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Utilizing Aggregate Mortality and Cause of Death Data as Adjunct to Survey Analysis

I. Potential Uses of Aggregate Data

- A. Important Supplementary Information
  1. Help provide explanations for observed survey patterns
  2. Highlight important or emerging trends (help guide future survey work)
- B. Check on Survey Results
  1. Confirm and alleviate limitations of small sample size
  2. Check on potential problems from panel reinterviews and panel attrition

II. How Mortality Intersects with Prevalence and Incidence Data

- A. Basic "Migration" Accounting Formulation
- B. Possible Interpretations of Observed Mortality Trends
- C. Strengthening Survey-Registration Interface

III. Mortality Trends 1975-2000 at Older Ages in Taiwan

- A. Life Expectancy Data—What They Do and Do Not Tell Us
- B. Age-Specific Mortality Trends
  1. Period data
  2. Cohort data
- C. Possible Influences on Mortality Trends
  1. Special ethnicity patterns (Mainlanders moving through the system)
     a. Regression analysis of mortality data
  2. Universal health insurance
  3. Adoption rate of new technologies

IV. Trends by Causes of Death, 1989-2000

- A. Overall Trends by Cause
- B. Age-Specific Causal Analysis

V. Summary and Conclusions

- A. Some Clear Trends and Some Puzzles
- B. Intriguing Hypotheses
- C. Promising Future Lines of Research
  1. Enriching survey data and analyses
  2. Micro-analysis of registration and census data
  3. "Joint" analyses of survey and aggregate data

Accounting Equation for Change in Prevalence Over Time in an Illness/Disability with Two States

Consider a Disability with Two States, Severe and Mild

At Time 1:

${}_1P_S$ = # with severe form (prevalence at t = 1)

${}_1P_M$ = # with mild form (prevalence at t = 1)

${}_{1\text{-}2}I_S$ = # of new cases with severe form between time 1 and time 2

${}_{1\text{-}2}I_M$ = # of new cases with mild form between time 1 and time 2

D_S = # of deaths among those with severe form

D_M = # of deaths among those with mild form

$T_{S\rightarrow M}$ = # changing status from severe to mild

$T_{M\rightarrow S}$ = # changing status from mild to severe

At time 2, prevalence of each type will be:

$${}_2P_S = {}_1P_S + {}_{1\text{-}2}I_S - D_S + T_{M\rightarrow S} - T_{S\rightarrow M}$$

$${}_2P_M = {}_1P_{M+1}\text{-}{}_2I_M - D_M + T_{S\rightarrow M} - T_{M\rightarrow S}$$

Table 1

Taiwan: Expectation of Life in Years at Older Ages, 1975-2000

MALE

Age	1975	1978	1980	1983	1986	1990	1995	1999	2000
60	16.10	16.60	16.86	16.71	17.48	17.93	18.44	18.65	18.61
65	12.45	13.22	13.48	13.23	13.92	14.35	14.93	15.08	n.a.
70	9.49	9.86	10.51	10.16	10.73	11.11	11.65	11.88	11.88
75	6.94	7.30	7.94	7.57	8.01	8.33	8.73	9.16	n.a.
80	4.83	5.11	5.80	5.50	5.86	6.12	6.41	7.04	7.15
85	3.03	3.05	4.09	4.08	4.45	4.76	5.18	5.85	n.a.

FEMALE

Age	1975	1978	1980	1983	1986	1990	1995	1999	2000
60	18.94	19.44	19.47	19.42	19.82	20.51	21.35	21.55	21.66
65	14.92	15.61	15.67	15.57	15.89	16.51	17.30	17.44	n.a.
70	11.40	11.90	12.25	12.10	12.36	12.88	13.57	13.60	13.56
75	8.98	8.83	9.21	9.09	9.32	9.74	10.28	10.21	n.a.
80	6.00	6.29	6.73	6.62	6.88	7.19	7.57	7.52	7.51
85	3.81	4.18	4.99	4.75	5.19	5.41	5.64	6.04	n.a.

n.a. = not available at present

Notes: Deaths based on dates of occurrence since 1975. Data include Taiwan-Fukien area since 1992 (Kinmen and Lienkiang Counties added).

Sources: 1975-1999*: Health and Vital Statistics 2000*, ROC, Vol. 1, Table 14
2000: *Statistical Yearbook of the Republic of China, 2001*, Table 17.

Table 2
Age-Specific Death Rates 50 and Older and Estimated Percent Male Mainlanders, 1975-2000

	1975		1980		1985		1990		1995		2000	
Age	% Main-landers	Death Rate	% Main-landers	Death Rate	% Main-landers	Death Rate	% Main-landers	Death Rate	% Main-landers	Death Rate	% Main-landers	Death Rate
						MALES						
52.5	40.1	8.99	37.0	8.69	15.5	8.28	4.0	8.3	4.6	8.15	7.2	7.34
57.5	35.3	15.3	40.7	13.08	36.8	11.7	16.1	12.26	4.0	11.78	4.6	10.96
62.5	29.9	18.7	35.3	21.53	40.6	18.77	36.7	17.7	16.1	18.07	4.0	16.24
67.5	19.2	37.78	29.9	34.04	35.4	30.54	40.6	27.66	36.7	25.88	16.1	24.16
72.5	15.3	59.78	19.9	52.81	24.9	49.36	35.5	45.62	40.6	40.91	36.7	35.96
77.5	13.2	98.02	15.3	83.49	20.9	78	29.9	71.99	35.5	66.35	40.6	56.96
82.5	10.0	154.92	11.2	127.65	18.6	117.24	21.9	112.37	29.9	103.1	35.5	90.58
87.9	9.7	288.02	10.0	211.57	15.3	195.46	19.9	184.46	21.2	169.74	27.3	150.4
						FEMALES						
52.5		5.98		5.75		4.66		4.04		3.73		3.24
57.5		9.24		8.98		7.43		6.53		6.05		5.42
62.5		11.59		13.71		12.11		10.71		9.87		8.35
67.5		22.7		22.84		20.5		18.93		16.58		14.15
72.5		42.3		36.7		35.7		32.82		29.1		24.29
77.5		69.61		63.79		60.55		59.15		51.26		41.99
82.5		123.75		100.52		99.31		92.89		85.94		72.81
87.9		235.6		181.79		176.57		168.98		161.84		146.55

Table 3

Taiwan: Rates of Change in Total Death Rates by Age, 65 Years and Older

	MALES				FEMALES			
	%Change per Period				% Change per Period			
Age	1985-1990	1990-1995	1995-2000	1990-2000	1985-1990	1990-1995	1995-2000	1990-2000
65-69	-9.4	-6.4	-6.6	-12.6	-7.7	-12.4	-14.0	-24.7
70-74	-7.6	-10.3	-12.2	-21.3	-8.1	-11.3	-16.5	-25.9
75-79	-7.7	-7.8	-14.2	-20.9	-2.3	-13.3	-18.1	-29.0
80-84	-4.2	-8.2	-12.1	-19.4	-6.5	-7.5	-15.3	-21.6
85+	-5.6	-8.0	-11.4	-18.5	-4.3	-4.2	-9.4	-13.3
65+	-5.5	-4.5	-2.6	-7.0	-4.0	-6.8	-10.9	-17.0

Table 4

Ratio of M/F Mortality by Age and Year and Percent Who Are Mainlanders in 1990

	Ratios						1990 % Mainlanders	
Age	1975	1980	1985	1990	1995	2000	**M**	**F**
50-54	1.50	1.51	1.78	2.05	2.18	2.27	4.0	12.0
55-59	1.66	1.46	1.57	1.88	1.95	2.02	16.1	10.2
60-64	1.61	1.57	1.55	1.65	1.83	1.93	36.7	12.5
65-69	1.66	1.49	1.49	1.46	1.56	1.69	40.6	13.4
70-74	1.41	1.44	1.38	1.39	1.41	1.48	35.5	10.8
75-79	1.41	1.31	1.29	1.22	1.29	1.36	29.9	8.2
80-84	1.25	1.27	1.18	1.21	1.20	1.24	21.9	5.9
85+	1.22	1.16	1.11	1.09	1.05	1.03	19.8	6.8
% of 65+ Who Are Male	46.9	49.5	51.5	53.3	54.7	52.9		

Table 5

Regression of Age, Year, % Mainlander
Against Male Age-Specific Death Rates, 1975-2000

D.V. = Age-Specific Death Rates, Age 50-54 to 85+ (in five-year age groups)

I.V.

Age	Midpoint of 5-year age group (Age 87.9 for those 85+)
Year	Year of observation, 1975-2000
% Mainlander	Estimated for each year and age group from 1980 and 1990 Censuses
Mainlander type	0 if younger Mainlander ≅ Soldier 1 if older Mainlander ≅ Administrators
Hi/Lo % Mainlander	0 if % Mainlander in Yr ≤ 21.2 1 if % Mainlander in Yr > 21.2
N = 48	(8 age groups for 6 observation points)

Table 6
Regression Equation

$DR = a + b_1 \text{ Age} + b_2 \text{ Yr} + b_3 \text{ \% Main} + e_i$

$= -228.03 + 4.83 \text{ Age} - 1.32 \text{ Yr} - 1.21 \text{ \% Main}$

Yr recoded so that 1975 = 0, 1980 = 5, 1985 = 10, etc.

Equation says that adding one percent Mainlander produces as much change as going forward .92 of a year,

or

A 5% increase in percent Mainlander is equivalent to a 4.6 year secular change in reducing mortality.

Regression can be used to decompose changes across age groups to say how much of the change came from time and how much came from percent Mainlanders and to conduct related analyses (e.g., what death rate would have been without Mainlanders).

Table 7 Leading Causes of Death, 65 Years and Older, Taiwan, 1989, 1995, 1999

Cause of Death	ICD Code #	Death Rate per 100,000			% Change		% Distribution		
		1989	1995	1999	1989-1995	1995-1999	1989	1995	1999
Total		4,806	4,462	4,290	-7.2	-3.9	100.0	100.0	100.0
CBV	29	860	652	528	-24.2	-19.0	17.9	14.6	12.3
Malign. Neoplasms	8-14	743	873	931	+17.5	+6.6	15.4	19.6	21.9
Heart Disease	250, 251, 27, 28*	658	538	473	-18.2	-12.1	13.7	12.1	11.0
Diabetes	181	222	324	367	+45.9	+13.3	4.6	7.3	8.6
Hypertension	26	199	134	85	-32.7	-36.6	4.1	3.0	2.0
Accidents	E42-E53	195	163	190	-16.4	+16.6	4.1	3.7	4.4
Pneumonia	321	181	157	188	-13.3	+19.7	3.8	3.5	4.4
Bronchitis, Emphysema, Asthma	323	176	100	83	-43.2	-17.0	3.7	2.2	1.9
Nephritis	350	113	161	148	+42.5	-8.1	2.3	3.6	3.4
Liver Disease, Cirrhosis	347	107	101	104	-5.6	+3.0	2.2	2.3	2.4
All Other		1352	1259	1194	-6.9	-5.2	28.1	28.2	27.8
T.B.	02	106	73	64	-31.1	-12.3	2.2	1.6	1.5
Septicaemia	038	76	64	39	-15.8	-39.1	1.6	1.4	0.9
Ulcers	341	55	47	47	-14.6	0	1.1	1.0	1.1
Suicide	E54	34	26	32	-23.5	+23.1	0.7	0.6	0.8
Other Protein-Cal malnutrition	192	13	--	--	--	--	0.3	--	--
Anaemias	200	--	7	8	--	+14.3	--	0.2	0.2

Sources: See Table 8
1989: Table 21
1995: Table 37
1999: Table 29

28* indicates that ICD-9 codes 420-429 included

Table 8 Taiwan: Death Rates per 100,000 by 10 Leading Causes of Death by Age, 1989, 1995, 1999

Age	Total			CBV			Malign. Neoplasms			Heart Disease		
	1989	1995	1999	1989	1995	1999	1989	1995	1999	1989	1995	1999
65-69	2492	2167	2000	442	306	225	581	627	627	284	225	182
70-74	4117	3554	3182	787	534	378	748	862	862	502	384	331
75-79	6571	5901	5127	1259	929	666	953	1154	1171	897	702	541
80+	12174	11902	11048	1953	1590	1395	1003	1296	1506	2023	1587	1382

Age	Diabetes			Hypertension			Accidents			Pneumonia		
	1989	1995	1999	1989	1995	1999	1989	1995	1999	1989	1995	1999
65-69	146	191	214	88	51	26	148	132	135	60	41	44
70-74	225	308	322	172	94	58	188	163	172	133	94	100
75-79	319	474	476	289	171	102	234	187	206	260	221	217
80+	350	574	695	531	419	224	321	223	338	609	556	677

Age	Bronchitis, Emphysema*			Nephritis			Liver Disease, Cirrhosis		
	1989	1995	1999	1989	1995	1999	1989	1995	1999
65-69	67	30	26	57	66	64	87	85	84
70-74	140	75	57	91	120	92	111	101	100
75-79	266	138	95	167	221	181	133	124	110
80+	518	315	256	282	458	426	135	123	151

*Bronchitis and Emphysema was not one of the 10 leading causes in 1999 for the total population.

Source: *Health Statistics 1. General Health Statistics 1989, Republic of China*, Department of Health, ROC, Table 22.
Health and Vital Statistics. 1. General Health Statistics 1995, Republic of China, Department of Health, ROC, Table 38.
1999 Republic of China Health and Vital Statistics. 1. General Health Statistics, Department of Health, ROC, Table 30.

Table 9 Taiwan: Annual Rates of Change in Leading Causes of Death, Ages 65 and Older

	Annual Rate of Change in Percent*	
	1989-1995	1995-1999
Total	-1.2%	-1.0%
CBV	-4.6	-5.3
Malign. Neoplasms	2.7	1.6
Heart Disease	-3.4	-3.2
Diabetes	6.3	3.1
Hypertension	-6.6	-11.4
Accidents	-3.0	3.8
Pneumonia	-2.4	4.5
Bronchitis, Emphysema, Asthma	-9.4	-4.6
Nephritis	5.9	-2.1
Liver Disease, Cirrhosis	-1.0	0.7
All Other	-1.2	-1.3
T.B.	-6.2	-3.2
Septicaemia	-2.9	-12.4
Ulcers	-2.6	0
Suicide	-4.4	5.2

*Annual rate calculated assuming continuous change for rates shown in Table 7, with 6-year and 4-year intervals, respectively.

Source: Calculated from Table 7.

Table 10 Death Rates per 100,000 from Specific Types of Accidents, by Age, 1989, 1995, 1999

	E47: Transport			E50: Accidental Falls			E52: Other Accidents, Including Late Effects		
Age	1989	1995	1999	1989	1995	1999	1989	1995	1999
65-69	87.0	84.1	57.2	17.8	14.3	16.5	31.1	27.0	55.1
70-74	104.0	98.0	67.4	29.4	21.9	25.6	39.0	32.8	72.5
75-79	112.2	103.2	65.7	38.5	27.3	40.4	65.0	46.7	91.9
80+	92.2	86.6	78.2	108.9	61.2	114.3	88.5	57.6	133.0
Total 65+	96.8	91.6	65.0	35.4	25.1	38.3	46.1	36.1	78.8

Sources: See Table 8
1989: Table 26; 1995: Table 42; 1999: Table 34.

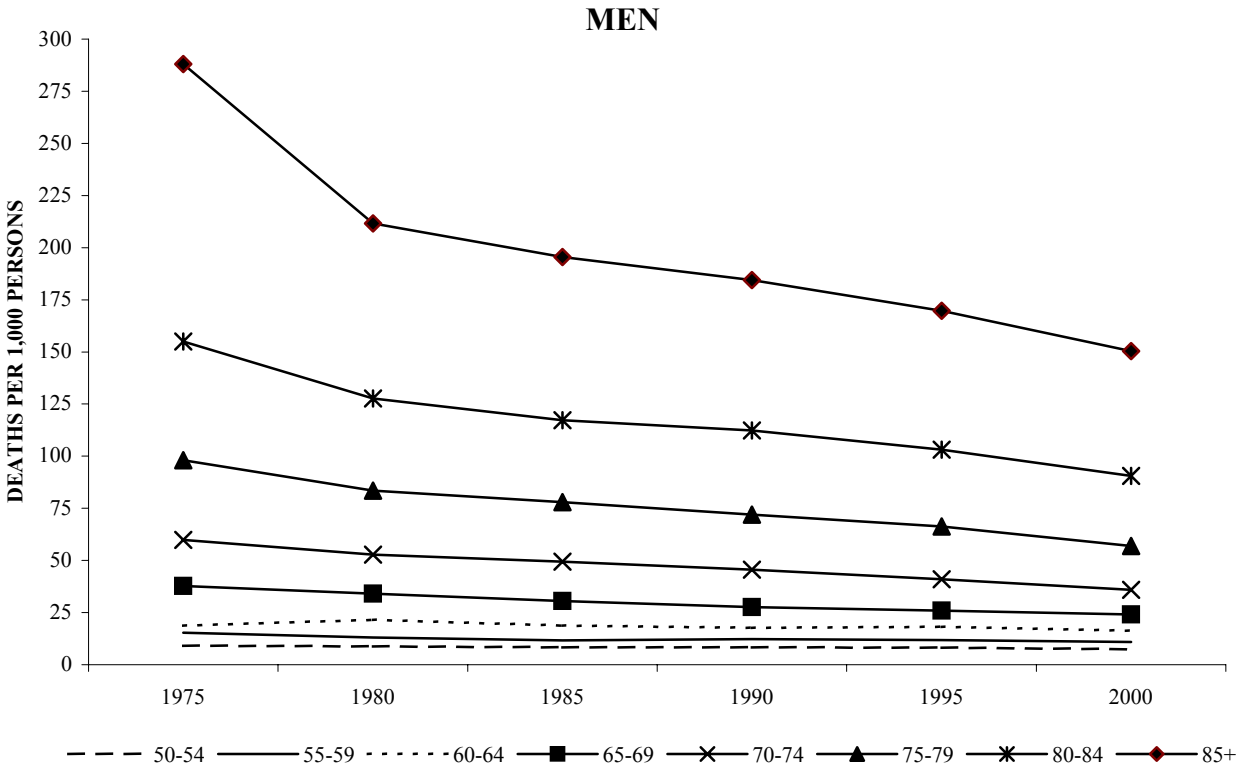
Table 11 Trends in New Medical Equipment

	Number of Units					
	In Operation Year End 1991	New Approved Units 1992-1995 (incl.)	In Operation Year End 1995	New Approved Units 1996-1999 (incl.)	In Operation Year End 1999	In Operation Year End 2000
Computerized Tomography Scanner	147	117	264	125	390*	416
Radiation Isotope Equipment						
Therapeutic	25	25	50	16	67*	69
Diagnostic	16	25	41	44	85	91
Linear Acceleration Equipment	21	15	36	34	70	80
Nuclear Magnetic Resonance Tomography (NMR))	14	24	38	34	72	85*
Shock Wave Lithotripsy Equipment	20	36	56	60	116	133

*As reported, exceeds by one previous total and number approved in interim period.

Sources: See Table 8
1995 volume: Table 74; 1998 volume: Table 65; 2000 volume: Table 65.

Figure 1. Age-Specific Death Rates 50 and Older, 1975-2000



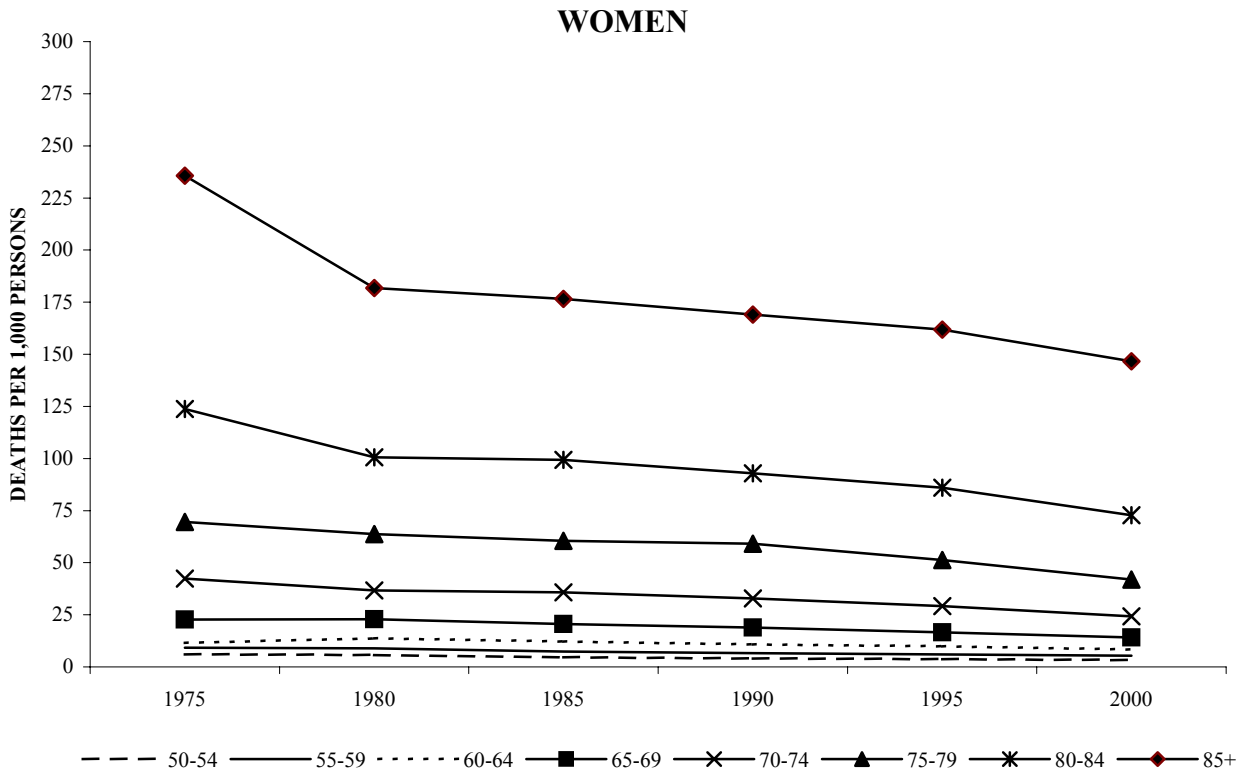


Figure 2. Ratios of Male/Female Mortality by Age and Year and Percent Mainlander Men and Women

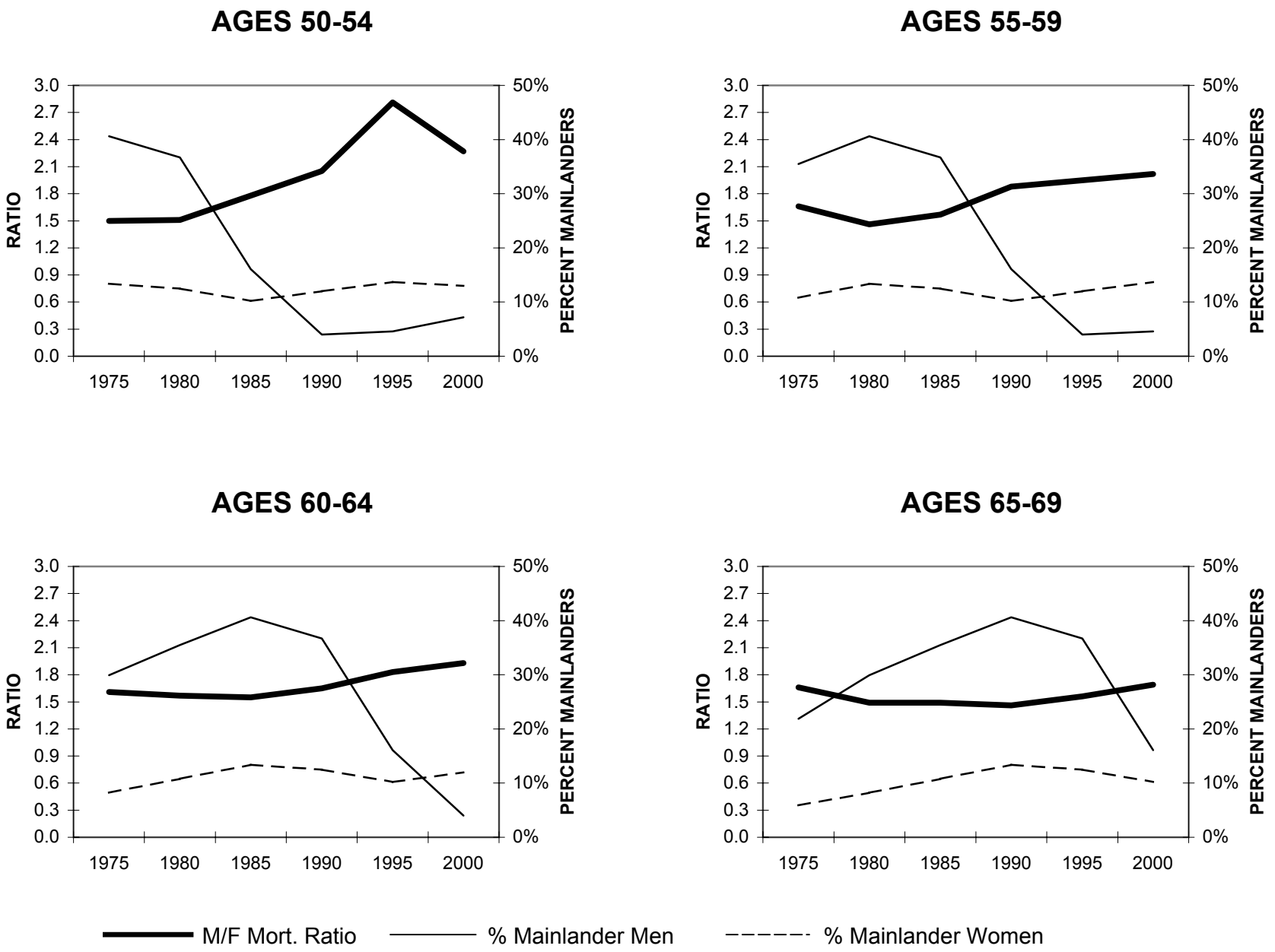


Figure 2. Ratios of Male/Female Mortality by Age and Year and Percent Mainlander Men and Women - continued

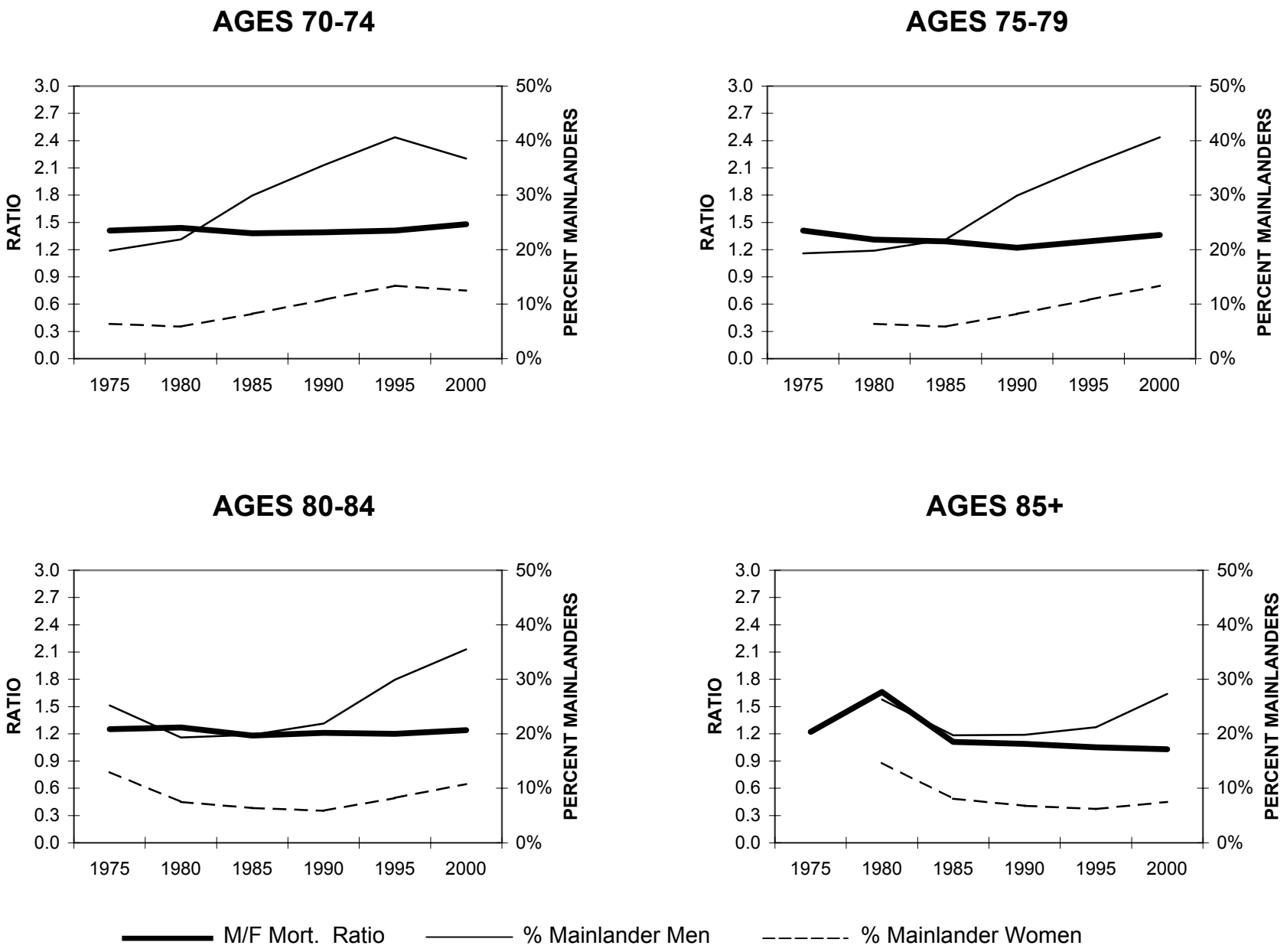


Figure 3. Age-Specific Death Rates for Cohorts Reaching Age 50-54 in Specified Years

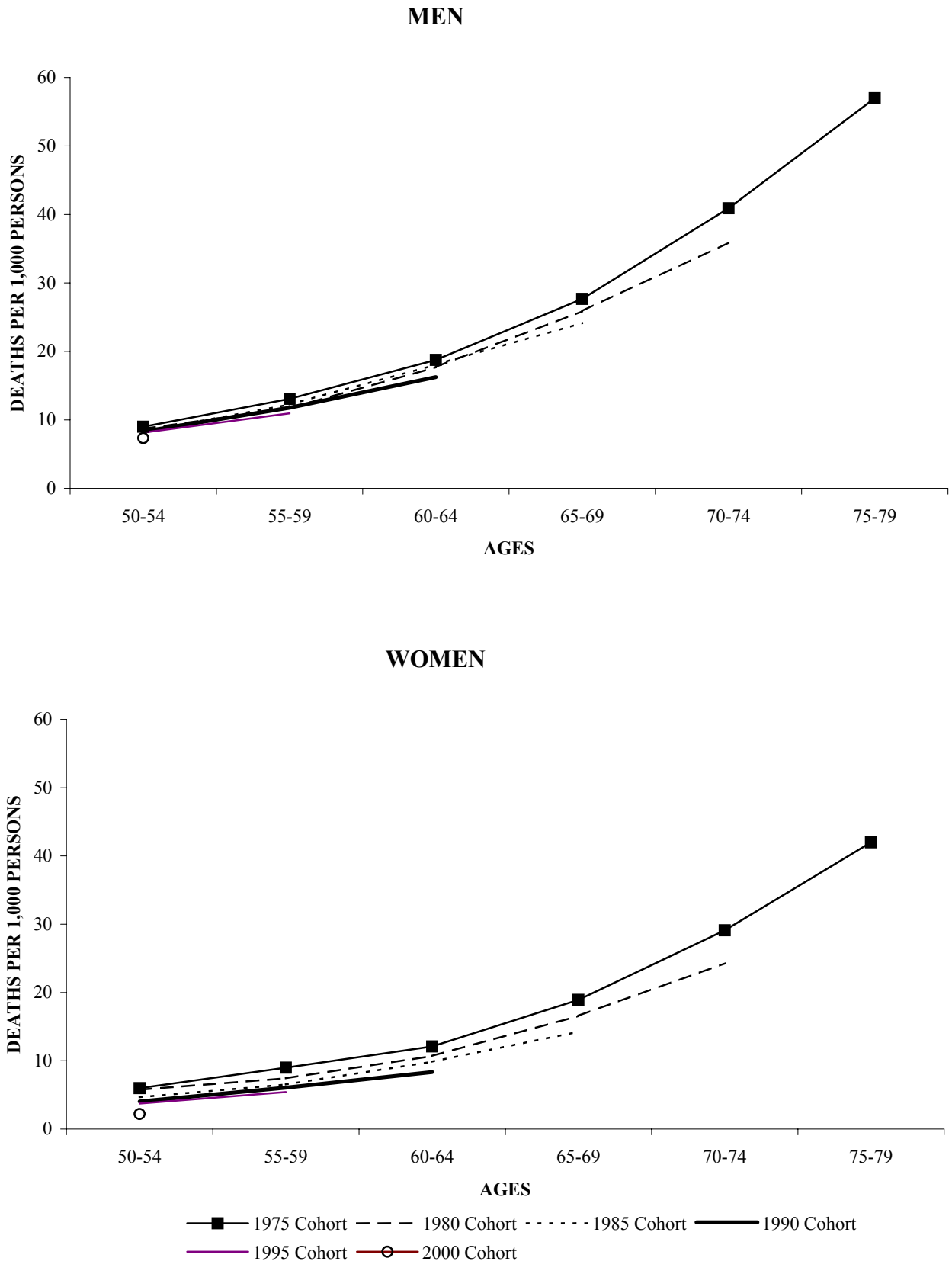
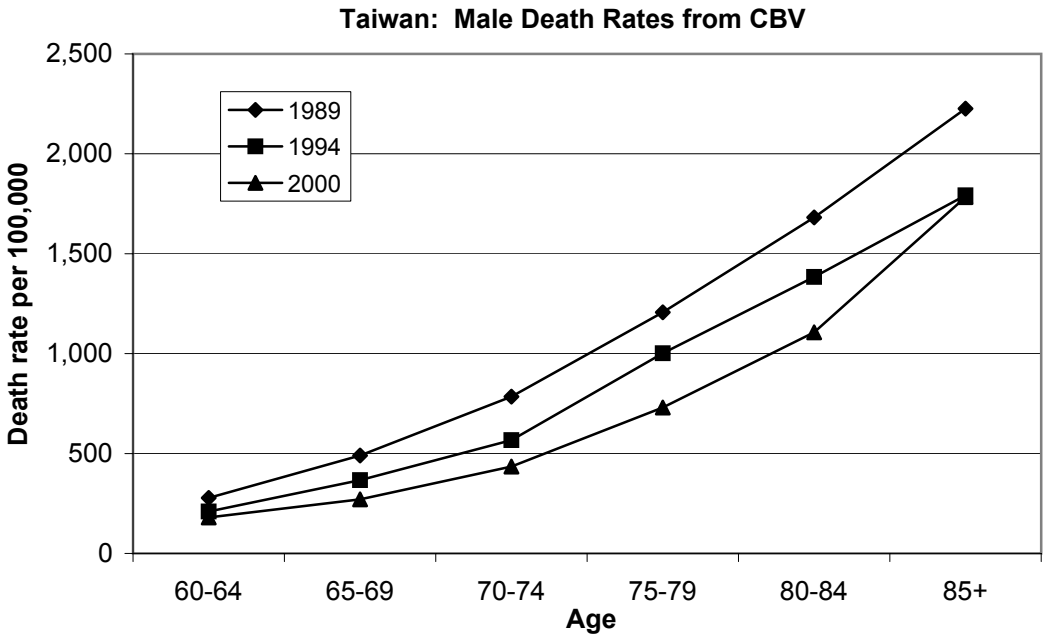
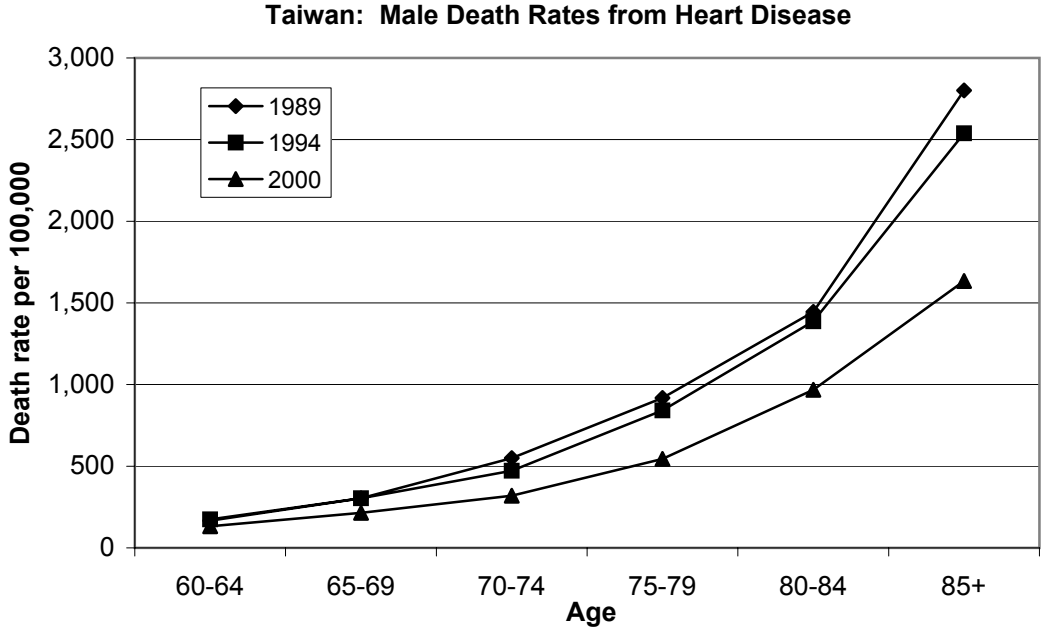


Figure 4A. Male Death Rates from CBV, Heart Disease and Hypertension, by Age and Year





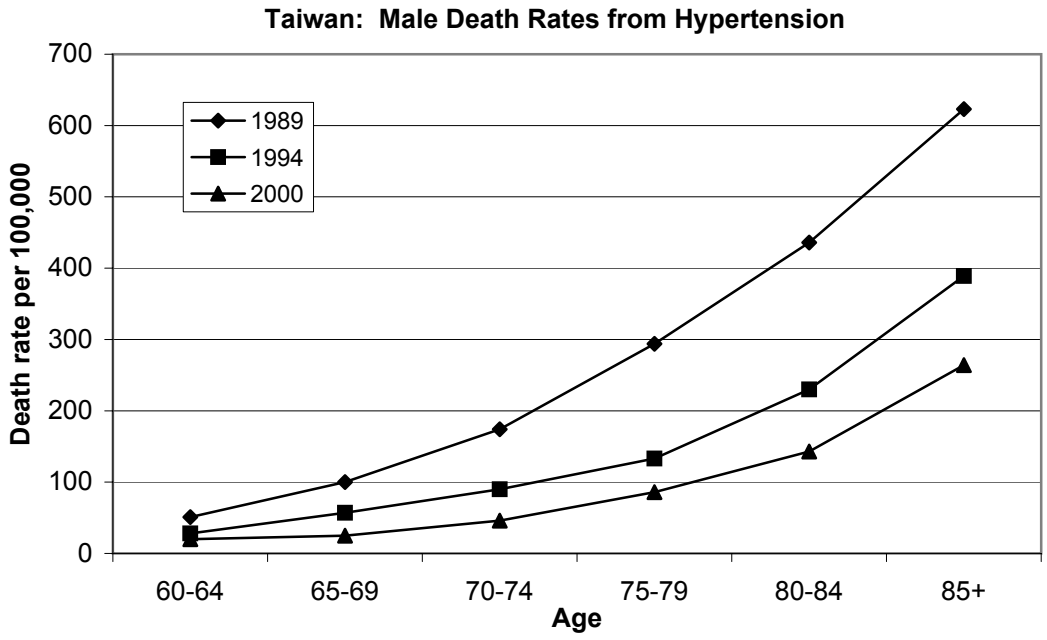
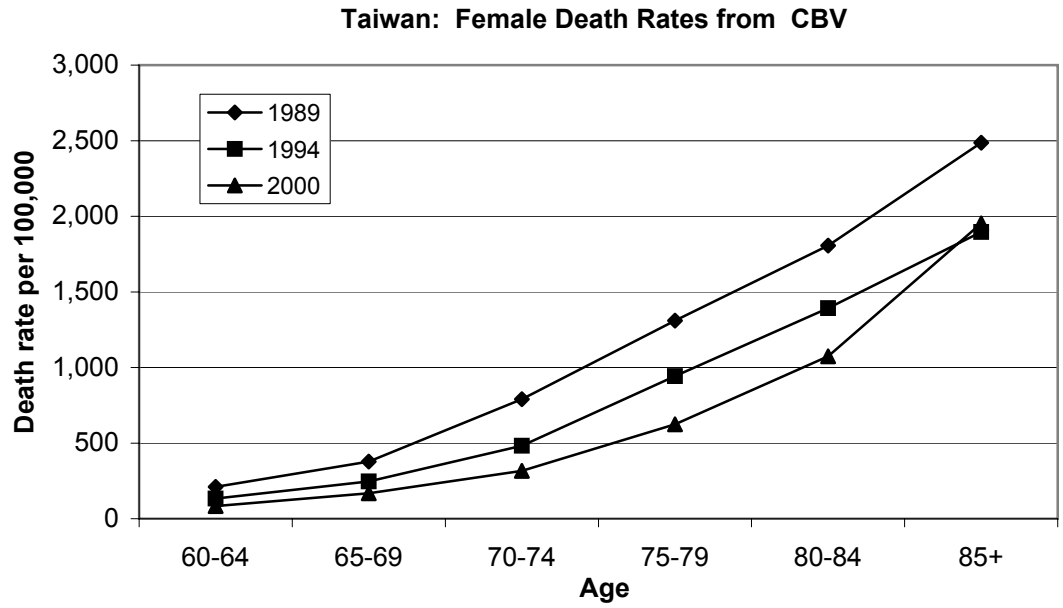
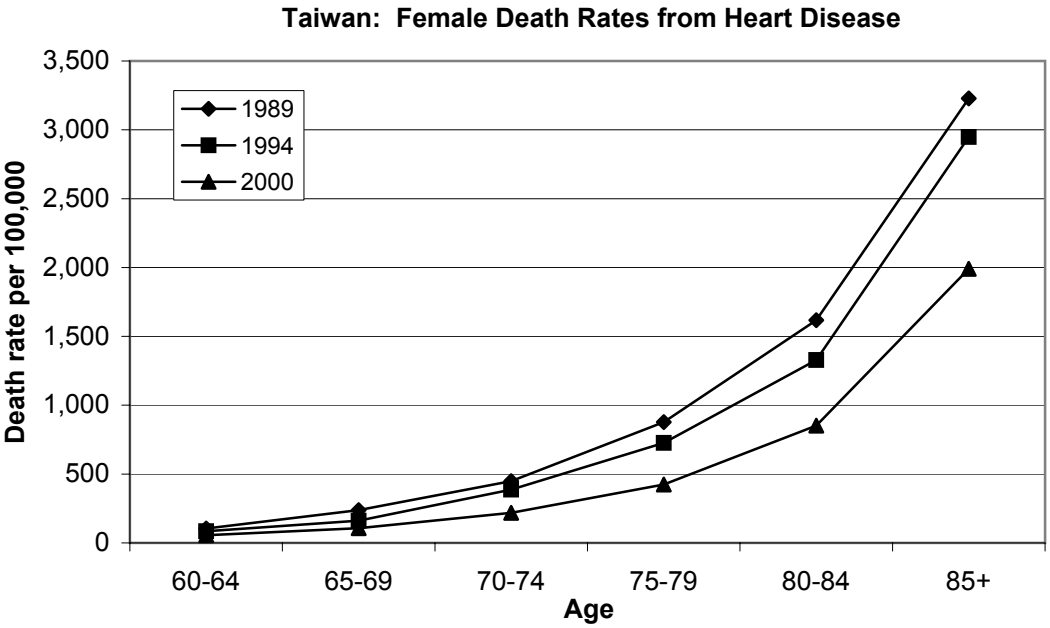


Figure 4B. Female Death Rates from CBV, Heart Disease and Hypertension, by Age and Year





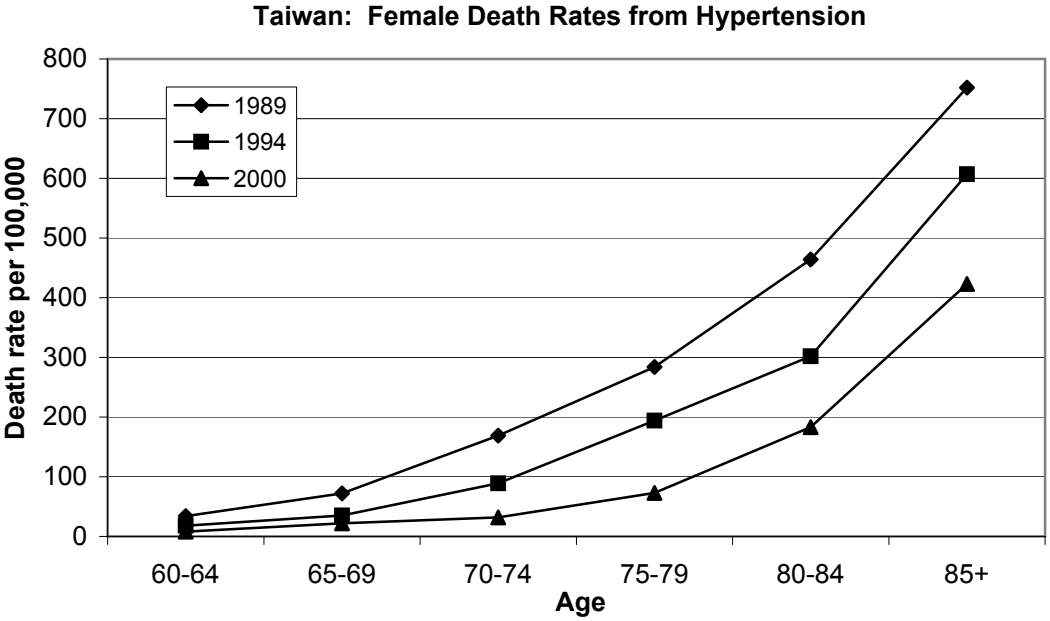
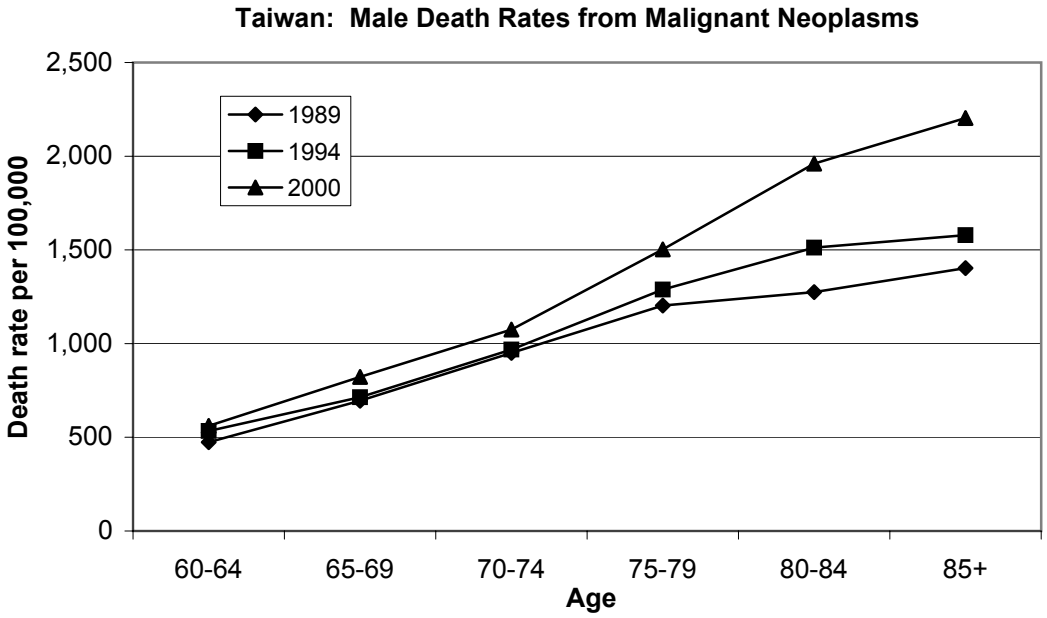
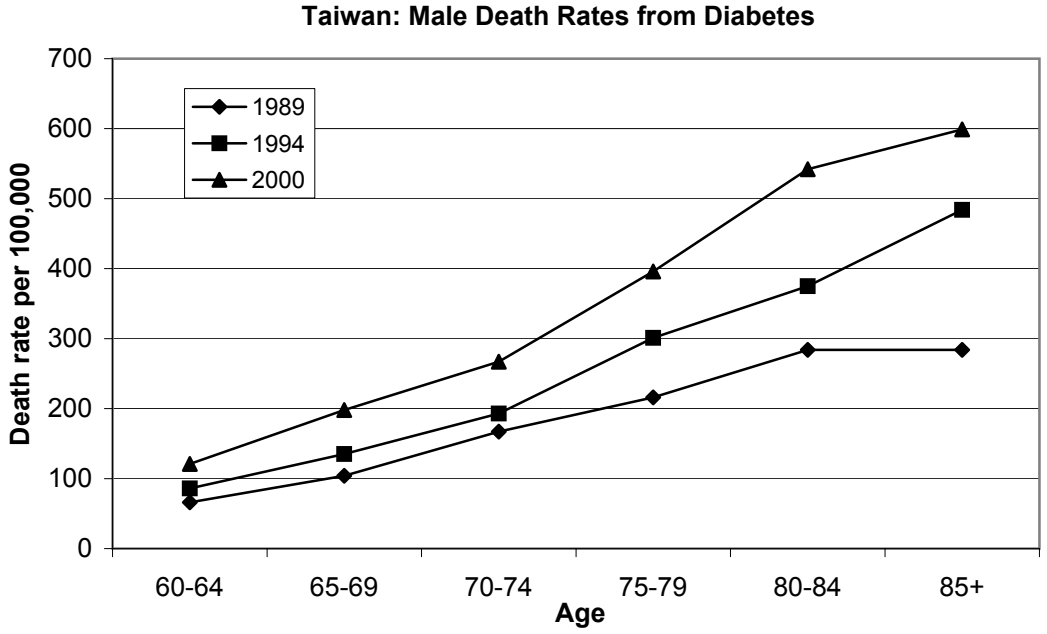
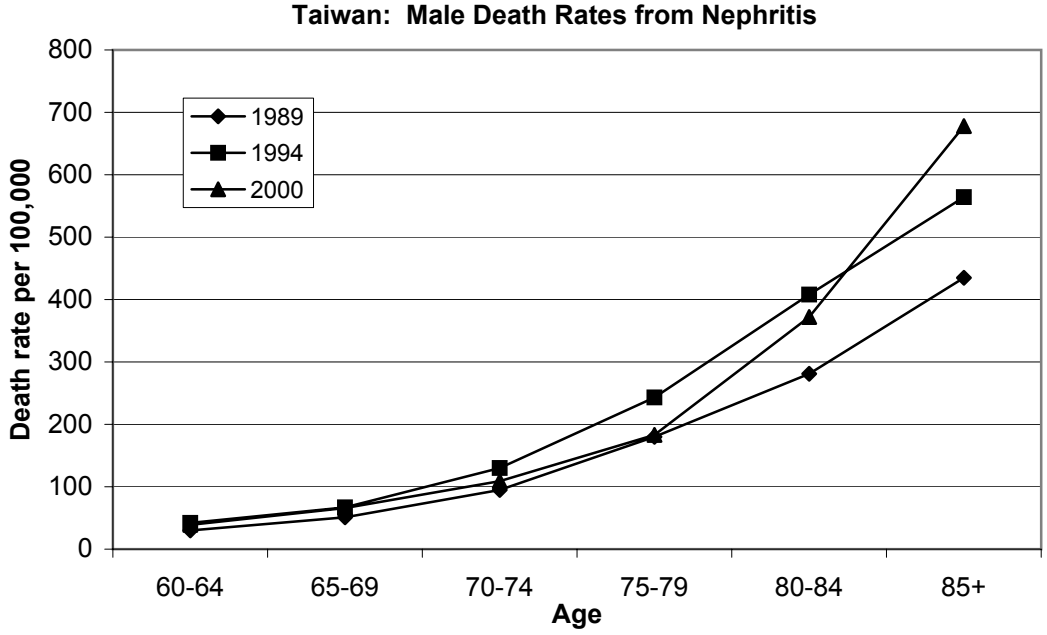


Figure 5A. Male Death Rates from Cancer, Diabetes and Nephritis, by Age and Year







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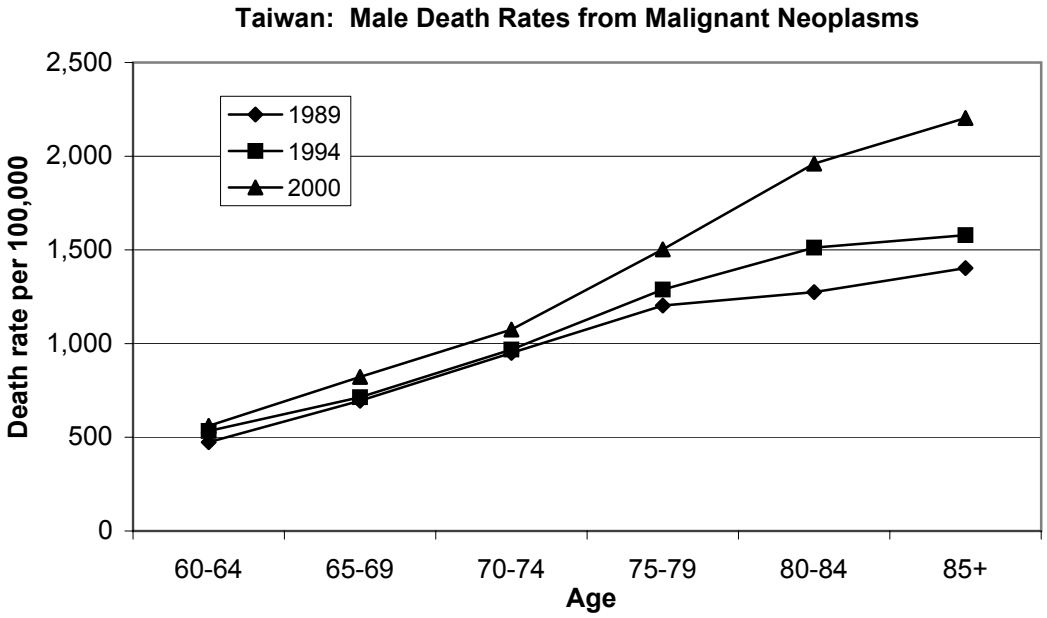
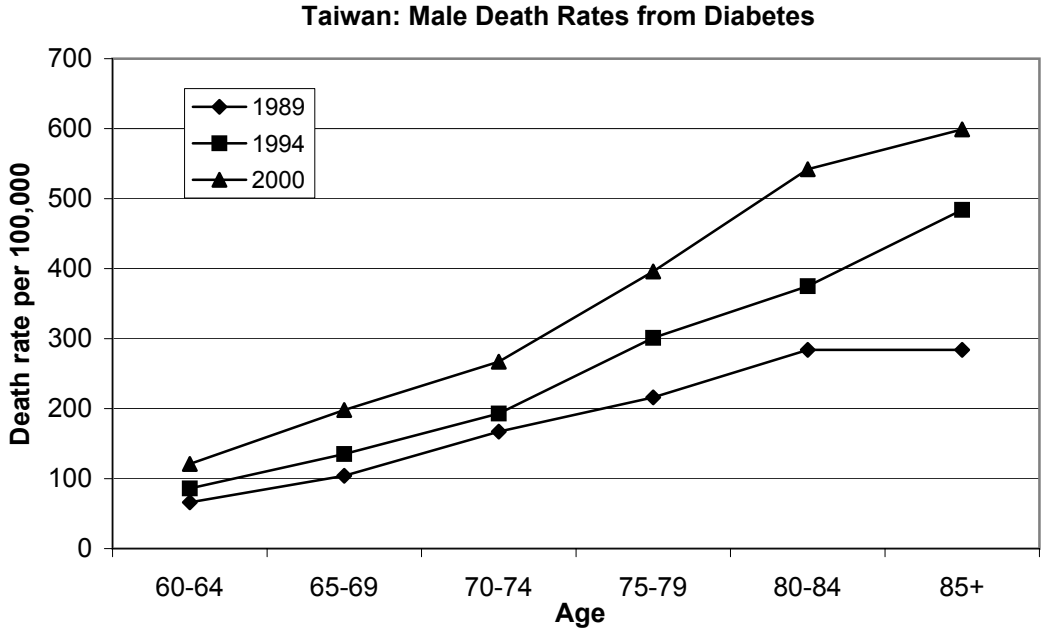




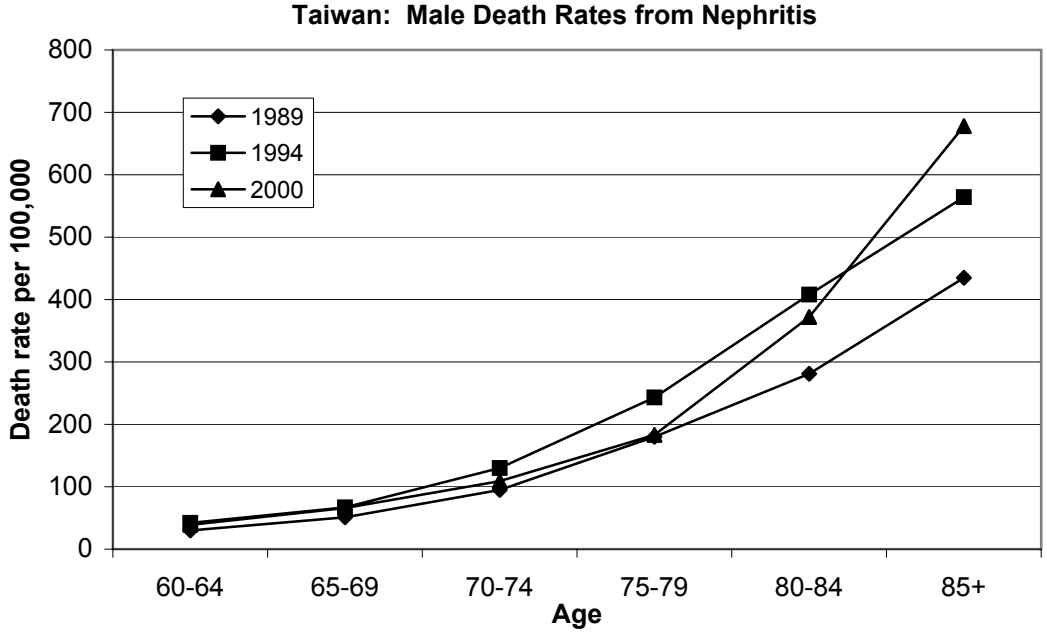
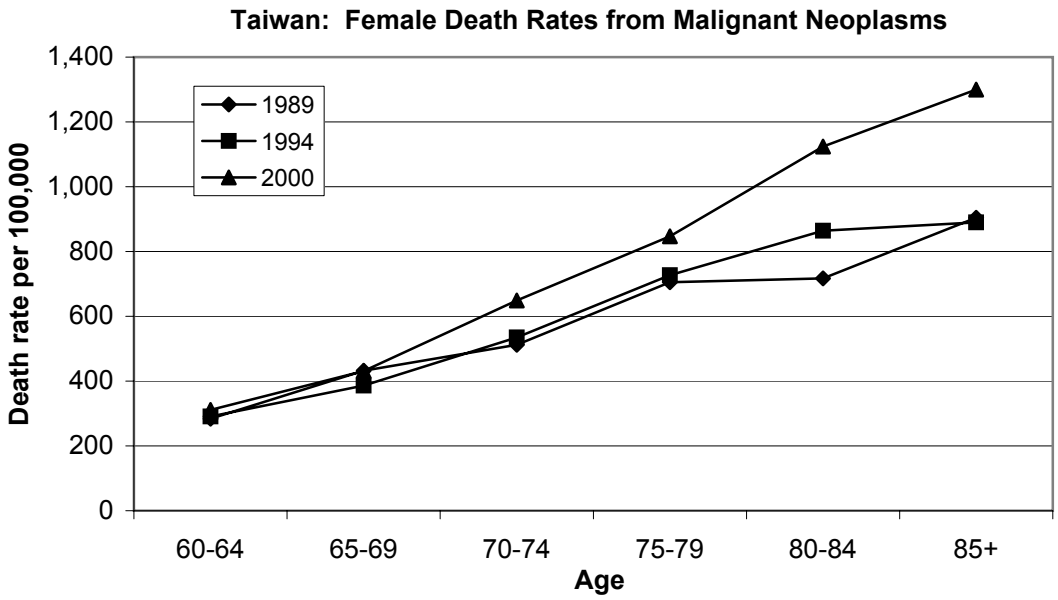
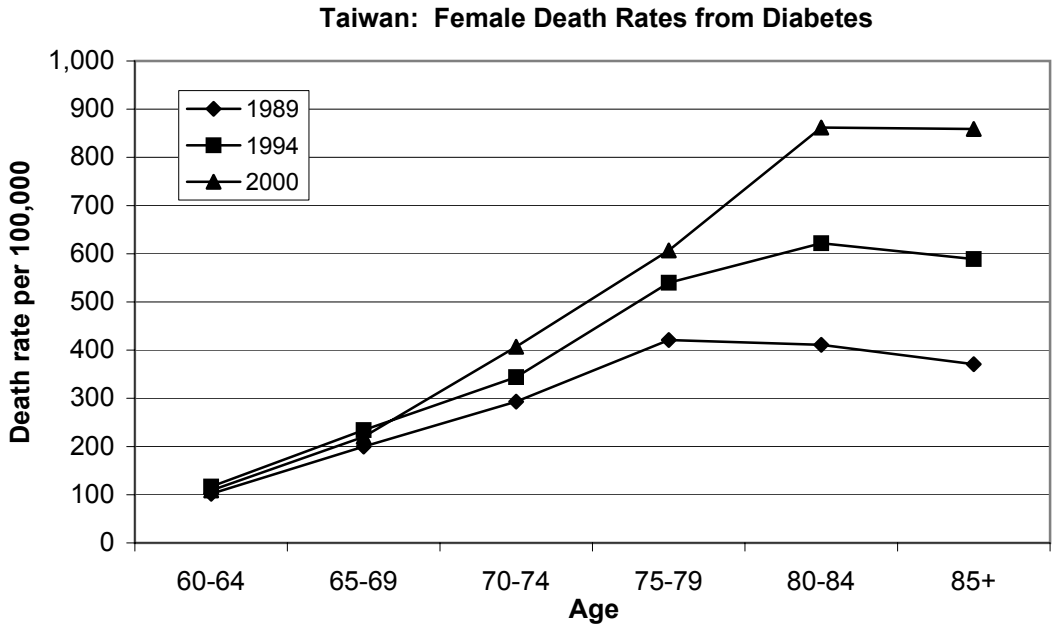


Figure 5B. Female Death Rates from Cancer, Diabetes and Nephritis, by Age and Year





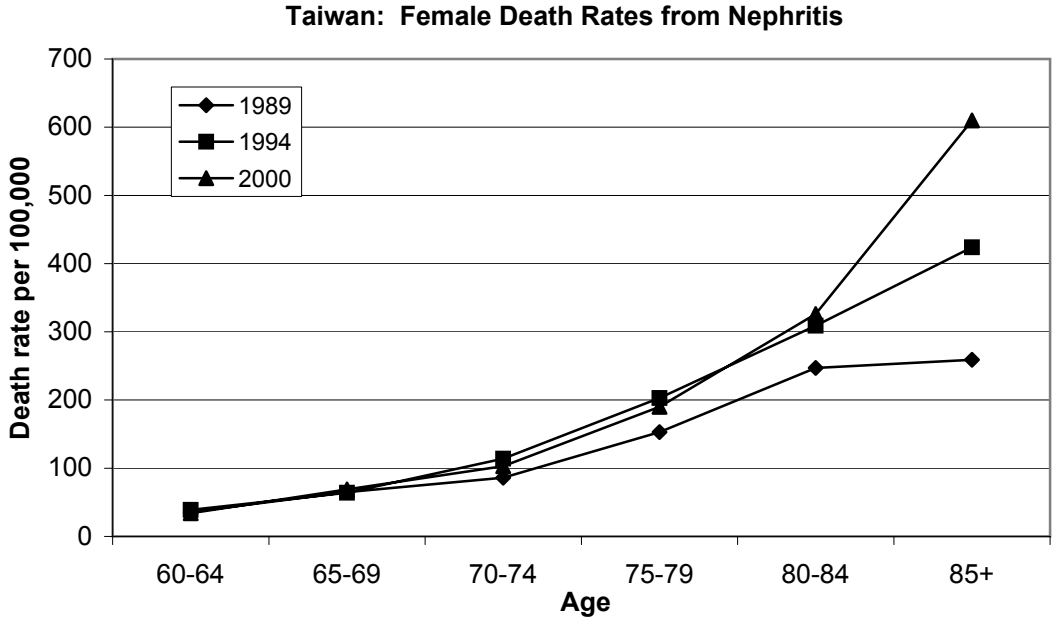
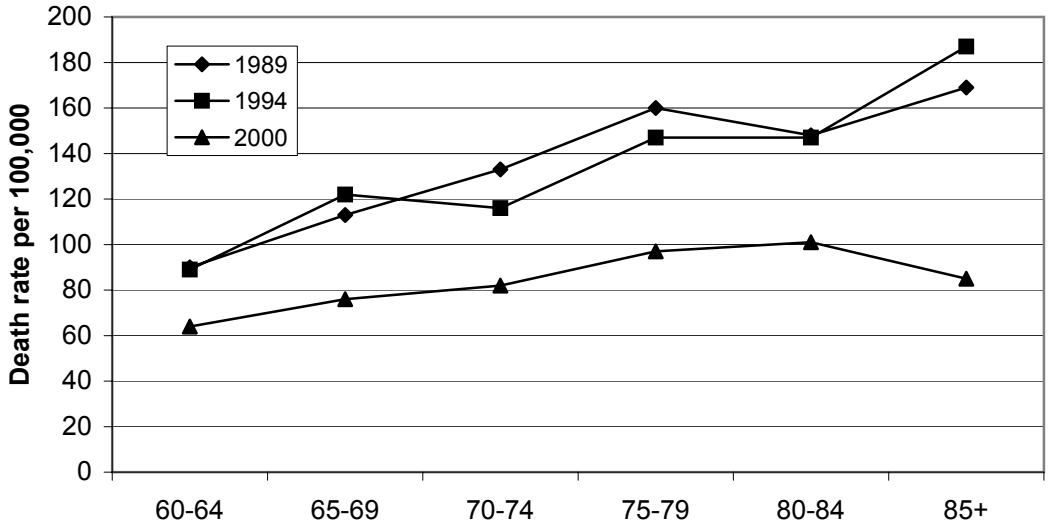
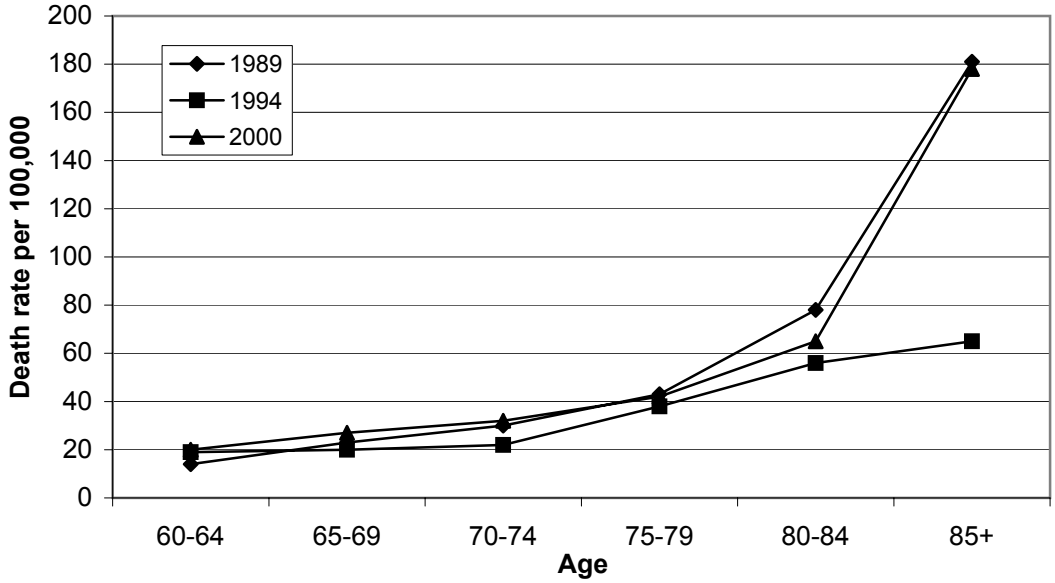


Figure 6A. Male Death Rates from Accidents and Bronchitis, by Age and Year

Taiwan: Male Death Rates from Motor Vehicle Accidents



Taiwan: Male Death Rates from Falls



Taiwan: Male Death Rates from Bronchitis and Emphysema

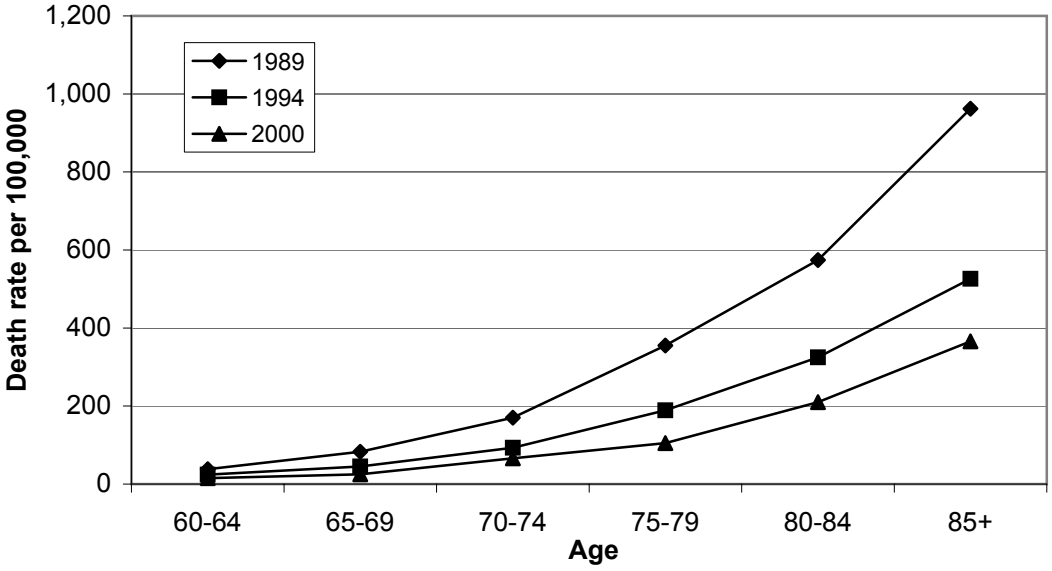


Figure 6B. Female Death Rates from Accidents and Bronchitis, by Age and Year