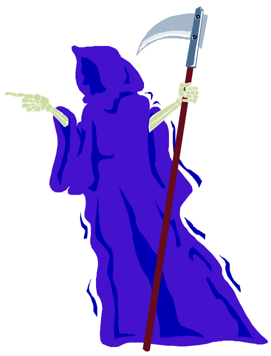
The mortality module for SVERIGE: Documentation v 1.0



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1.0 Microsimulation model history and structure

SVERIGE is a dynamic economic-demographic-environmental spatial microsimulation model for Sweden. By microsimulation is meant that the model represents lifetime events and choices of individual units (or objects) as a combination of structural factors (usually included in discrete choice models as independent variables or used to organise transition matrices) and random disturbance (a Monte Carlo randomisation component). By dynamic is meant that microunit ageing and development occurs in a life cycle pattern, with initial microunit conditions being changed for subsequent periods by counters and sequenced model equations. Its core is based upon CORSIM (Cornell Microsimulation Model), which itself is a modification of Guy Orcutt's DYNASIM (Dynamic Microsimulation Model), the first dynamic microsimulation model of its kind (Caldwell and Keister 1996). CORSIM has since sired other children as well, including a Canadian model named DYNACAD (Dynamic Microsimulation Model for Canada) (Morrison 1997).

SVERIGE will differ in several important respects from its CORSIM parent and DYNACAD sibling (see figure 1). First, SVERIGE is a Swedish model and thus must explain behaviour in a different institutional context than either the CORSIM and DYNACAD North American models. The model core of CORSIM consists of nine modules (mortality, fertility, marriage, divorce, re-marriage, leaving home, education, employment and earnings, and immigration) that describe the human life cycle. Each module consists of equations that describe the behavioural responses of individuals as a function of their socio-economic characteristics. Although these module equations appear to be informed by economic theory, such as Becker's theories of marriage, divorce, education, fertility, and labour force participation, they are quite sensitive to cultural and institutional peculiarities. Thus, one cannot simply transport the specifications and parameters used by CORSIM to Sweden. For instance, power relations between men and women, the degree of class distributional equity, the elaborateness of social support mechanisms, and the varieties of social groupings (e.g., married couples, cohabitants, families, households) define the social context in which individual decisions are made and constrain the ways in which microactors interact. Therefore, while the life-cycle model that constitutes the CORSIM core will remain the same, the equations that explain transitions between various stages of the life-cycle may vary considerably between the North American and Swedish contexts.

Second, SVERIGE is a spatial model while CORSIM is not. In fact, SVERIGE will be the first national-level spatial microsimulation model. Geographical environment and distance play no role in aspatial models. However, SVERIGE will model individual spatial transitions (such as internal migration) and model life-cycle transitions described by the model core within a spatial context. In addition, certain geographical objects (including land parcels, neighbourhoods, and labour markets) will have attributes that influence the attributes of objects such as individuals, households, employers, and homes (see figure 2. for a full listing of objects and their attributes) and vice versa. For instance, property values, pollution levels, and housing characteristics will change and, in turn, modify choices made by other microactors (or objects) within the microsimulation model. Furthermore, because objects have geographical attributes, the model will be capable of generating geographically detailed reports that may interest regional scientists and policymakers.

Third, SVERIGE is an environmental model. An important premise of the model is that non-production, non-point, household consumption activities generate many unsafe emissions such as heavy metals, carbon monoxide, and sewage. This orientation arose for both empirical and practical reasons. The empirical justification is that if current trends are continued into the future, consumer generated pollution will make up a substantial proportion of overall pollution levels. This is expected to occur because point pollution is technologically and financially easier to reduce than non-point emissions (Tietenberg 1988). There are also practical reasons for not extending the model to production point emissions sources, because to develop modules that explain large firm behaviour would introduce unmanageable complexity and require proprietary firm-level data that are unavailable to the project.

Figure 1. The Sverige Model

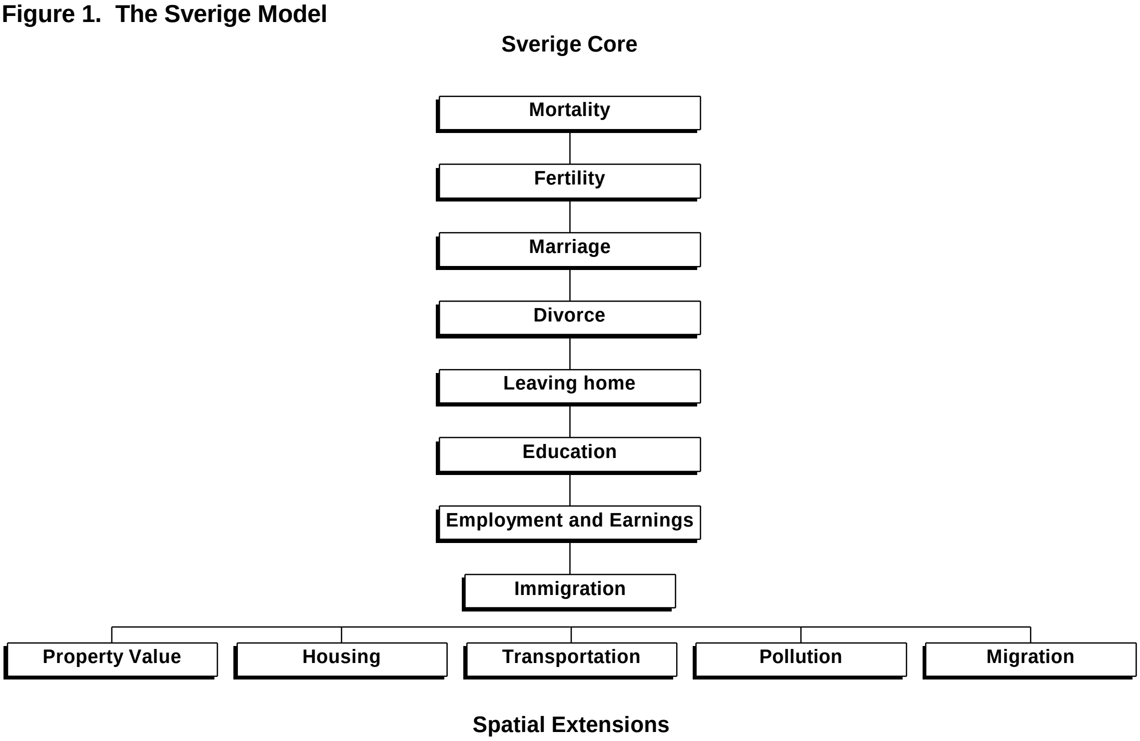
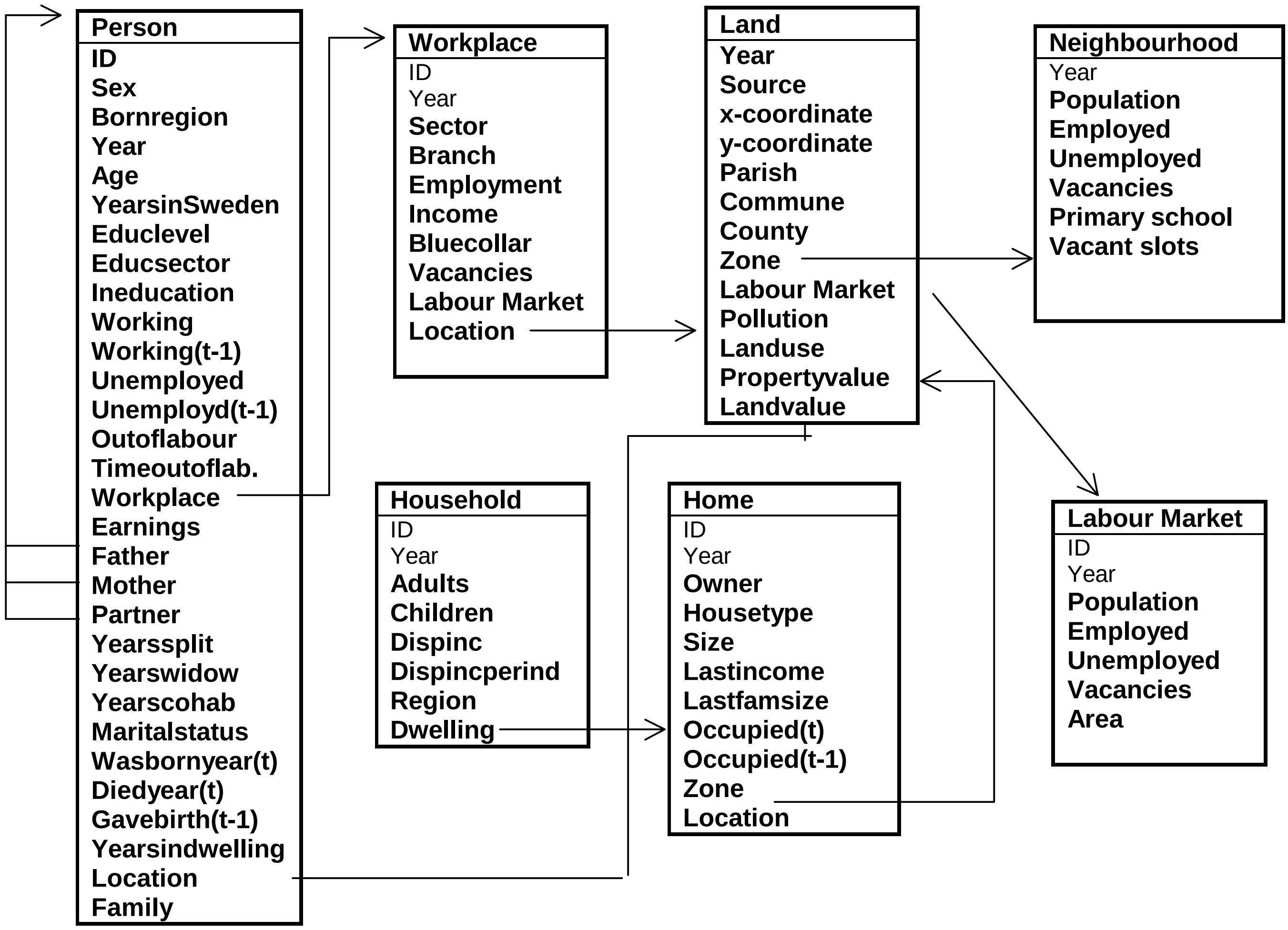


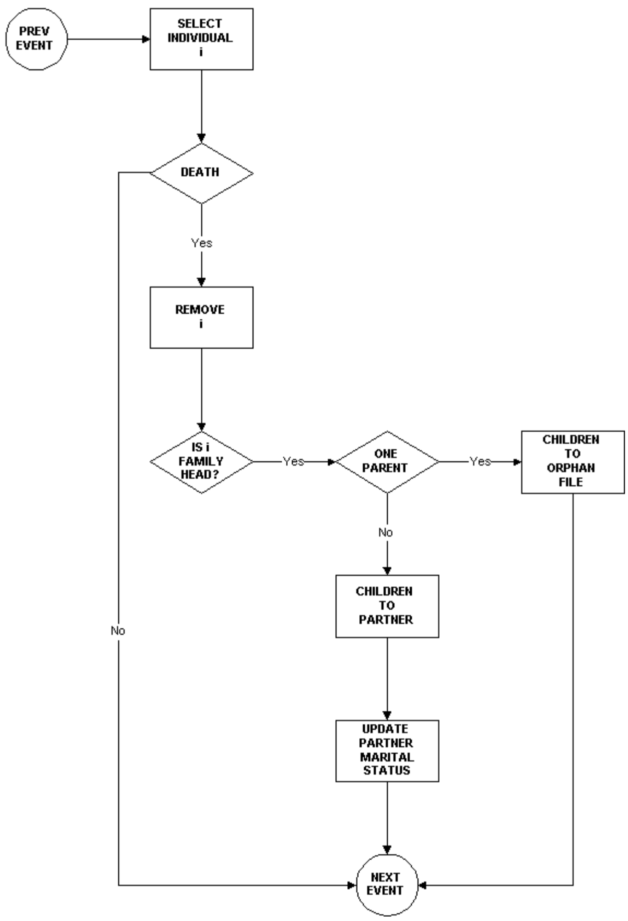
Figure 2. Relations between objects and attributes



2.0 Rationale and role for a mortality module

The primary role of the mortality module is to terminate lives in the microsimulation model (see figure 3 below). Since the model is dynamic, each individual is aged and characteristics such as education level, employment status, and marital status are modified during the life cycle. These attributes, discussed below, directly influence an individual's probability of dying in any year. In addition to removing individuals from the simulation, deaths will directly trigger changes in households and families. For instance, when a death occurs, a surviving spouse will become a widow or widower (i.e., WIDOW changes from zero to one). In addition, if a single head of household dies, his or her dependents are assigned to other families in an adoption routine which will be documented elsewhere. The module is aligned with mortality rate information from the period 1985-95 grouped by age and marital status. This information was obtained from annual issues of the *Statistical Yearbook of Sweden* between the years of 1987 and 1997.

Figure 3. Mortality module structure



3.0 The CORSIM equations.

The CORSIM mortality equations for individuals under 25 years of age are exponential time trend equations based on historical mortality rates grouped by age and sex.

(1) $P_{it} = (a_{i1} + a_{i2}e^{a_{i3}t})$

The CORSIM mortality equations for individuals between the ages of 25 and 100 are discrete choice equations. The occurrence of death (INDDEA) is estimated for groups defined by gender, age group, and race. They are estimated via logistic regression.

(2) $$\Pr ob(INDDEA=1)=\frac{e^{\beta'x}}{1+e^{\beta'x}}$$

$b'\mathbf{x}=\beta_0+\beta_1\mathbf{AGE}+\beta_2\mathbf{AGE2}+\beta_3\mathbf{ELEMENT}+\beta_4\mathbf{SOMEHS}+\beta_5\mathbf{SOMHS}+\beta_6\mathbf{COMPHS}+\beta_7\mathbf{SOMECOLL}$
$+\beta_8\mathbf{COMPCOLL}+\beta_9\mathbf{INC1}+\beta_{10}\mathbf{INC2}+\beta_{11}\mathbf{INC3}+\beta_{12}\mathbf{INC4}+\beta_{13}\mathbf{INC5}+\beta_{14}\mathbf{EMPLOYED}$
$+\beta_{15}\mathbf{IMM}+\beta_{16}\mathbf{DIVSEP}+\beta_{17}\mathbf{WIDOW}$

where:

β_0	constant
AGE	age, years
AGE2	square of age
ELEMENT	fewer than 9 years of school
SOMEHS	completed some high school (years of education 9- 12)
COMPHS	graduated from high school (years of education = 12)
SOMECOLL	completed some college (years of education 13 - 15)
COMPCOLL	graduated from college (years of education = 16)
INC1	family income < 5000 (in 1979 $)
INC2	family income between 5000 and 9999 (in 1979 $)
INC3	family income between 10000 and 14999 (in 1979 $)
INC4	family income between 15000 and 19999 (in 1979 $)
INC5	family income between 20000 and 24999 (in 1979 $)
EMPLOYED	weeks worked > 0
IMM	born in US*
DIVSEP	divorced or separated
WIDOW	widowed

*Not used in final estimations.

The probabilities of death for individuals who survive to 100 are hard coded probabilities based on a life table. All survivors are automatically terminated by age 115.

4.0 Reasons for re-estimating CORSIM equations using Swedish data.

Unlike DYNACAN, which draws heavily upon CORSIM and adopts many of its internal equations and parameters, new mortality equations are estimated here. However, in order to initially compare the results of Swedish runs with CORSIM results, a similar specification and research design was adopted. The CORSIM equations were estimated using American data that is now more than fifteen years old. One would expect that the relationships would change over time and that there are some differences between Sweden and the U.S. in mortality risk. For instance Himes (1994) writes that “The United States has a cause-of-death structure similar to that of Sweden, but the age pattern of mortality is very different. High mortality in the middle age range in the United States results in approximately a one-year loss of life expectancy at age 45 in comparison with Sweden.” This situation is confirmed by a mortality table appearing in Appendix C based on a Swedish sample of 458K individuals. Wallace et al. (1985) notes that Sweden has much lower infant mortality rates than the U.S. Finally, Minder (1991) writes that “Sweden has the lowest socio-economic mortality differences” for an industrialised country because of the strong Swedish social support system. Therefore, we may anticipate smaller coefficients for the educational and income variables than those used in CORSIM.

5.0 Alternative specifications of mortality equation.

The mortality equations estimated here are very similar to those used in CORSIM with a few exceptions. First, a variable indicating dissolved marital relationships due to the death of a spouse (i.e., widow or widower) was impossible to extract from the SMC database because no distinction is made in the corresponding database variable (CIVRED and BCIVRED) between relationships dissolved because of death or divorce. Therefore, a variable indicating whether an individual is divorced, separated, *or* *widowed* (DIVSEP) is used instead. Second, the very disaggregate groupings used for estimating CORSIM equations were consolidated into three groups based on age alone (25-59, 60-74, and 75-99). The decision to combine the groups was made on the basis of model fit and collinearity diagnostic statistics.[1] Third, the specifications for older age groups are more limited than those for younger age groups because certain variables are not relevant or available for the older age groups. Earnings variables (NINC1-NINC5) are not used in regressions for the 60-74 and 75-99 age groups because these groups typically derive most of their income from pensions rather than work earnings. Yet, transfer payments or pension income variables cannot be used in lieu of the earnings variables in regressions for this group because they currently are not generated by the microsimulation model. Education variables are not used in regression equations for the 75-99 age group because educational achievement data is not available in 1990 for individuals in this group.

It may be worthwhile at some point in the future to modify the mortality equation specifications because the microsimulation will be capable of producing demographic and socioeconomic information that may be relevant. For instance, a more comprehensive measure of income (combining earnings, transfers, and pension income) would be possible if transfer payments and pensions were modelled. Some Swedish studies suggest that additional socio-economic factors may be relevant also. For instance, infant and child mortality may be affected by the family's socio-economic condition (Ostberg 1992; Leon et al. 1992; Ericson et al. 1993). Adult mortality may be influenced by factors such as housing tenure (Sundquist and Johannson 1997a), length of unemployment (Sundquist and Johannson 1997a, 1997b; Stefansson 1991), ethnicity/country of origin (Sundquist and Johannson 1997a), receiving a sickness pension (Sundquist and Johannson 1997a), occupation (Faresjö et al. 1997; Andersen 1991; Starrin et al 1988), childhood conditions (Vågerö and Lundberg 1995; Lundberg 1993; Ostberg 1991), downward social mobility or "status incongruence" (Faresjö et al. 1997), and regional location (Westerling 1993; Starrin et al. 1988).

A handful of these variables, country of origin and locational factors, were tested in a very elementary fashion. A variable indicating whether an individual is an immigrant or not was tried but it was not statistically significant and therefore was dropped from the equation. However, no distinction was made among the countries of origin or the amount of time the immigrant had lived in Sweden, two factors that may condition the risk of dying. The influence of spatial or regional factors was explored in two ways. First, two variables (average earnings and unemployment rate) measured at the labour market (LA region) level were used in regressions. They did not yield statistically significant signs. Second, average residual values resulting from the basic equations (stripped of regional variables) by commune were plotted on maps. These maps are contained in appendix E. They do not show a marked north-south gradient in unexplained mortality.

6.0 Data.

In order to both replicate the CORSIM estimation procedure as closely as possible and make estimation manageable, a Swedish sample of 458k individuals living in 1990 was chosen. These individuals were followed over a five year period, 1991-95 for occurrence of death. Therefore, the dependent variable DEAD indicates whether or not an individual expired during the period (1=Death, 0=Living). The independent variables for persons over twenty-four years of age are variables that are associated with the probability of dying and include age (AGE), sex (SEX), socio-economic conditions (NINC1-NINC5, ED2, ED3), employment status (EMP), and marital status (DIVSEP). They are measured in the base year, 1990. The rationale for including these variables is discussed at length in the CORSIM documentation. Although many of these baseyear conditions can be expected (e.g., marital status, earnings) to have changed during the five year interval, it was decided to use five year death occurrence in order to be able to make comparisons with the CORSIM results, to limit the amount of recoding needed for the adapted CORSIM computer model and to reduce the time needed for data retrieval and estimation. It is doubtful that another sampling procedure would substantially change these results. For persons under the age of twenty-five only, annual data on cohort specific death rates were obtained from 1987-97 issues of the Statistical Abstract published by Statistics Sweden.

7.0 Results

Appendix A. shows mortality trends for children and young adults in Sweden during the period 1985-1995. This data was used as input data to estimate the exponential time trend equation described in section 1.0 using the Gauss-Newton non-linear model estimation procedure in SAS. t=0 is equivalent to the base year 1985. Parameter values are consistent with those obtained using U.S. data for CORSIM. The parameter α_3 is negative, indicating that mortality rates were declining over time. The parameter values $\alpha_1+\alpha_2$ sum approximately to the base 1985 mortality rate. The former parameter estimate represents a component that cannot be reduced by technical progress.

Appendix D. reports the results for logistic regressions for the occurrence of death (DEAD) for adults. Three separate regressions were conducted, one each for age groups, 25-59, 60-74, and 75-99. Because of the data limitations discussed earlier, slightly different specifications were used. Specification (1) below was used for 25-59 year olds, (2) was used for 60-74 year olds, and (3) was used for 75-99 year olds.

(1) $b'\mathbf{x}=\beta_0+\beta_1\mathbf{AGE}+\beta_2\mathbf{AGE2}+\beta_3\mathbf{ED2}+\beta_4\mathbf{ED3}+\beta_5\mathbf{NINC1}+\beta_6\mathbf{NINC2}+\beta_7\mathbf{NINC3}+\beta_8\mathbf{NINC4}+\beta_9\mathbf{NINC5}$
$+\beta_{10}\mathbf{EMP}+\beta_{11}\mathbf{SEX}+\beta_{12}\mathbf{DIVSEP}$

(2) $b'\mathbf{x}=\beta_0+\beta_1\mathbf{AGE}+\beta_2\mathbf{AGE2}+\beta_3\mathbf{ED2}+\beta_4\mathbf{ED3}+\beta_5\mathbf{EMP}+\beta_6\mathbf{SEX}+\beta_7\mathbf{NINC3}$

(3) $b'\mathbf{x}=\beta_0+\beta_1\mathbf{AGE}+\beta_2\mathbf{AGE2}+\beta_3\mathbf{EMP}+\beta_4\mathbf{SEX}+\beta_5\mathbf{DIVSEP}$

where:

AGE	age in years
AGE2	square of age
ED2	highest educational level high school (HSUN=2,3, or 4) (1=Yes, 0=No).
ED3	highest educational level college (HSUN=5,6, or 7) (1=Yes, 0=No).
NINC1	family earnings (ARBINK) less than 600 (100s of SEK).[2]
NINC2	family earnings between 600 and 999 (1=Yes, 0=No).
NINC3	family earnings between 1000 and 1399 (1=Yes, 0=No).
NINC4	family earnings between 1400 and 1799 (1=Yes, 0=No).
NINC5	family earnings between 1800 and 2199. (1=Yes, 0=No).
EMP	employed during the year (LON>0 or FORINK>0 or SYSS=1) (1=Yes, 0=No).
SEX	gender (1=Male, 0=Female).
DIVSEP	divorced, separated, or widowed (1=Yes, 0=No).

The signs and magnitudes of the coefficients are consistent with expectations. Males and the unemployed have a higher likelihood of dying as do individuals with a lower level of education and lower earnings. Divorce, separation, or death of a spouse is associated with higher mortality. The quadratic form for in which AGE is represented is accurate for the 75-99 age group, but AGE2 is statistically insignificant for the 25-59 age group and AGE is statistically insignificant for 60-74 year olds. The measures of model fit are slightly better than those obtained in CORSIM.

ENDNOTES

[1]More groups increased the collinearity problems by reducing the size of the samples used to estimate equations and creating samples that are much more homogenous in terms of socioeconomic and demographic characteristics. It is clear from the large and unstable intercept terms obtained in the CORSIM equations that they are affected by this problem (basically the intercept term is highly correlated with the AGE variables). In addition, the CORSIM equations are not very good predictors. For instance, the c statistic (a measure of model fit) ranges from .582 to .717 for the CORSIM equations.

[2] Family earnings were computed only for those family members between the ages of 16 and 65 in order to produce an earnings measure that is consistent with that generated by the employment and earnings module (see Alfredsson and Åström 1998). ARBINK from the SMC/TOPSIM database was used as the earnings variable.

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APPENDIX A. Death rates (per 1,000 residents) by sex, age, and year.

	Males						Females					
	<1	1-4	5-9	10-14	15-19	20-24	<1	1-4	5-9	10-14	15-19	20-24
1985	7.21	.31	.20	.17	.62	.91	6.29	.29	.10	.15	.31	.33
1986	6.60	.32	.19	.28	.63	.98	5.23	.36	.12	.13	.24	.33
1987	6.68	.33	.16	.22	.66	.93	5.53	.33	.11	.12	.29	.33
1988	6.57	.35	.17	.23	.63	.97	5.01	.29	.12	.12	.28	.39
1989	6.57	.34	.15	.17	.71	.83	4.94	.31	.11	.13	.33	.30
1990	6.62	.37	.18	.17	.63	.86	5.27	.25	.13	.17	.27	.32
1991	6.61	.28	.13	.13	.64	.79	5.67	.29	.10	.17	.24	.26
1992	5.98	.32	.14	.15	.45	.74	4.68	.20	.13	.14	.23	.30
1993	5.49	.27	.19	.17	.48	.73	4.16	.22	.13	.14	.27	.33
1994	4.88	.24	.13	.14	.43	.66	3.99	.16	.08	.12	.20	.25
1995	4.70	.20	.12	.15	.45	.67	3.57	.13	.09	.10	.23	.29

APPENDIX B. Regression Results for Personss < 25 years of age.

Males

Age group	α_1	α_2	α_3
Less than 1	2.67	4.63	−0.058
1-4	0.13	0.22	−0.058
5-9	0.09	0.10	−0.079
10-14	0.05	0.18	−0.070
15-19	0.25	0.45	−0.070
20-24	0.37	0.63	−0.070

Females

Age group	α_1	α_2	α_3
Less than 1	2.42	3.63	−0.078
1-4	0.051	0.311	−0.090
5-9	0.051	0.066	−0.020
10-14	0.003	0.138	−0.010
15-19	0.021	0.280	−0.030
20-24	0.088	0.258	−0.030

APPENDIX C. Sample sizes, deaths, and death proportions by sex, marital status and age (over 25 years).

	Females			**Males**		
Married	Sample	Deaths	P	Sample	Deaths	p
25-45	36,891	155	.0042	32,134	403	.0125
46-59	27,908	397	.0142	29,581	603	.0203
60-69	12,805	608	.0475	14,255	1,146	.0803
70-79	8,087	1,076	.1331	10,322	2,220	.2151
80+	1,933	627	.3244	3,713	1783	.4802
Unmarried						
25-45	29,300	171	.0058	38,791	160	.0041
46-59	12,181	292	.0240	11,518	512	.0445
60-69	8,240	537	.0651	5,812	805	.1385
70-79	10,840	1,811	.1671	4,835	1,390	.2875
80+	10,345	4,846	.4684	3,223	1,909	.5923

APPENDIX D. Regression Results for Adults ≥25 years of age.

Ages 25-59

The LOGISTIC Procedure

Data Set: WORK.TWO
Response Variable: DEAD
Response Levels: 2
Number of Observations: 212306
Link FunctionLogit

Response Profile

Ordered Value	DEAD	Count
1	1	2833
2	0	209473

WARNING: 1983 observation(s) were deleted due to missing values for the response or explanatory variables.

Model Fitting Information and Testing Global Null Hypothesis BETA=0

Criterion	Intercept Only	Intercept and Covariates	Chi-Square for Covariates
AIC	30088.407	27495.367	.
SC	30098.672	27628.822	.
-2 LOGL	30086.407	27469.367	2617.040 with 12 DF (p=0.0001)
Score	.	.	3237.044 with 12 DF (p=0.0001)

The LOGISTIC Procedure

Analysis of Maximum Likelihood Estimates

Variable	Parameter Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Standardized Estimate	Odds Ratio
INTERCPT	-7.7696	0.4741	268.5144	0.0001	.	.
AGE	0.0743	0.0208	12.7009	0.0004	0.399639	1.077
AGE2	0.00004	0.00023	0.0334	0.8549	0.018890	1.000
ED2	-0.0361	0.0457	0.6219	0.4303	-0.009796	0.965
ED3	-0.1940	0.0624	9.6611	0.0019	-0.045401	0.824
NINC1	0.8568	0.0729	138.2914	0.0001	0.135795	2.356
NINC2	0.6844	0.0826	68.6911	0.0001	0.087940	1.983
NINC3	0.6230	0.0669	86.5899	0.0001	0.108641	1.864
NINC4	0.4154	0.0631	43.3233	0.0001	0.080245	1.515
NINC5	0.1761	0.0752	5.4912	0.0191	0.028991	1.193
EMP	-0.6763	0.0633	114.0691	0.0001	-0.097188	0.508
SEX	0.6088	0.0400	231.2544	0.0001	0.167781	1.838
DIVSEP	0.1920	0.0496	15.0139	0.0001	0.035423	1.212

Association of Predicted Probabilities and Observed Responses

Concordant = 72%8	Somers' D = 0.504
Discordant = 22%5	Gamma = 0.529
Tied = 4.7%	Tau-a = 0.013
(593437009 pairs)	c = 0.752

Ages 60-74

The LOGISTIC Procedure

Data Set: WORK.THREE
Response Variable: DEAD
Response Levels: 2
Number of Observations: 57567
Link Function: Logit

Response Profile

Ordered Value	DEAD	Count
1	1	6162
2	0	51405

WARNING: 1399 observation(s) were deleted due to missing values for the response or explanatory variables.

Model Fitting Information and Testing Global Null Hypothesis BETA=0

Criterion	Intercept Only	Intercept and Covariates	Chi-Square for Covariates
AIC	39180.106	37453.370	.
SC	39189.067	37516.095	.
-2 LOGL	39178.106	37439.370	1738.736 with 6 DF (p=0.0001)
Score	.	.	1742.218 with 6 DF (p=0.0001)

The LOGISTIC Procedure

Analysis of Maximum Likelihood Estimates

Variable	Parameter Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Standardized Estimate	Odds Ratio
INTERCPT	-1.8964	3.8376	0.2442	0.6212	.	.
AGE	-0.1220	0.1141	1.1432	0.2850	-0.285991	0.885
AGE2	0.00168	0.000846	3.9414	0.0471	0.526284	1.002
ED2	-0.2147	0.0310	48.0576	0.0001	-0.055162	0.807
ED3	-0.4137	0.0549	56.7854	0.0001	-0.065962	0.661
SEX	0.6821	0.0289	558.7591	0.0001	0.187850	1.978
DIVSEP	0.2504	0.0311	64.7377	0.0001	0.061142	1.285

Association of Predicted Probabilities and Observed Responses

Concordant = 65.0%	Somers' D = 0.317
Discordant = 33.3%	Gamma = 0.322
Tied = 1.8%	Tau-a = 0.061
(316757610 pairs)	c = 0.658

Ages 75-99

The LOGISTIC Procedure

Data Set: WORK.FOUR
Response Variable: DEAD
Response Levels: 2
Number of Observations: 30942
Link Function: Logit

Response Profile

Ordered Value	DEAD	Count
1	1	12136
2	0	18806

Model Fitting Information and Testing Global Null Hypothesis BETA=0

Criterion	Intercept Only	Intercept and Covariates	Chi-Square for Covariates
AIC	41447.556	37815.543	.
SC	41455.896	37857.242	.
-2 LOGL	41445.556	37805.543	3640.014 with 4 DF (p=0.0001)
Score	.	.	3532.272 with 4 DF (p=0.0001)

The LOGISTIC Procedure

Analysis of Maximum Likelihood Estimates

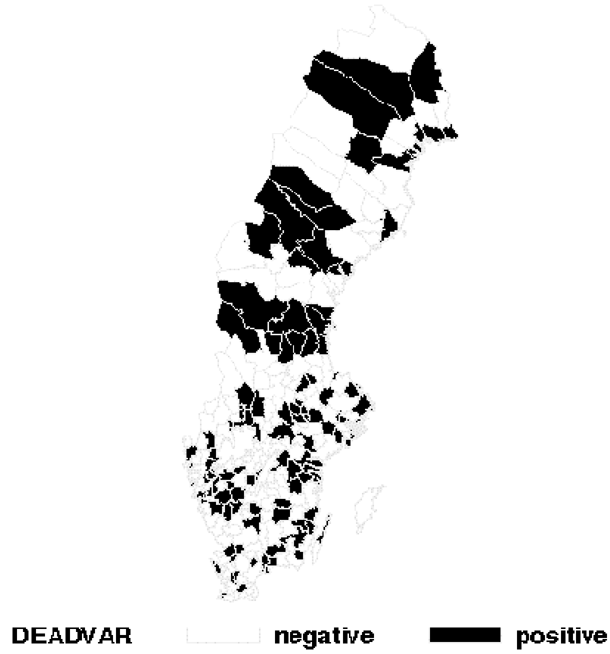
Variable	Parameter Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Standardized Estimate	Odds Ratio
INTERCPT	0.1295	3.4642	0.0014	0.9702	.	.
AGE	0.1595	0.0840	3.6033	0.0577	-0.417267	0.853
AGE2	0.00187	0.000508	13.5305	0.0002	0.812036	1.002
SEX	0.5894	0.0273	467.0794	0.0001	0.157817	1.803
DIVSEP	0.1220	0.0270	20.4494	0.0001	0.033614	1.130

Association of Predicted Probabilities and Observed Responses

Concordant = 68%.1	Somers' D = 0.385
Discordant = 29%.6	Gamma = 0.393
Tied = 2.3%	Tau-a = 0.183
(228229616 pairs)	c = 0.692

APPENDIX E. Maps of regression residuals.

Mortality Residuals, Ages 25—59



Mortality Residuals, Ages 60—75

Mortality Residuals, Ages 75—99