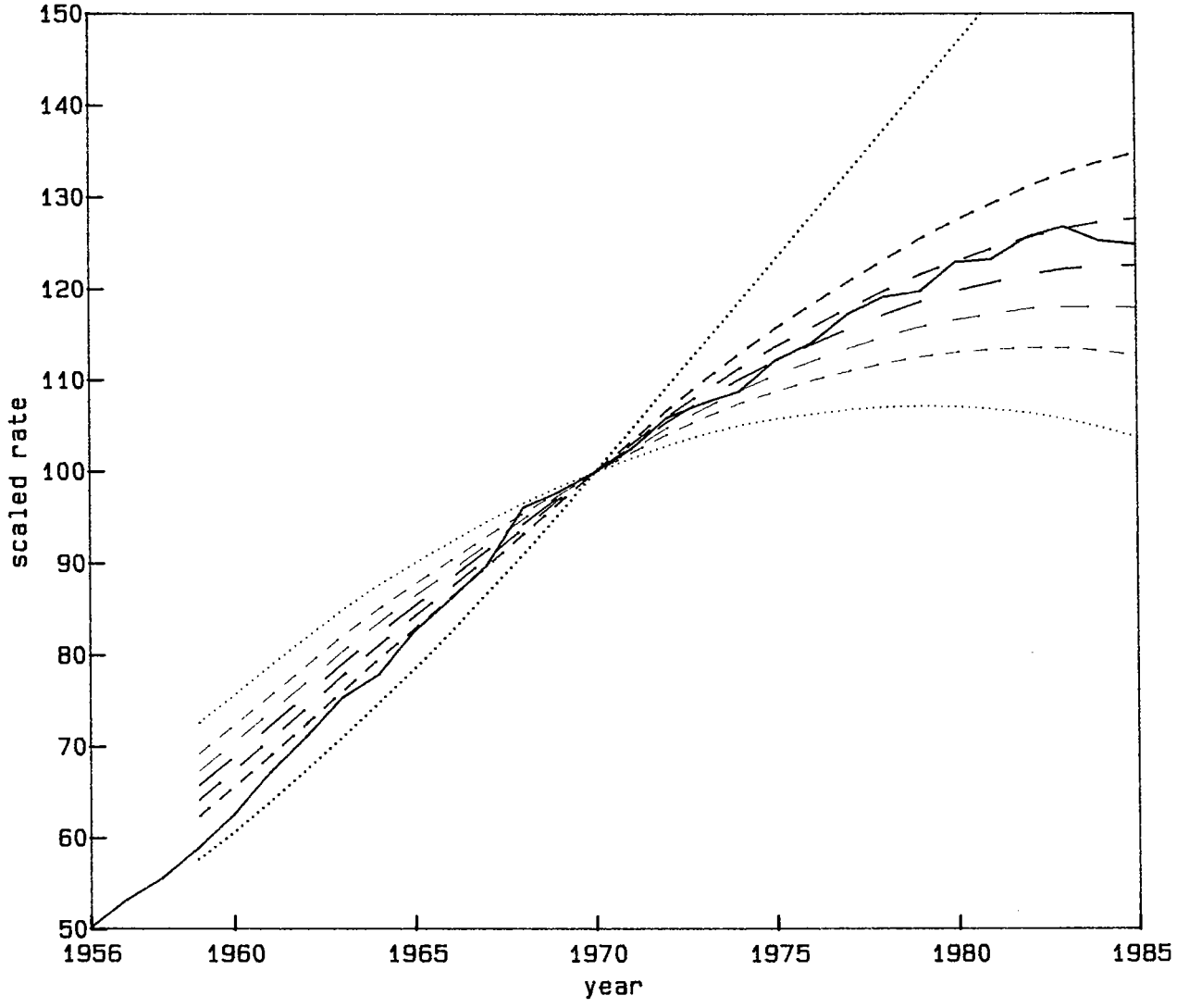
Model
1: 0 (20)
5: 1 (20)
2: 1 (20)
1: 1 (20)
1: 2 (20)
1: 5 (20)
0: 1 (20)

Observed rate

Figure 4Mc

Observed and predicted trends in lung cancer rate
Effects of various assumptions on ratio between stages

Multistage model, cigs/smoker Method 2, square root tar level
Males, 65-74



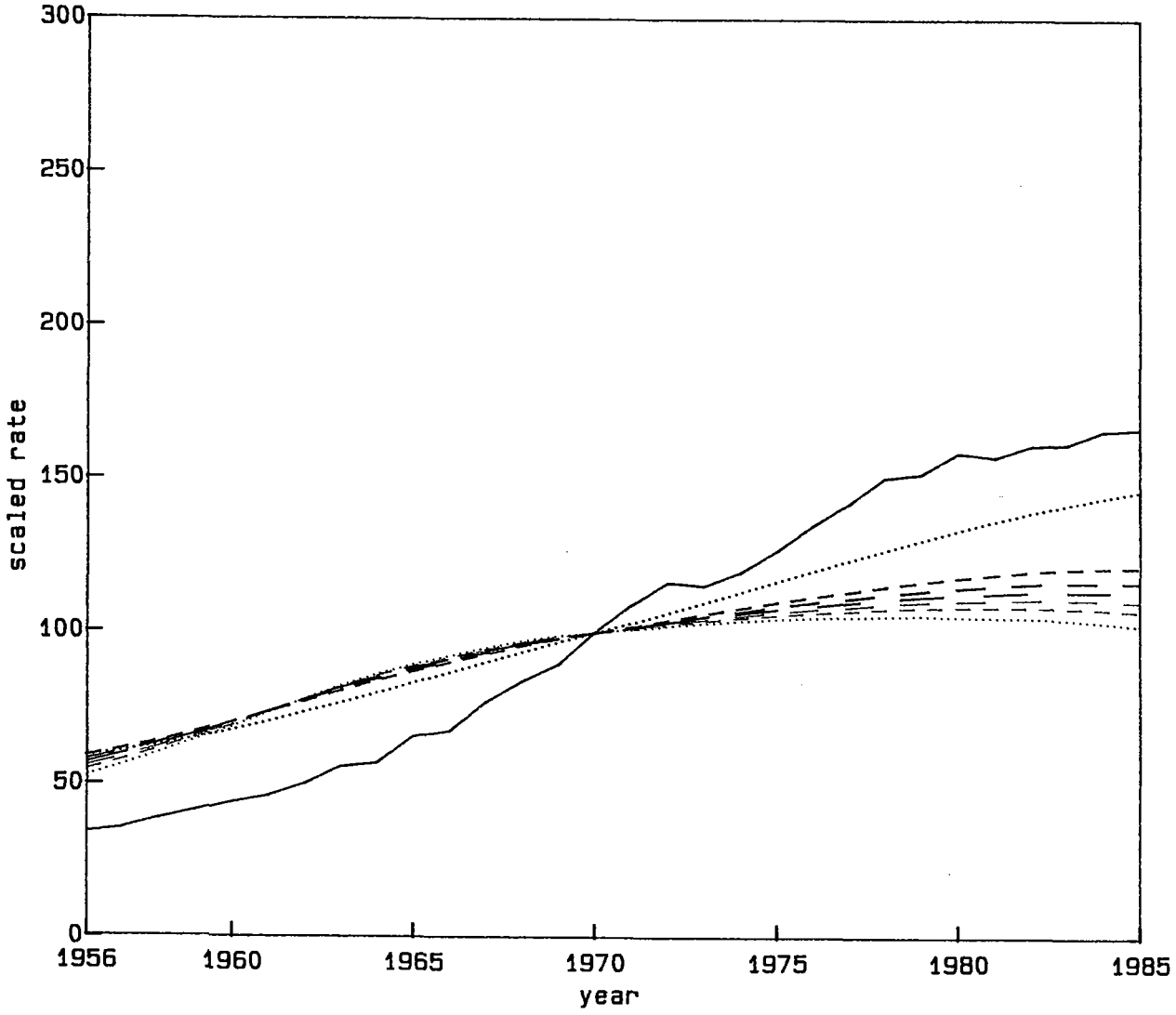
Model
1: 0 (20)
5: 1 (20)
2: 1 (20)
1: 1 (20)
1: 2 (20)
1: 5 (20)
0: 1 (20)

Observed rate

Figure 4Fa

Observed and predicted trends in lung cancer rate
Effects of various assumptions on ratio between stages

Multistage model, cigs/smoker Method 2, square root tar level
Females, 45-54



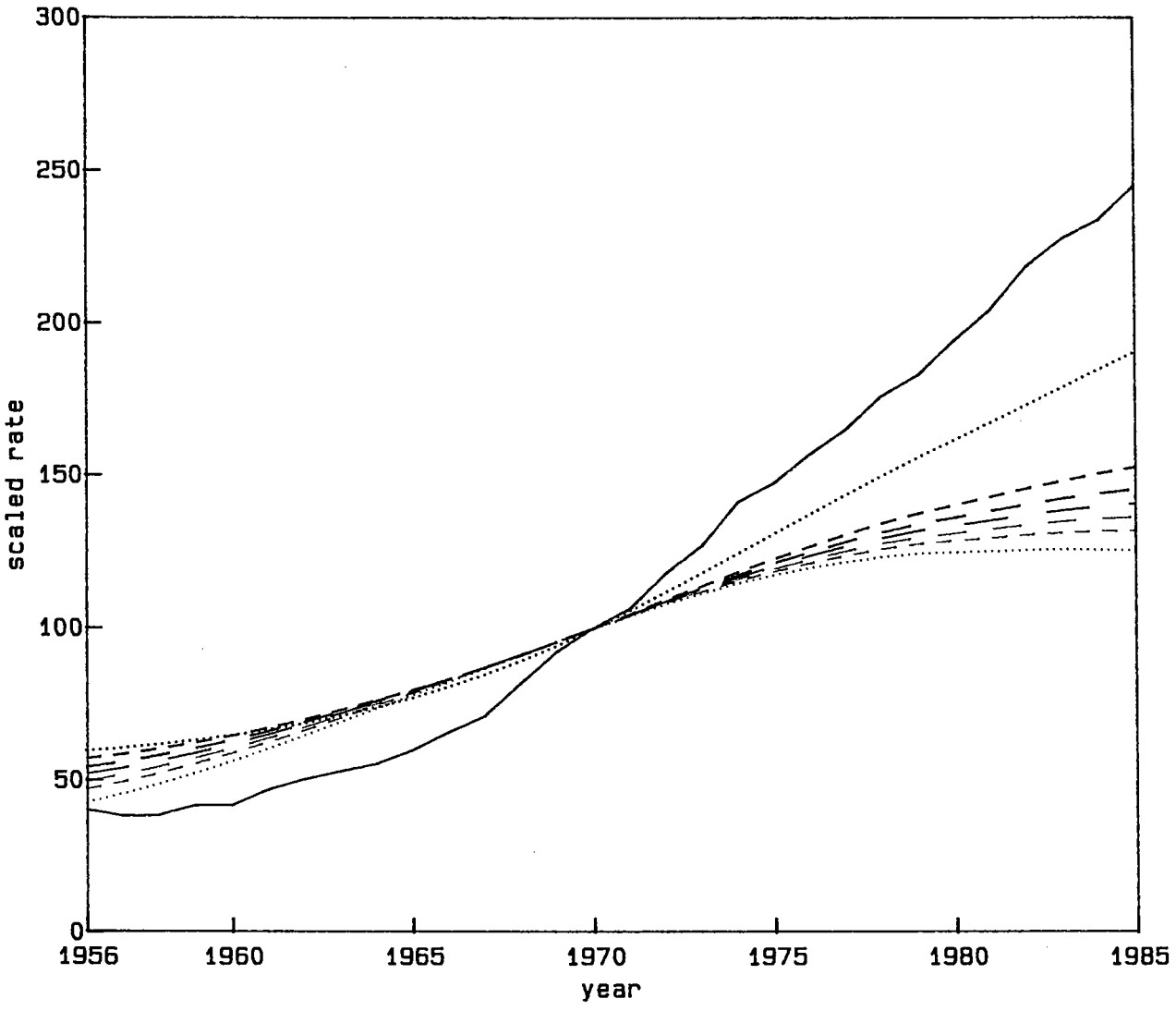
Model
1: 0 (20)
5: 1 (20)
2: 1 (20)
1: 1 (20)
1: 2 (20)
1: 5 (20)
0: 1 (20)

Observed rate

Figure 4Fb

Observed and predicted trends in lung cancer rate
Effects of various assumptions on ratio between stages

Multistage model, cigs/smoker Method 2, square root tar level
Females, 55-64



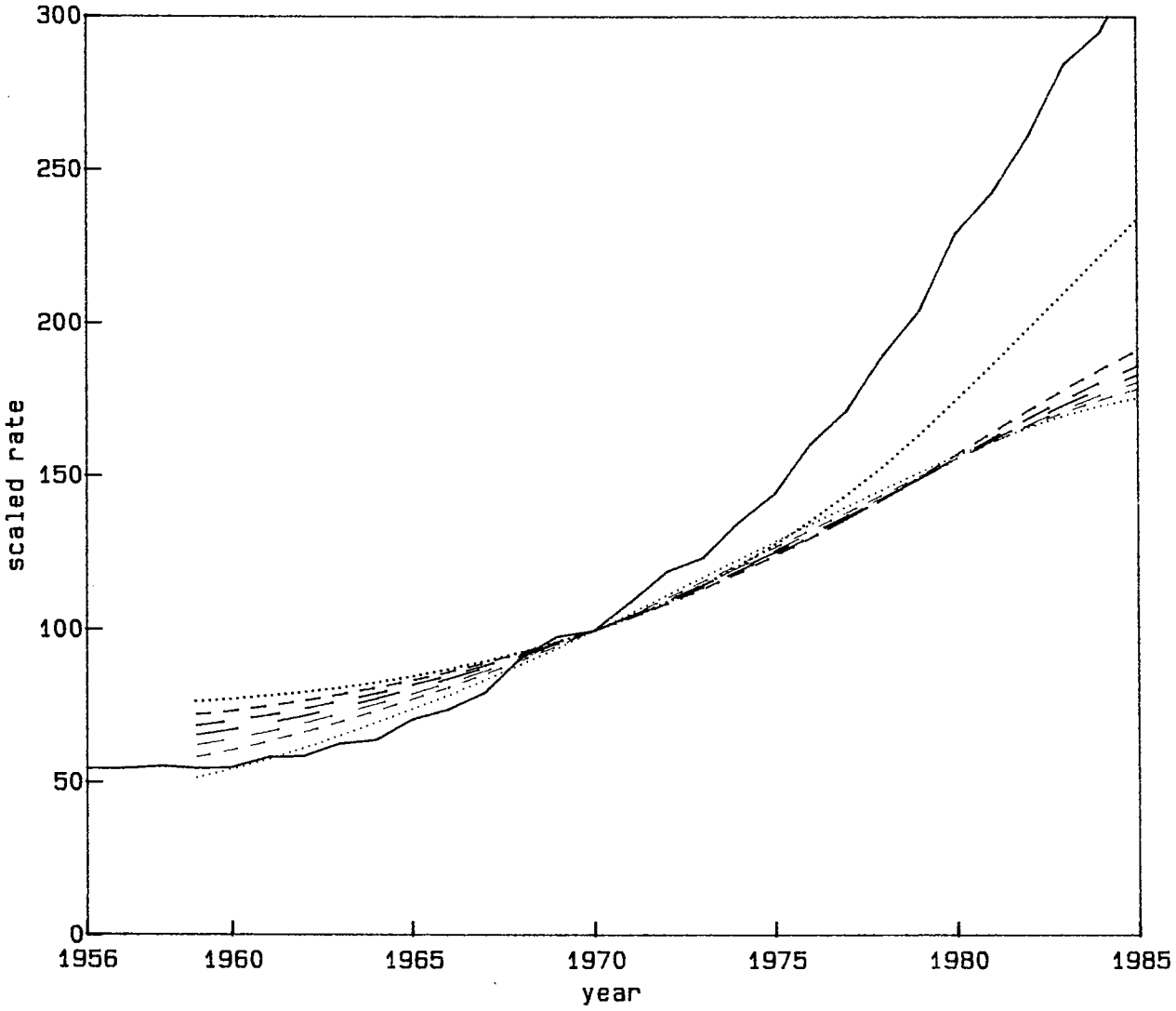
Model
1: 0 (20)
5: 1 (20)
2: 1 (20)
1: 1 (20)
1: 2 (20)
1: 5 (20)
0: 1 (20)

Observed rate

Figure 4Fc

Observed and predicted trends in lung cancer rate
Effects of various assumptions on ratio between stages

Multistage model, cigs/smoker Method 2, square root tar level
Females, 65-74



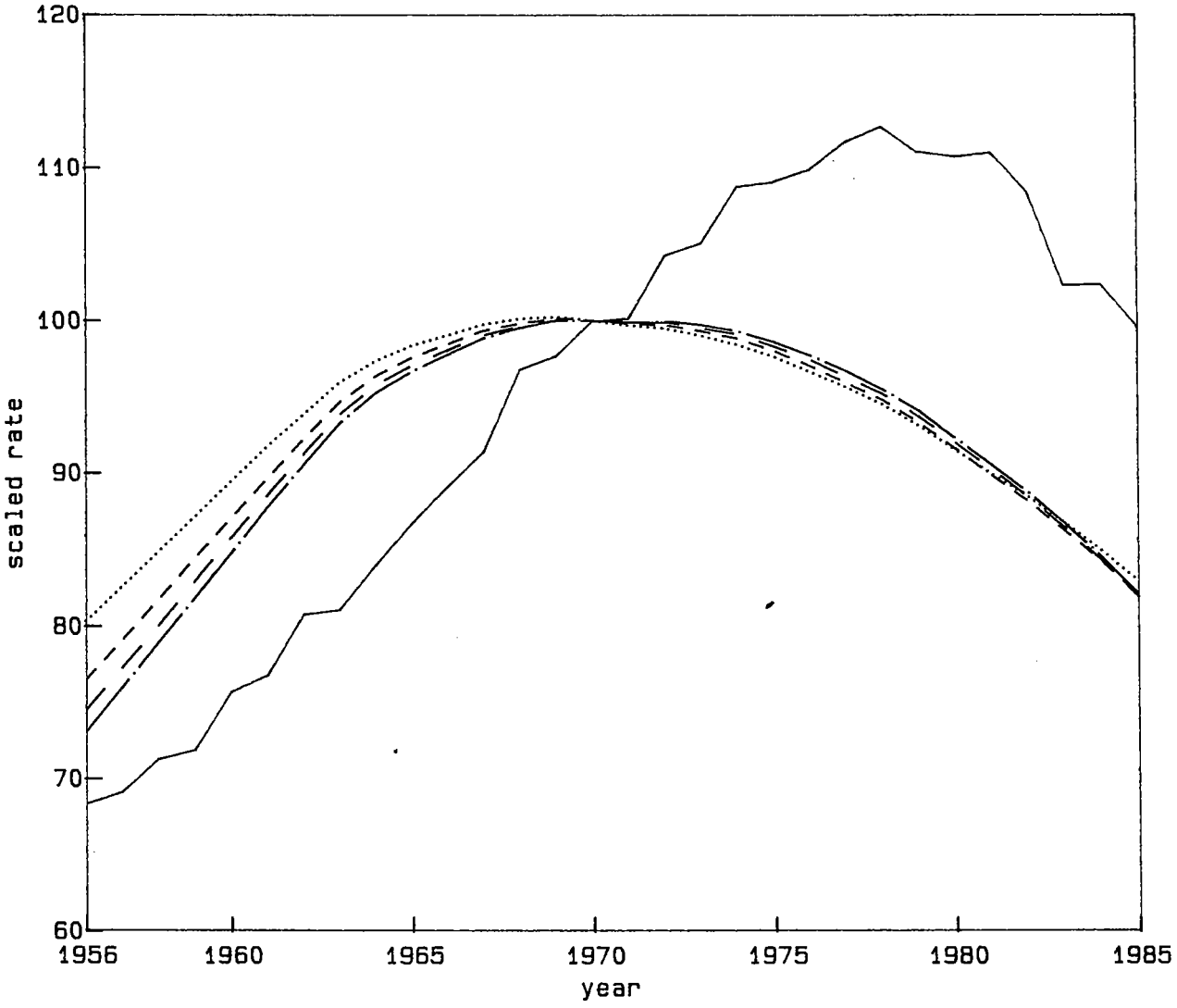
Model
1: 0 (20)
5: 1 (20)
2: 1 (20)
1: 1 (20)
1: 2 (20)
1: 5 (20)
0: 1 (20)

Observed rate

Figure 5Ma

Observed and predicted trends in lung cancer rate
Effects of various assumptions on relative risk of smoking

Multistage model, cigs/smoker Method 2, square root tar level
Males, 45-54



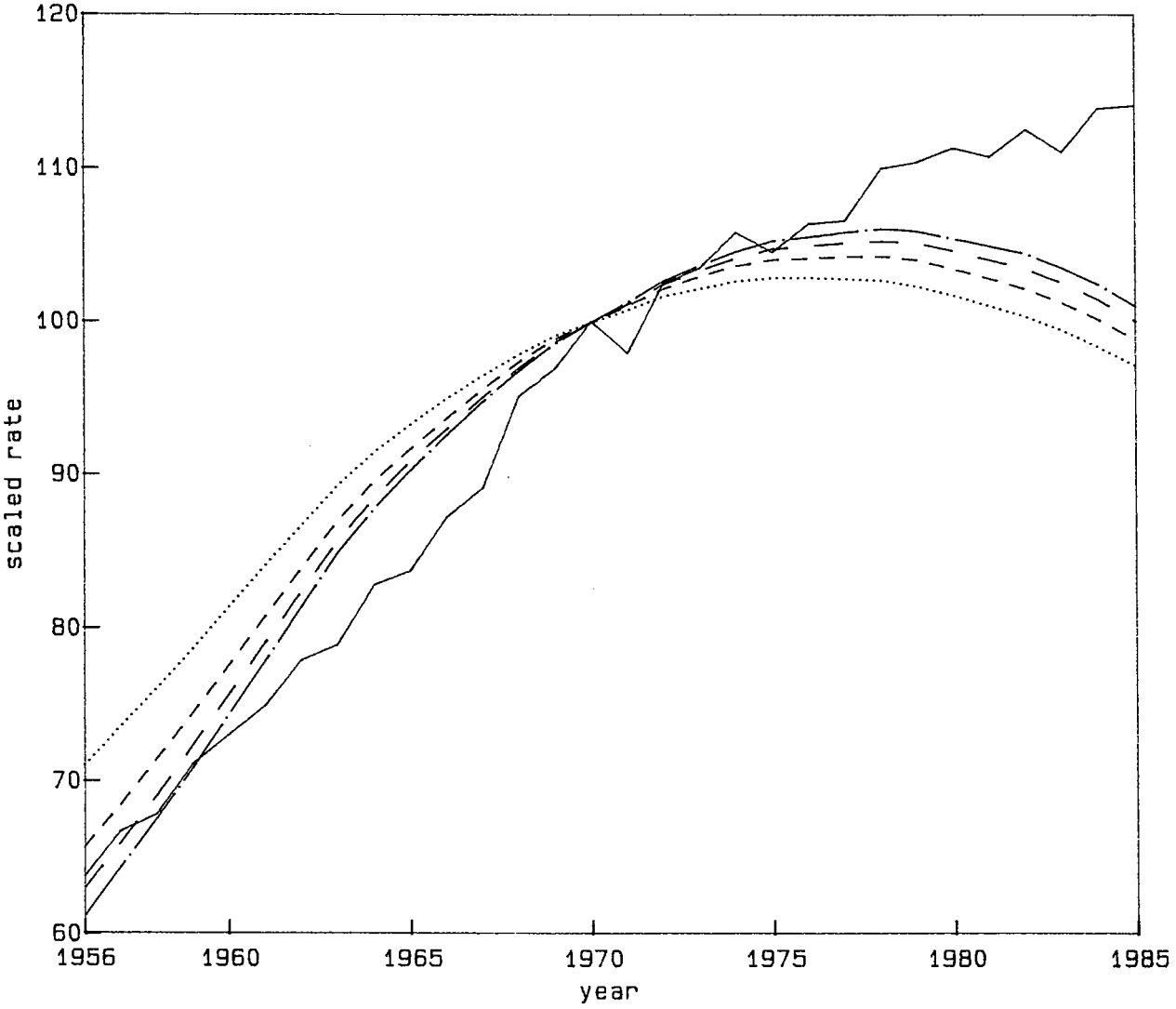
Model
1: 2 (10)
1: 2 (20)
1: 2 (30)
1: 2 (40)

Observed rate

Figure 5Mb

Observed and predicted trends in lung cancer rate
Effects of various assumptions on relative risk of smoking

Multistage model, cigs/smoker Method 2, square root tar level
Males, 55-64



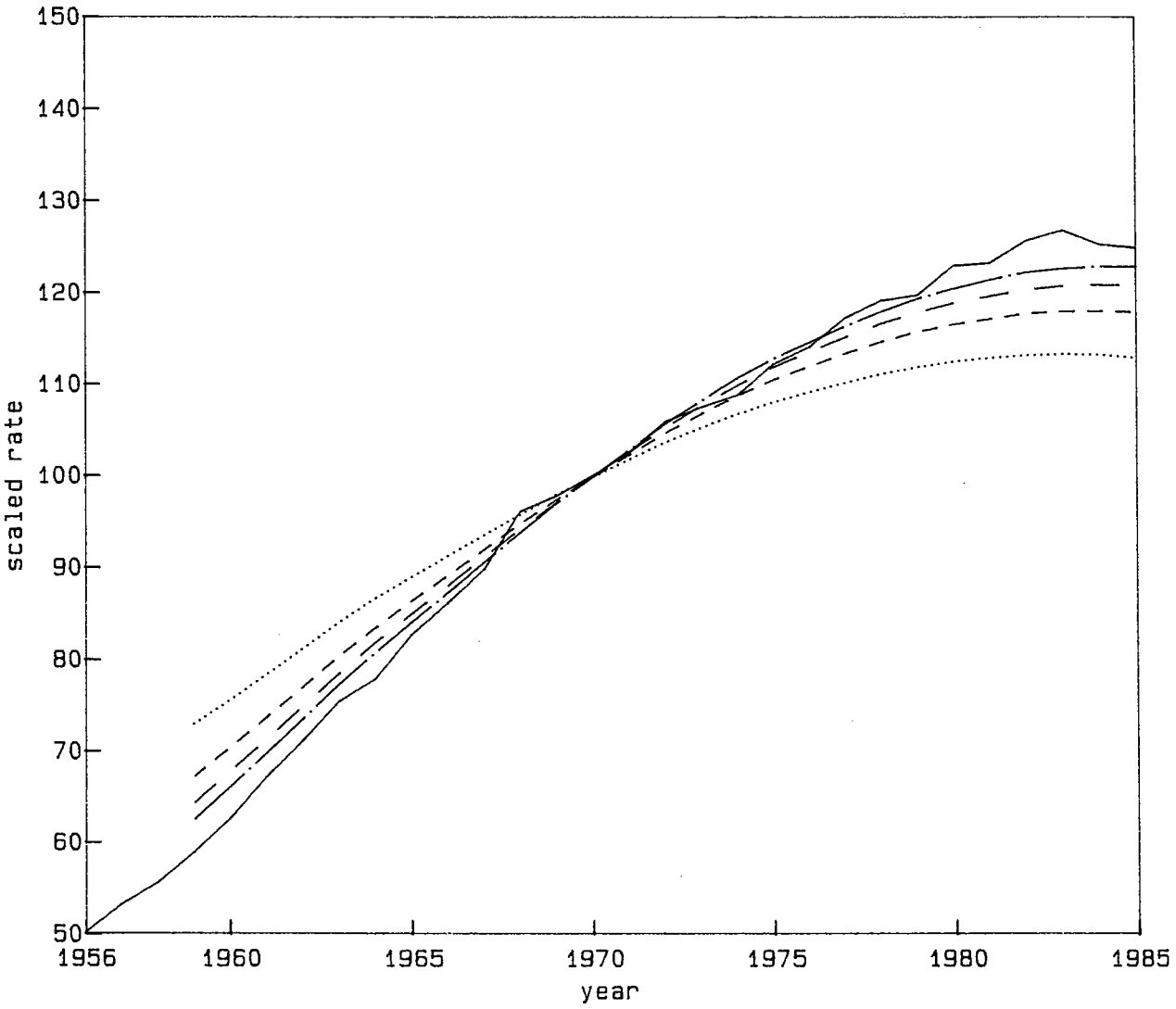
Model
1: 2 (10)
1: 2 (20)
1: 2 (30)
1: 2 (40)

Observed rate

Figure 5Mc

Observed and predicted trends in lung cancer rate
Effects of various assumptions on relative risk of smoking

Multistage model, cigs/smoker Method 2, square root tar level
Males, 65-74



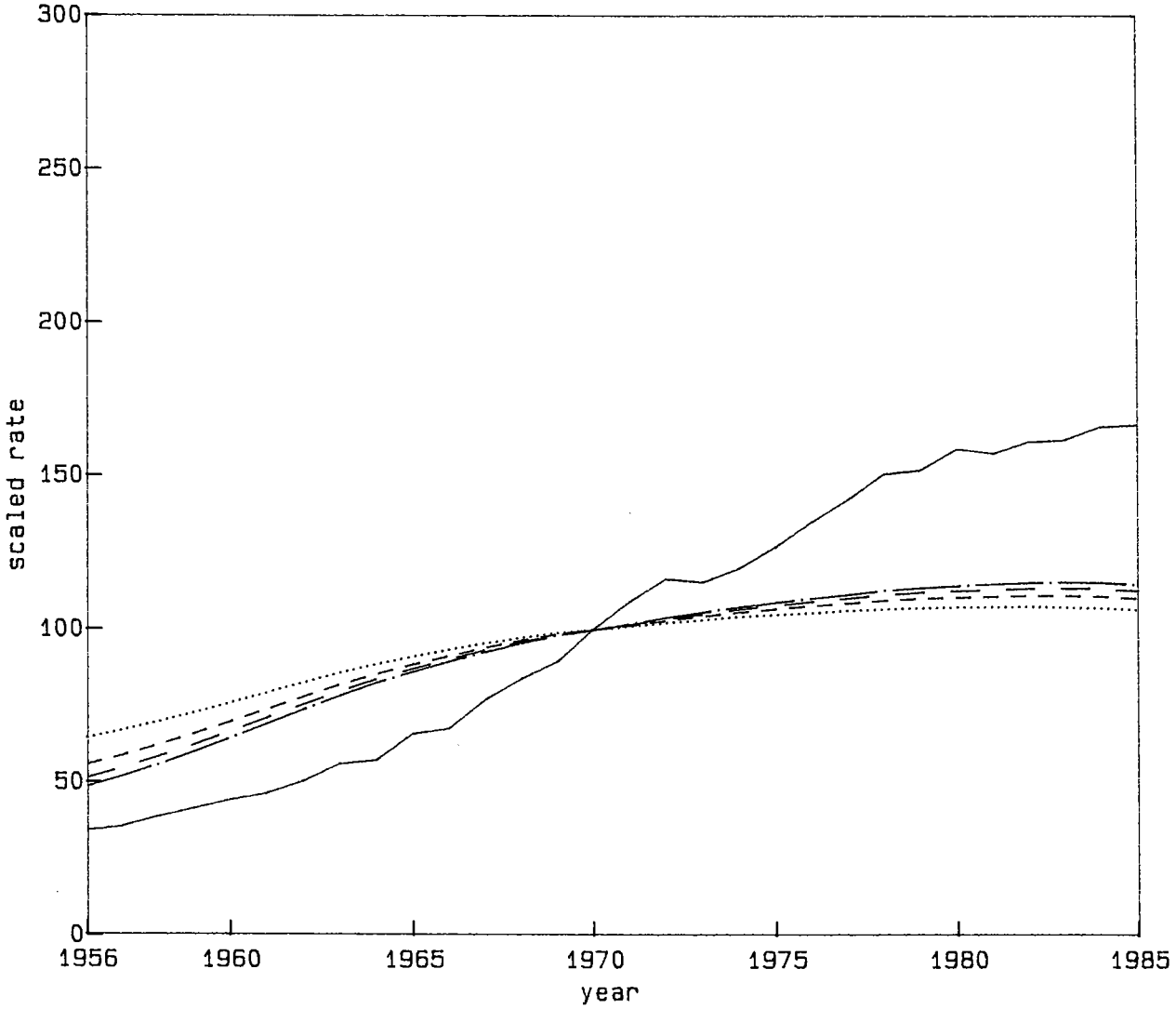
Model
1: 2 (10)
1: 2 (20)
1: 2 (30)
1: 2 (40)

Observed rate

Figure 5Fa

Observed and predicted trends in lung cancer rate
Effects of various assumptions on relative risk of smoking

Multistage model, cigs/smoker Method 2, square root tar level
Females, 45-54



Model
1: 2 (10)
1: 2 (20)
1: 2 (30)
1: 2 (40)

Observed rate

Figure 5Fb

Observed and predicted trends in lung cancer rate
Effects of various assumptions on relative risk of smoking

Multistage model, cigs/smoker Method 2, square root tar level
Females, 55-64

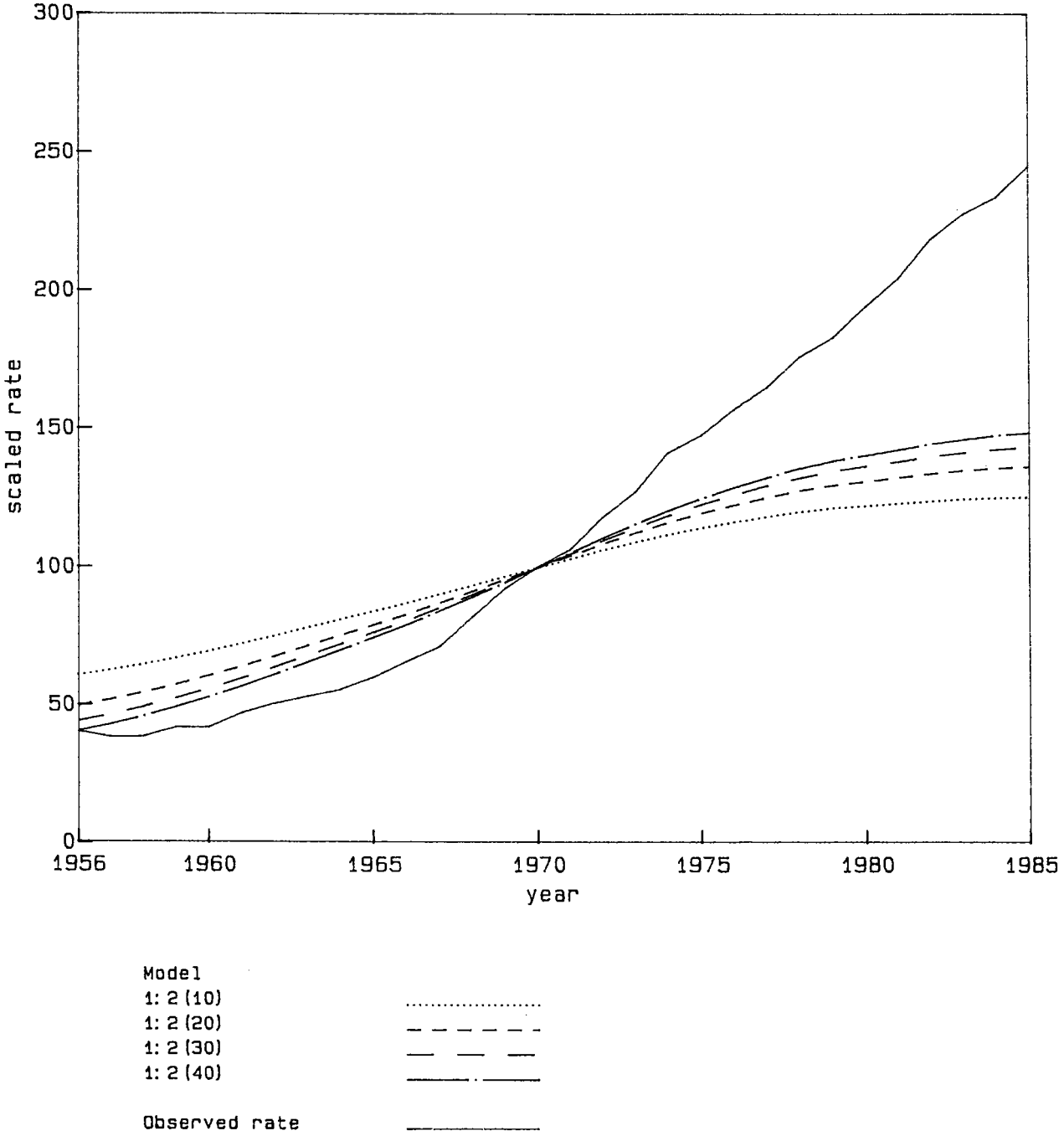
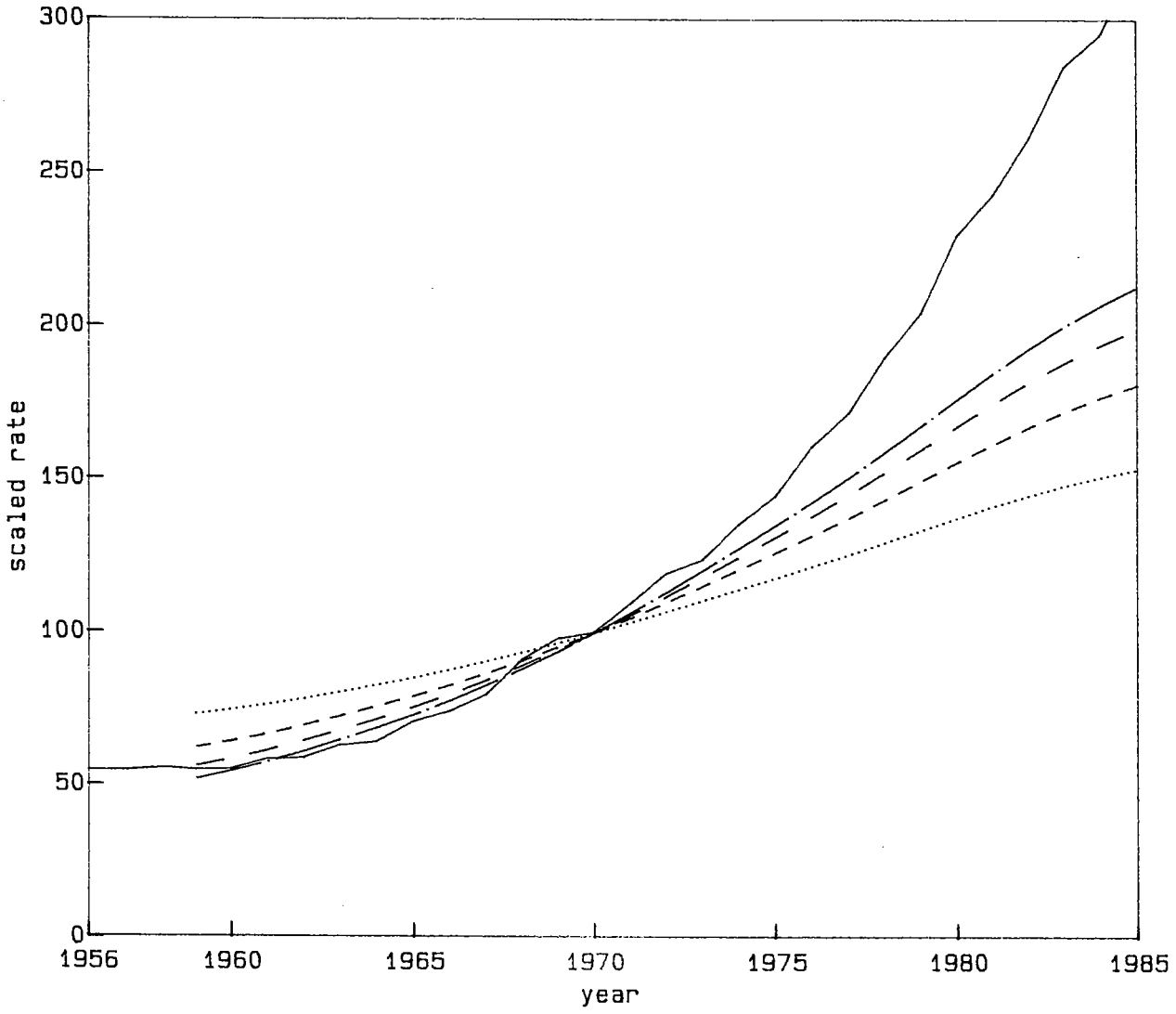


Figure 5Fc

Observed and predicted trends in lung cancer rate
Effects of various assumptions on relative risk of smoking

Multistage model, cigs/smoker Method 2, square root tar level
Females, 65-74



Model
1: 2 (10)
1: 2 (20)
1: 2 (30)
1: 2 (40)

Observed rate