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Kinship and Family Support in Aging Societies

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IIASA Working Paper

WP-86-081

December 1986

WORKING PAPER

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Acknowledgements

This is a revised version of a paper originally presented at the United Nations International Symposium on Population Structure and Development, held in Tokyo, Japan from 10-12 September 1986, and to be published in 1987 by the United Nations. This research was supported in part by Grant No. AG05153 from the U.S. National Institute on Aging. Important contributions to the research were made by Nathan Keyfitz, Gun Stenflo and Jan Bartlema. Helpful comments on an earlier version of the paper were provided by Naohiro Ogawa, Shiro Hoiruchi, Jack Habib and Shigemi Kono.

Foreword

The main direction of research in IIASA's Population Program is population aging—a phenomenon which almost all countries in the world are experiencing today. Many social economic consequences of aging for society depend on the existing family structure and its future evolution.

This paper describes the micro-simulation approach to the analysis of the kinship patterns. The only data which one needs are the data on fertility and mortality. Among other findings the paper shows that, as a result of fertility reduction, the links between generations became weaker.

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Deputy Leader
Population Program

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KINSHIP AND FAMILY SUPPORT IN AGING SOCIETIES

Douglas A. Wolf

I. INTRODUCTION

A general concern with the worldwide phenomenon of increasingly aged populations has existed for many years. This concern will presumably grow as the phenomenon continues its progress during the coming decades. It is generally held that the aging of the world's population presents serious problems, or, at a minimum, makes necessary significant adjustments in public policies and social and economic institutions (see, for example, United Nations, 1985a). The issue remains somewhat controversial, however: a recent paper argues that, at least for the United States, the burdens implied by the projected increase in the over-65 elderly are exaggerated (Aaron, 1986). Aaron suggests nonetheless that the prospective increase in the relative size of the over-80 population presents problems that have received insufficient attention. However problematic the transition to a more elderly world proves to be, there can be little doubt that the transition will be accompanied by important changes in the economic and social structures of many countries.

This paper addresses issues related to kinship in increasingly aged populations: patterns of nuclear-family kin, the consequences of these patterns, and, especially, the way in which the aged "dependency burden" can be allocated along family lines. The perspective adopted is that of the 16 countries affiliated with the International Institute for Applied Systems Analysis (IIASA), all of which are industrialized countries.[1] As shall be illustrated, the aging phenomenon exhibited in the IIASA countries is rather different from that of the world as a whole.

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[1]These countries are: Austria, Bulgaria, Canada, Czechoslovakia, Finland, France, the German Democratic Republic, the German Federal Republic, Hungary, Italy, Japan, the Netherlands, Poland, Sweden, the Union of Soviet Socialist Republics, and the United States of America.

Kinship patterns represent only one of numerous social dimensions that can be expected to undergo change as a result of population aging. As countries become more aged, social institutions such as the educational system and the concept of family will change. Aspects of social structure, such as the spatial arrangement of the population, and the degree and nature of migration patterns, will be affected. With an increasing share of the lifetime spent at ages currently regarded as "retirement age", the conception of the worklife, and possibly of productive activity itself, may undergo change. And, norms and expectations regarding lifetime upward mobility, and the implied lifetime path of consumption opportunities, will inevitably be changed as a consequence of new patterns of labor availability at various levels of the seniority hierarchy, and the need for support over a greater range of years. Perhaps uniquely among these several social implications of aging populations, the issue of kinship patterns lends itself to a demographic analysis.

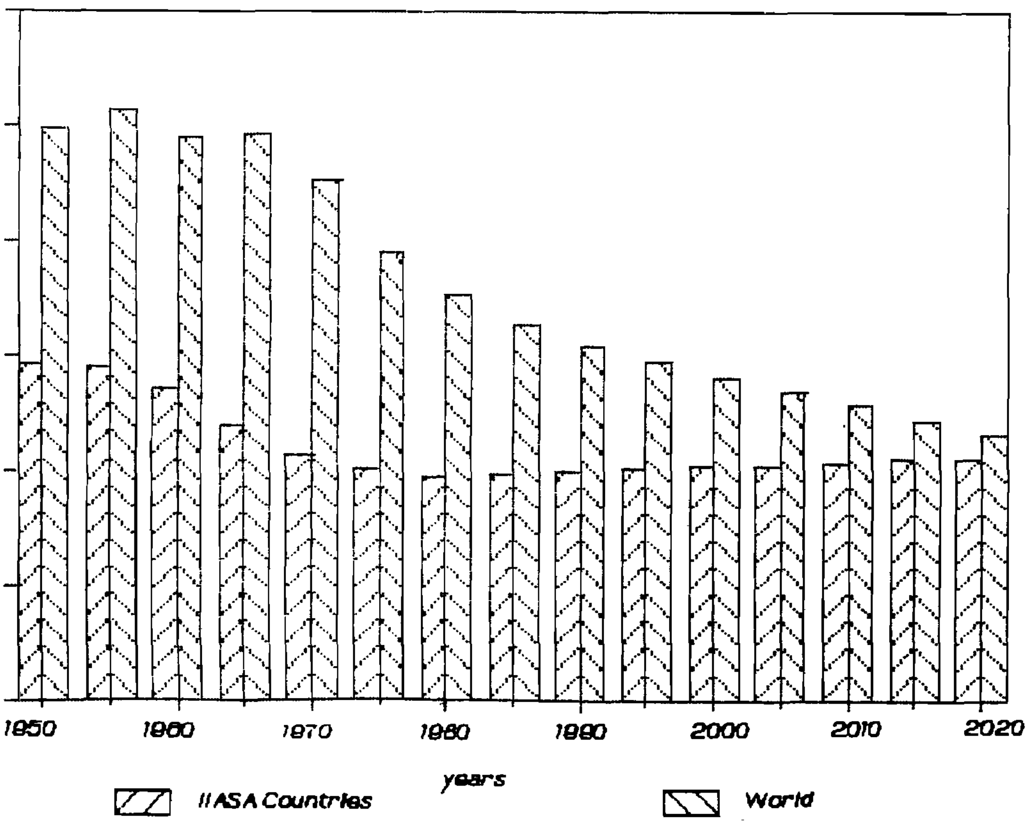
Kinship patterns are of practical importance for a number of reasons, prominent among which is the issue of support for the elderly. Family members, especially nuclear-family members (spouse, siblings, children) play important roles in the support for the elderly in many countries. Support for the elderly can take many forms, including the provision of direct financial support, the provision of informal health-care services, and shared living arrangements. At the most basic level, the complete absence of such family members from the kinship network means that the potential for support of the elderly from this important source is nonexistent. However, even given the existence of such family members, patterns of support show considerable variation according to the number, sexes, ages, and other demographic characteristics of individual members of the kin network. For example, recent research conducted by Wolf and Soldo (1986) using the U.S. 1982 National Long Term Care Survey showed that the probability that a given child provides health care to an elderly, disabled, formerly-married mother, ranges from near zero to near one according to the sex, age, marital and work status of the child, and to the corresponding attributes of any siblings.

The plan of this paper is as follows. In part II, several aggregate indicators of the aging process, as experienced by the IIASA countries, are briefly summarized. Part III presents results from a new analysis of kinship patterns, and uses these results to show how the dependency burden can be disaggregated along family lines. Family linkages between the aged and the working-age populations are illustrated for three alternative demographic scenarios, using a microanalytic simulation technique. Part IV summarizes and concludes the paper.

II. INDICATORS OF THE AGING PROCESS

In order to provide a context for the subsequent analysis, selected demographic indicators for the IIASA countries as a whole, and for the world, are shown in Figures 1-4. The graphs present historical data beginning in 1950, and continue with projected data through 2025; the source for the projections is the United Nations publication *World Population Prospects: Estimates and Projections as Assessed in 1982*. The data shown for the IIASA countries as a group in Figures 1-3 are simply weighted totals, with weights based upon 1985 total population figures. Accordingly, the data for IIASA countries as a whole are heavily influenced by that of the USSR and the US, which together receive 53.8 percent of the weights used in the calculations.

Figure 1. Total fertility rates for IIASA countries and world, 1950-2020.



In general, the figures depict a situation whereby the IIASA countries are farther along the trend than is the world at large with respect to the demographic determinants of increasingly aged population structure. In Figure 1, the total fertility rate (TFR) is shown; the IIASA countries, all of which are industrialized, have much lower fertility rates in the recent past, and in the projected near future, than does the world at large. From 1980 onwards, the TFR in the IIASA countries is actually projected to rise somewhat, while that of the world as a whole is projected to decline sharply. As a consequence, the differences between the IIASA countries and the world as a whole will be greatly diminished, although not completely eliminated, by 2020. The projected world's TFR for 2020 is at about the level shown by the IIASA countries in 1965.

Together, fertility and mortality rates determine the age composition of the population. Indicators of mortality rates--life expectancy at birth (for both sexes combined)--are pictured in Figure 2. Again, life expectancy in the IIASA countries presently exceeds that of the world as a whole, but this gap is projected to diminish greatly between now and 2020.

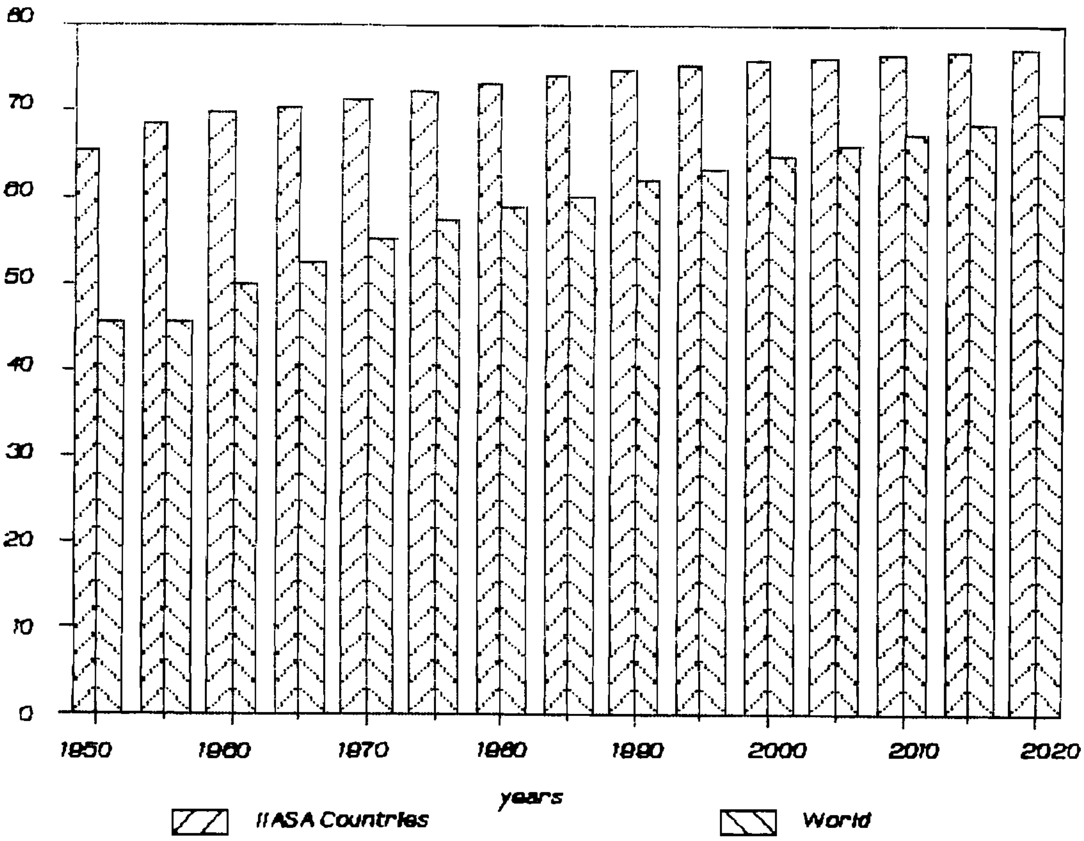
Aspects of the population age structure implied by the paths of fertility and mortality are presented in Figures 3 and 4. In Figure 3 we see the median age of the population. Here, the IIASA countries are older at the outset than is the world as a whole, but the difference between the two grows rather than diminishes throughout most of the period up to 2025. This, of course, reflects the vastly different current age structure of the industrialized countries compared to the rest of the world. The median age of the population of the combined IIASA countries, which was about 28 years in 1950, will rise to nearly 40 years by 2025.

Finally, we see in Figure 4 the aged dependency ratio, constructed as the ratio of persons over 65 to persons 20-64, for the IIASA countries and the world. As we would expect, this ratio is higher in the IIASA countries than in the world in general at present, and is projected to remain higher throughout the period covered by the projection. The dependency ratio is, in fact, one of the principal indicators cited in discussions of the potential problems posed by population aging. In the following section, this paper examines the dependency burden in greater detail.

III. DISAGGREGATING THE DEPENDENCY RATIO

As mentioned before, the aged dependency ratio commands considerable attention as an indicator of the potential problems facing an increasingly aged population. Computed as the ratio of persons 65 and older to persons aged 20 to 64, the ratio is roughly the number of retirees per worker, or potential worker. As such,

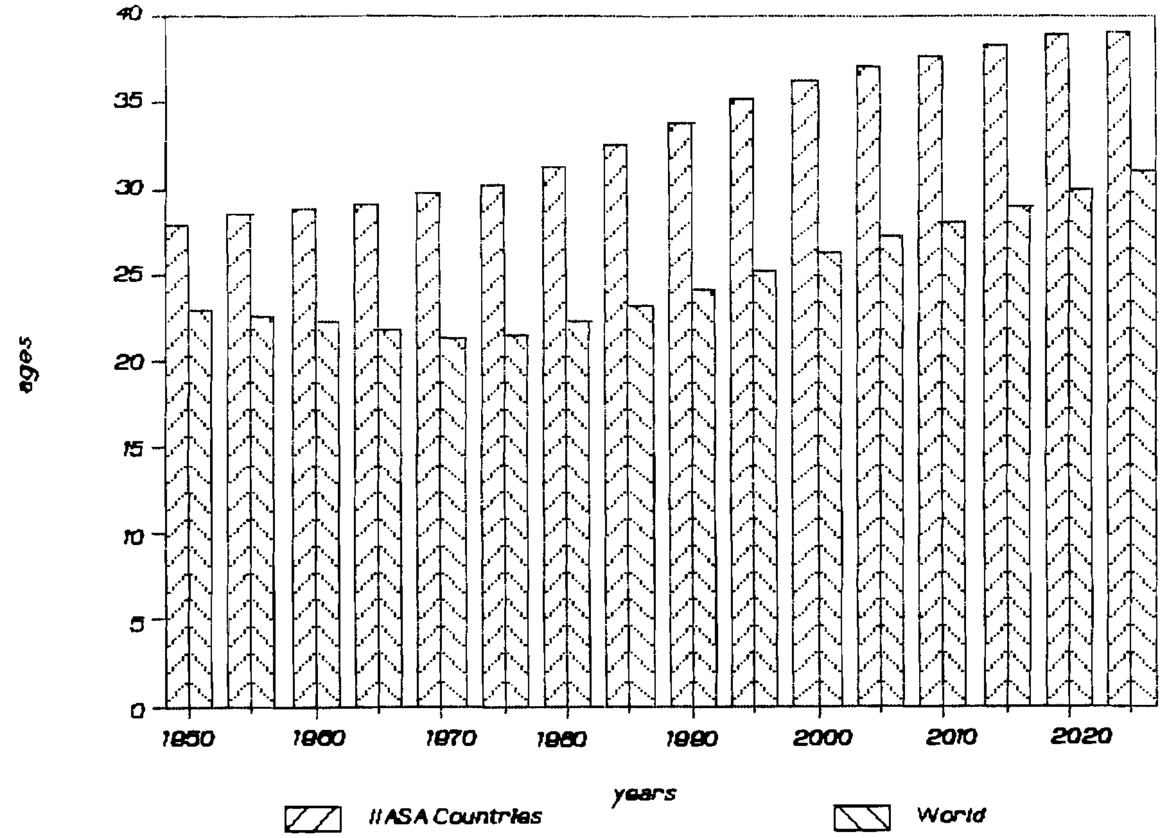
Figure 2. Life expectancy, for both sexes combined, IIASA countries and world, 1950-2020.



it can be taken as a proxy for the ratio of the elderly component of the dependent population to the economically active population. Obviously this interpretation of the ratio embodies several simplifying assumptions: it ignores the facts that many persons over 65 are economically active, that many persons over 65 contribute to their own support, and that many persons under 65 are themselves dependent--for example, as a result of ill health or disability.

Nonetheless, this aged dependency ratio forms the basis for the following discussion. Perhaps the leading reason for concern with the ratio lies in the extent to which current resources are allocated to the support of the aged. There are three broad categories of resources available for the support of the aged: the assets held by the aged themselves; collective resources, the ultimate origin of which is those currently working; and family members. In most IIASA countries, collective resources, provided via programs administered by the state, are a ma-

Figure 3. Median age of population in IIASA countries and world, 1950-2025.

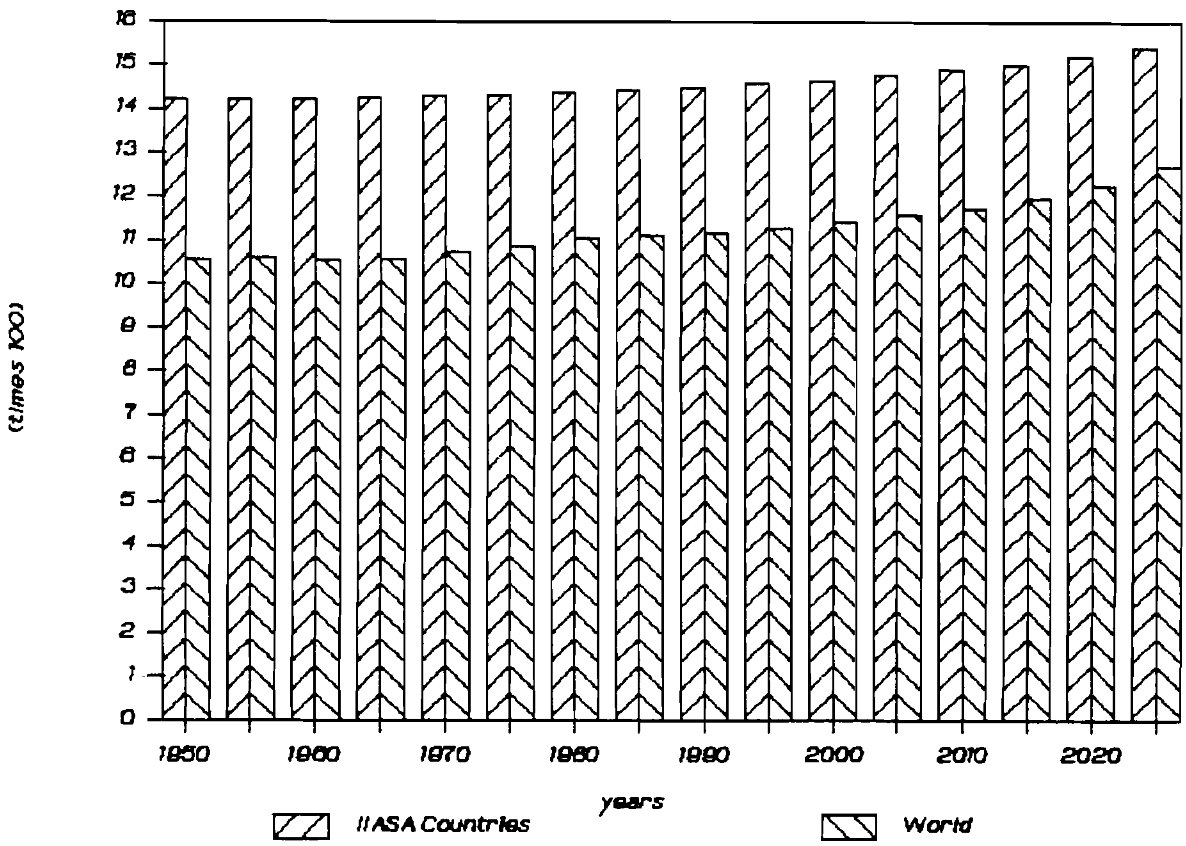


jor source of support for the aged. And it is the prospect of pressure on the state's resources, resulting from an increase in the size of the recipient populations of these programs—especially, in relation to the size of the working populations from whom the resources come—which motivates much of the policy concern about population aging.

One possible response to the prospective pressures upon public programs for the support of the aged is an attempt to shift some of the potential burden of caring for the aged away from public programs, and onto the family (for a policy-oriented discussion of this issue, see Schorr, 1980).

However, the very demographic trends that are producing the dramatic ongoing and projected trends in the age structure of the population are also altering the patterns of family networks that can, in theory, serve to substitute for the public (that is, the working population as a whole) in providing support for the aged. Reduced fertility rates and increasing longevity each influence the pattern of linkages between members of the aged population and their offspring within the working-age population. The study of this pattern requires a model of kinship, to which we now turn.

Figure 4. Aged dependency ratio for IIASA countries and world, 1950-2025.



Modelling Kinship Patterns

Demographers have a long tradition of analyzing kinship structures. At present, work on this issue can be classified into analytic models and simulation models. Examples of analytic models include the work of Goodman, Keyfitz, and Pullum (1974, 1975), further elaborated in Keyfitz (1985); Krishnamoorthy (1980); Pullum (1982); and Joffe and Waugh (1982). The Goodman et al. approach has been extended and applied by others, including Goldman (1978, 1986), Schmueli (1985), and Bartlema and de Jong (1985). Simulation analyses of kinship patterns have been reported by several authors, among which are Howell and Lehotay (1978), Hammel, Wachter and McDaniel (1981), Le Bras and Wachter (1978), and Bartlema and Winkelbauer (1986). The analytic models, while more elegant formally, are limited with respect to the goals of the present analysis: as so far developed, they are unable to represent the frequency distribution of kin over the life cycle. Consequently, the simulation approach is adopted here.

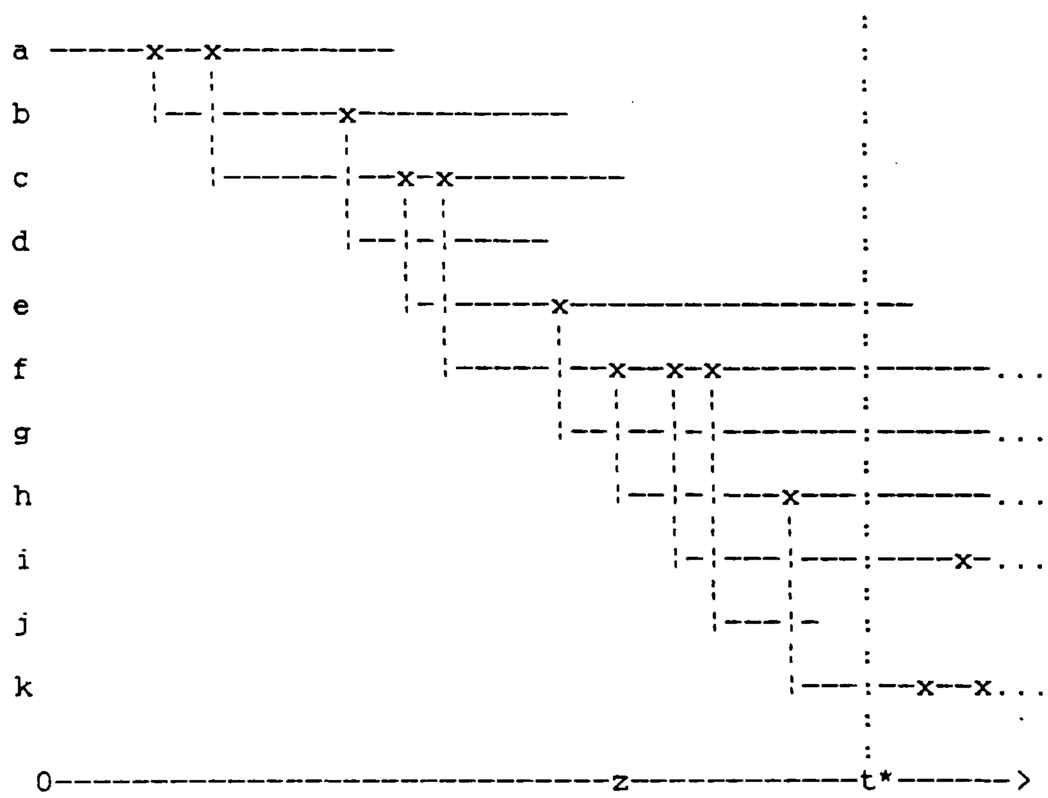
The advantage of the micro-simulation methodology used here is that it generates observations on hypothetical ***individuals***, to which attributes such as sex and the dates of birth and death are associated. Moreover, each hypothetical individual is linked to other individuals, with their corresponding attributes, in the same hypothetical population. The results presented below are generated by a new simulation procedure based upon a continuous-time stochastic event-history process; details regarding the features of the event-history process, and the technique used to simulate the process, can be found in Wolf (1986).

The assumptions underlying the simulations reported here are in many respects identical to those adopted by Goodman et al. (1974). In particular, the population is assumed to be stable and homogeneous with respect to rates of dying and childbearing; birth rates are also assumed not to depend upon parity. However, in the present simulations a minimum interval of exactly 12 months between births is assumed. And, the simulations employ a two-sex model, in the limited sense that both daughters and sons are born to the women in the hypothetical population; there is, however, no mating or "marriage market". Thus, the simulation model in its present stage of development can represent the distributions of brothers and sons as well as of sisters and daughters, but cannot represent spouses and fathers.

Basically, the approach consists of simulating *family trees* which evolve in calendar time, and then sampling from the resulting population in cross-section to obtain a picture of the kinship patterns then prevailing. Figure 5 helps to clarify the problem. The horizontal axis in Figure 5 represents calendar time, set arbitrarily to zero at the leftmost point. Horizontal line segments shown above the time axis depict individual lifetimes; the left endpoint of a segment represents one's own date of birth, while the right endpoint of a segment represents one's own date of death. x's along the segments represent times at which one's children are born.

Figure 5 depicts the lifetimes of 11 hypothetical individuals, labelled a through k. This is in fact an excerpt from a family tree, since individuals b – k are all descended from individual a. The vertical dashed lines in the figure connect mothers with their children. Thus, b and c are a's children; d is b's child; e and f are c's children; and so on. It follows that d, e, and f are a's grandchildren; more distant relationships can be additionally derived.

Figure 5. Pictorial representation of family-tree simulation problem.



A cross-sectional picture of the population pictured in Figure 5 can be obtained by "sampling" from the population at an arbitrarily chosen time, shown as t^* in the figure. At time t^*, individuals e through i, and k, are alive. Each individual's age at the time of the "survey" can readily be determined: for example, point z on the time axis corresponds to h's date of birth; therefore, h's age at the time of the survey is $t^* - z$. Similarly, it is easy to establish how many living kin, in each possible kin relationship, can be associated with each person living at time t^*. For example, in Figure 5, individual h's mother (designated as f), one of two siblings ever-born (individual i), and child (individual k) are all alive.

The simulations reported below consist of the generation of a large sample of family trees, each of which begins with a single initial mother or "seed". Each seed produces offspring, and each of these offspring produces further offspring, and so on, until some limit (expressed relative to calendar time) is reached. To each individual is attached a life-history, which consists of (1) event-history data-

-a sequence of items representing dates of own birth and death, and dates, if any, of one's children's births—and (2) "accounting" or cross referencing data--that is, identifying numbers, and references to the identifying numbers of one's mother and any children. Each such life-history is entered into a data base, which is subsequently "sampled", as depicted in Figure 5, the sample information being then tabulated for analysis.

The only input data required in order to carry out such a simulation are schedules of birth and death rates, and the ratio of males to females among all births. For the simulations reported here, sex-specific vital rates for 5-year age groups were used. The rates were treated as the parameters of an age-dependent continuous-time semi-Markovian event-history process, a special case of the general framework laid out in Wolf (1986). In particular, the probability of first birth at age a_1 is given by

$$b^*(a_1)exp\ -\int_0^{a_1} [b^*(x) + \mu(x)]dx \quad ; \tag{1}$$

and the probability of a birth at age a_t, given that there was a previous birth at age a_{t-1}, is given by

$$b^*(a_t)exp\ -\left\{\int_{a_{t-1}}^{a_{t-1}+1} \mu(x)dx + \int_{a_{t-1}+1}^{a_t} [b^*(x) + \mu(x)]dx\right\} \quad , \tag{2}$$

provided that $a_t \geq a_{t-1}+1$.

In (1) and (2) $\mu(x)$ is the death rate for females at age x, taken directly from the input data. $b^*(x)$ is the birth rate at age x, adjusted upward from the observed birth rates—$b(x)$—in order to compensate for the imposition of a minimum waiting time of exactly one year between births.

This adjustment is derived as follows. First note that the birth rate at exact age x can be expressed as

$$\begin{aligned} b(x) &= \pi_x \cdot 0 + (1 - \pi_x)b^{**}(x) \quad , \\ &= (1 - \pi_x)b^{**}(x) \end{aligned} \tag{3}$$

where π_x is the proportion of women not at risk of childbearing at age x, due to childbirth at some time in the preceding 12 months. However, the proportion π_x is simply the probability of giving birth between $x-1$ and x, given by

$$\pi_x = \int_{x-1}^{x} b(a)da \quad .$$

Thus, (3) can be rearranged, yielding

$$b^{**}(x) = \frac{b(x)}{1 - \int_{x-1}^{x} b(a)da} \tag{4}$$

which allows us to express the birth rate for those actually at risk in terms of the observed birth rate.

In most applied demographic analysis the $b(x)$ schedule is treated as piecewise constant. The data used in this analysis included birth rates constant over 5-year age groups 15-19, 20-24, and so on. In the second through fifth years of any such group, $b^{**}(x)$ as given by (4) is also constant. In the first year of each group, however, the $b^{**}(x)$ transformation is nonconstant. In particular, at age y such that $x < y = x + \Delta x < x + 1$,

$$b^{**}(y) = \frac{b(x)}{1 - [\Delta x b(x) + (1-\Delta x)b(x-1)]} \quad . \tag{5}$$

A constant-rate equivalent to $b^{**}(a)$ for use on the interval $x,x+1$ can be obtained by integrating $b^{**}(a)$ over this interval, yielding

$$b^{*}(x) = \frac{b(x)}{b(x-1) - b(x)} \{\ln[1 - b(x)] - \ln[1 - b(x-1)]\} \quad . \tag{6}$$

Equation (6) was used to calculate the adjusted birth rates used in the simulations reported below.

Further generality could be incorporated into the analysis, for example by introducing "duration dependence" as well as age dependence, by using parity-specific birth rates, and by taking account of persistent intergenerational patterns, such as positive correlations between the fertility behavior of mothers and their daughters (see Preston, 1976), or between the longevity of parents and their offspring (Jaquard, 1982; Hrubec et al., 1984); such generalizations are, however, beyond the scope of the present paper.

Simulations Performed

Three variants of the simulation procedure described above were performed for this study. All are based upon period fertility and mortality data for the Netherlands, supplied by Jan Bartlema (for a rather different approach to the study of kinship, based upon the same data, see Bartlema and Winkelbauer, 1986). The base run uses a fertility schedule implying a total fertility rate of 2.65, which is approximately the rate prevailing in 1970, and a mortality schedule implying life expectancies at birth of approximately 78 years for women, and 72 years for men (figures close to those prevailing in the period data for 1980). Since the simulations produce kin frequencies for the *stable* populations implied by the input parameters, the results are to be interpreted as illustrative of a given pattern of births and deaths, rather than a representation of a real population.

Two variants upon the base simulation were also performed. The first, a low-mortality variant, used age-specific mortality rates uniformly 25 percent lower than those in the base run. This modification implies, in turn, about a 5 percent increase in life expectancy. This increase is only slightly higher than the projected increase, by 2020, for the Netherlands as given in the United Nations projections.

The second simulation variant, a low-fertility variant, assumes a uniform 40 percent drop in age-specific fertility rates; that is, a drop to a total fertility rate of approximately 1.6. A drop this dramatic was, in fact, attained in the Netherlands between 1970 and 1980. According to the United Nations projections, the total fertility rate in the Netherlands will be only slightly below the 1.6 level for the rest of the 20th century, and will again rise, and surpass this level, early in the next century. The two variant simulations are included in order to assess the likely consequences—with respect to the patterns of living kin available to provide support for aged parents—of realistic demographic trends.

Results

Base simulation. The results obtained for the base simulation are summarized in Table 1, which presents kin patterns from the viewpoint of women. This table refers to a simulated population containing approximately 30,000 women. The population was generated by simulating the successive offspring of a large number of "seeds", as explained above, and sampling from the resulting population after 300 years of simulated evolution. Column (2) of the table shows the distribution of the cross-sectional population after 300 years of evolution by 5-year age groups;

this distribution agrees quite well with the stable age distribution obtained when the same vital rates are used to construct a conventional life table. In other words, the simulation appears to have successfully represented the stable population implied by the input data.

Table 1. Summary of simulated kinship patterns, base simulation.

Basic result

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
0- 4	0.09	1.00	29.75	0.	0.	1.00	0.	0.	1.00	0.	0.	1.00
5- 9	0.09	0.99	34.68	0.	0.	1.00	0.	0.	1.00	0.	0.	1.00
10- 14	0.08	0.99	39.66	0.	0.	1.00	0.	0.	1.00	0.	0.	1.00
15- 19	0.08	0.98	44.55	0.01	1.06	0.99	0.01	1.12	0.99	0.02	1.09	0.98
20- 24	0.07	0.98	49.62	0.18	1.71	0.83	0.17	1.58	0.84	0.36	1.65	0.68
25- 29	0.07	0.96	54.61	0.66	3.23	0.49	0.65	3.16	0.52	1.31	3.20	0.24
30- 34	0.06	0.93	59.60	1.11	5.80	0.30	1.03	5.69	0.32	2.13	5.75	0.08
35- 39	0.06	0.89	64.21	1.29	9.41	0.25	1.23	9.53	0.26	2.52	9.47	0.05
40- 44	0.06	0.80	68.96	1.37	14.26	0.22	1.30	14.00	0.25	2.67	14.13	0.04
45- 49	0.06	0.67	73.21	1.31	19.05	0.25	1.33	19.16	0.24	2.63	19.11	0.04
50- 54	0.05	0.51	77.54	1.33	23.90	0.24	1.27	24.07	0.26	2.60	23.98	0.04
55- 59	0.05	0.32	81.50	1.34	29.01	0.24	1.25	29.21	0.25	2.59	29.11	0.05
60- 64	0.04	0.16	85.77	1.33	34.07	0.24	1.26	34.16	0.25	2.59	34.11	0.04
65- 69	0.04	0.07	89.62	1.34	39.19	0.23	1.23	38.91	0.26	2.58	39.05	0.04
70- 74	0.03	0.02	92.30	1.28	44.09	0.23	1.30	43.91	0.23	2.58	44.00	0.04
75- 79	0.03	0.00	96.00	1.27	48.78	0.27	1.24	48.91	0.27	2.51	48.85	0.05
80- 84	0.02	0.	0.	1.21	53.74	0.28	1.16	53.72	0.28	2.37	53.73	0.05
85- 89	0.01	0.	0.	1.25	58.79	0.25	1.03	58.09	0.33	2.28	58.47	0.05
90- 94	0.00	0.	0.	1.14	63.91	0.33	1.08	62.66	0.34	2.22	63.30	0.08
95- 99	0.00	0.	0.	0.95	68.65	0.29	1.14	66.58	0.38	2.10	67.52	0.19
100-104	0.00	0.	0.	0.50	66.00	0.50	0.	0.	1.00	0.50	66.00	1.00

Key to columns:

(1) Age group
(2) Proportion of population in age group
(3) Proportion in age group with living mother
(4) Average age of living mothers of those in age group
(5) Mean number of living daughters of those in age group
(6) Average age of living daughters of those in age group
(7) Proportion in age group with no living daughters
(8) Mean number of living sons of those in age group
(9) Average age of living sons of those in age group
(10) Proportion in age group with no living sons
(11) Mean number of living children of those in age group
(12) Average age of living children of those in age group
(13) Proportion in age group with no living children

Existing kinship models, notably that developed by Goodman, Keyfitz and Pullum (1974), yield information such as that shown in columns (3) and (5) of the table: the mean numbers, respectively, of living mothers and daughters of living members of the stable population. The expected patterns appear here as well: at birth, everyone's mother is alive (in this simulated population, no one under the age of 5 has lost their mother); the proportion with a living mother declines steadily, slowly at first, and more rapidly in the middle ages, reaching zero in the 80-84 age group.

Column (5) shows that the mean number of daughters exhibits an inverted-u shape over the lifetime: the mean becomes positive in the earliest age group exhibiting fertility behavior—the 15-19 age group—and rises to its maximum at approximately the completion of childbearing.[2] Thereafter, the mean number of living daughters drops, reflecting mortality among the daughters. The mean number of sons [column (8)] and of all children [column (11)] behave exactly as does the mean number of daughters.

However, the microsimulation approach to studying kinship permits us to go beyond the use of average values, viewing the living-kin phenomenon in considerably greater detail. Of particular interest are columns (7), (10), and (13) which present information on the frequency distribution of living offspring by age. In the base simulation the proportion of women with no living children reaches its low of 0.04 in the 40-44 age group, remaining virtually unchanged at that level through the 70-74 age group. There is an indication that the proportion childless begins to rise rather rapidly among the oldest-old, especially those 90 and over. This must remain a rather tentative conclusion, since so few members of the simulated population fall into these age groups. For example, the proportion childless in the 95-99 age group (0.19) is based upon a sample of 21 hypothetical women; in a random sample from a real population yielding the same results, a 95-percent confidence interval for the true proportion childless would range from 0.022 to 0.358. Moreover, the conclusion is of little significance in populations with the structure of that depicted in Table 1; in such a population less than one percent of the population falls into the 90-and-over category. However, if present demographic trends continue the oldest-old groups will greatly increase in relative terms, and their unique family situation will take on added significance.

Also of interest is the data provided in column (12) of Table 1: the average age of the living children available to the population by age group. This average is, of course, increasing over the life cycle. Note that, on the average, the children of the "oldest-old" are themselves approaching retirement age.

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[2]There are some minor irregularities in column (5)—and elsewhere in Table 1—reflecting the inevitable presence of Monte-Carlo "sampling error" in the simulation; even a simulated population of over 30,000 is "small" for purposes of some of the disaggregated statistics shown in Table 1.

Table 1 advances somewhat our understanding of the constraints faced by a society which wishes to turn to the family as a source of support for the aged population. As we consider successively older ages, an increasing proportion of the elderly are without living offspring; among those with living offspring, the average age of the offspring is itself approaching, or within, the bounds of the aged category.

However, we can gain additional insights into the problem by taking further advantage of the microsimulation approach, and tabulating the simulated population along family lines. Table 2 does this, in a rather simple way, taking account only of the mother-child relationship. Two age groups are recognized: 20-64 and 65 plus, the two groups used in calculating the aged dependency ratio. In Table 2 members of the aged group are tabulated according to the number of living children they have. Only women are counted in the tabulation of the aged group. Those in the 20-64 age group are tabulated according to (1) whether their mother is alive *and* 65 or older, and (2) the size of their "sibship"—that is, the number of brothers and sisters they have, plus one (for themselves). Both men and women are included in the tabulation of the 20-64 group, since both sexes represent potential sources of support for their elderly mothers.

In Table 2, a woman in the 65+ age category will be counted twice if her mother is alive; once as one of the children of her mother, and once as an aged mother herself, classified according to the number of living children (age 20+) she has. The table is arranged such that as we read down the columns, we encounter children at *increasing* risk of being responsible for the care of an elderly mother, and we encounter mothers with a *decreasing* pool of child-resources to call upon for support. Thus, in column (1), which shows the number of children according to the existence of an aged mother and the size of sibship, we see that 69.8 percent of children 20-64 do not have an aged mother. This can mean either that their mother is alive but less than 65 years old, or that their mother is not alive. The next figure in column (1) is for children with an aged mother, and from sibships of five or more. Such children, because they have several brothers and/or sisters, bear proportionately less of the burden of parental care than do children from smaller sibships—at least, on average. Moving down this column, we see that 2.4 percent of all persons aged 20-64, in the simulated population, are only children—more precisely, only *living* children—with a living mother 65 or older.

Table 2. Cross-tabulation of aged mothers and working-age children, base simulation.

	Population Group							
	Children					Mothers		
	Age 20-64			Age 65+				
	(1) Number	(2) Proportion of Total	(3) Cumulative Proportion of Total	(4) Number	(5) Proportion of 20-64 Group	(6) Number	(7) Proportion of Total	(8) Cumulative Proportion of Total
No living mother 65+	21442	.698	.698	—	—	—	—	—
Mother 65+;								
sibship = 5+	1107	.036	.734	13	.012	300	.075	.075
sibship = 4	2208	.072	.806	36	.016	570	.143	.218
sibship = 3	3032	.099	.905	58	.019	1042	.262	.480
sibship = 2	2173	.071	.976	53	.024	1113	.280	.760
sibship = 1	737	.024	1.00	20	.027	775	.195	.955
No living children	—	—	—	—	—	176	.044	.999
Total	30699	1.00		180		3976	1.00	

In recognition of the fact that those 65 or older may not be forced to rely exclusively on family members under 65, columns (4) and (5) of Table 2 show the numbers of "old siblings": these are children, aged 65 or more, of a living mother. In all cases, of course, the living mother is at least 80 years old. The numbers are also expressed as ratios to the number of working-age children in each sibship [in column (5)]. The "old sibling" group ranges in size from 1.2 percent to 2.7 percent of the corresponding "young sibling" group.[3] In other words, the pool of 65-and-older siblings, available to assist working-age children in the care and support of aged mothers, is relatively small.

Columns (6) and (7) present the distribution of aged mothers according to the number of living children. The largest single group are those with two living children (28 percent of the total); a rather small 4.4 percent of the women 65 or older have no living children.

The figures given in Table 2 allow us to construct an aged dependency ratio that is family-based, as well as the usual population-based dependency ratio. Thus, we can establish the boundaries of family-based support for the aged population. This in turn should be of considerable interest to those who seek to use the instruments of public policy to encourage a shift of responsibility for the support of the elderly away from the state, and onto the family.

First, the conventional aged dependency ratio for the simulated population represented in Table 2 is readily computed as 3976—the size of the 65+ population—divided by 30699 in the working-age group, yielding a ratio of 0.13. In other words, if the prevailing policy for this population dictated that the working-age population shared fully and equally the burden of support of the aged, and if the aged all received an equal level of support, then each working-age individual would be required to provide .13 units of support for the aged (ignoring, in this artificial situation, the existence of aged men).

At the opposite extreme, we might envision a system whereby the state provides no support for the elderly, and requires any such support to come from family members. However improbable such a scheme may seem, it is instructive to examine the distribution of the aged dependency burden in such a situation. First, it is apparent that between 4 and 5 percent of the aged, under this extreme policy,

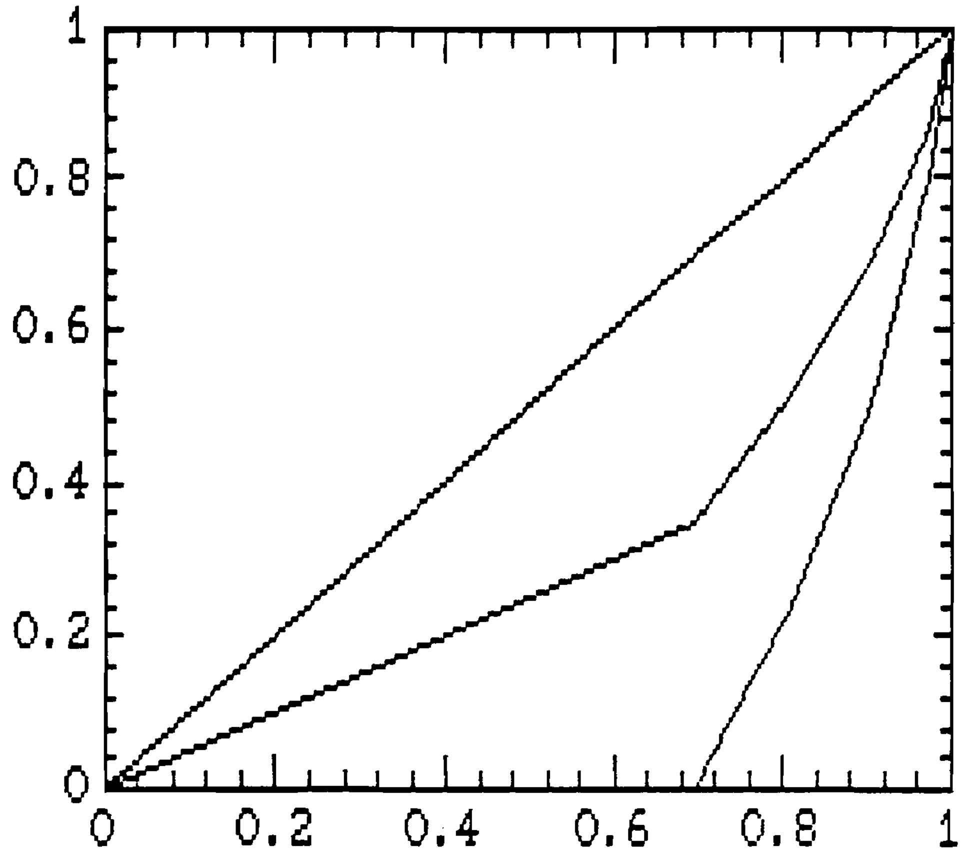
[3]The "older/younger" distinction is not appropriate in the case of only children; the relevant row of Table 2 tells us that of all living only children with a mother of 65 or older, 737 were in the 20-64 age group, and 20 were in the 65+ age group.

have access to no support from the working-age population whatsoever. Moreover, nearly 70 percent of the working-age population bears none of the aged dependency burden whatsoever. Among those working-age individuals who do have an aged parent, the dependency ratio is quite high: it is 3976 minus 176 (or, the number of aged with at least one living working-age offspring) divided by 30699 minus 21422 (or, the number of working-age children with a living aged mother), or 0.41.

An intermediate scheme for the provision of support to the aged population can also be examined. Imagine, for example, the following simple scheme: the state provides a minimum level of support to all members of the aged population; those with no family members to call upon receive only this minimum. Those aged with working-age family members receive a standard supplement to the minimum, the cost of which is shared within working-age "sibships". Thus, a working-age individual with an aged parent to support, but with no working-age siblings, must contribute a full share of the supplemental support allowance; a working-age individual with an aged parent, and with one working-age sibling, need contribute only half a share of the supplemental support allowance; and so on. In this plan, aged with many offspring are no better off than aged with few offspring.

Each of the three hypothetical support systems described above--the population-based scheme, the family-based scheme, and the mixed scheme--implies a different distribution of the aged dependency burden across the working-age population. These distributions are represented pictorially, as Lorenz curves, in Figure 6. In this figure the horizontal axis represents cumulative proportions of the working-age population, and the vertical axis represents cumulative proportions of the support burden borne by this population. The working-age population is ordered, by individual, according to the share of the support burden individually borne. The ordering is from the lowest to the highest shares of the aged support burden borne. Thus, in the extreme family-only scheme, each of the nearly 70 percent of the working-age population without living aged parents bears none of the support burden, and comes first in the array. Next come children from the largest "sibships", since they must provide the smallest fraction of a unit of support; last come only-children (that is, only-working-age children) with a living aged parent, each of whom is fully responsible for the support of their parent. This scheme is represented by the lowest of the three lines graphed in Figure 6, the data for which can be found in columns (3)--representing the horizontal axis, cumulative proportion of children by support burden borne--and (6)--representing the cumulative amount of support burden borne--of Table 2.

Figure 6. Distribution of aged dependency burden under alternative support schemes: base simulation.



The uppermost line shown in Figure 6 shows the distribution of the aged dependency burden under the population-based support scheme: this is a scheme characterized by complete equality, and hence it appears as a 45-degree straight line. The middle line represents a mixed system, in which one-half of a "standard unit" of support is collectively provided, while family members share equally in the provision of the remaining half of the standard unit. Even this intermediate scheme distributes the burden of support for the elderly rather unequally, as indicated by the divergence of the line from the 45-degree line of complete equality.

The distributions shown in Figure 6, it must be remembered, refer only to the support burden borne by the working-age population. The distribution of support *received* by the aged themselves under the three schemes is a completely different matter, although the relative patterns of inequality in the provision and receipt of support are the same across schemes: the population-based scheme confers equal shares of the burden across the entire working-age population, and bestows equal benefits across the aged population. At the other extreme, the strictly family-based scheme distributes both the support burden, and the provision of support, most unequally: a majority of the working-age population bears no support burden, and a small minority (about 4 percent) of the aged population receives no support. The mixed scheme is intermediate, with respect to both the working-age and the aged population.

We have seen how prevailing population parameters constrain the scope for shifting the burden of support for the aged from the state to the family. How does this picture change, if at all, when we consider the situation under alternative demographic scenarios?—that is, in the case of increased life expectancy and reduced fertility, both of which are expected to take place? For an answer to this question, we can examine the patterns implied by each of the variant simulations described earlier.

Variant simulations. The reduced-mortality and reduced-fertility variant simulations allow us to explore the partial effects of ongoing demographic trends that are being experienced in both IIASA and non-IIASA countries. Appendix Tables A and B—identical in format to Table 1—present details of the kinship patterns generated by the two variant simulations. The most important change caused by a drop in mortality rates is a rise in the proportion of the population with a living mother. This rise first becomes apparent in the 25-29 age group, and is on the order of a 50-100 percent increase for those approaching retirement age.

A comparison of the reduced-fertility scenario to the base simulation reveals a substantial increase in the proportion of the population over 65, and in the proportion childless at virtually all ages 15 and over. However, while there are dramatic changes with respect to offspring, there is essentially no change with respect to parents: the proportion with a living mother is about the same, at all ages, as in the base simulation.

Key findings from all three simulations are displayed in Table 3. For each indicator shown, the reduced-mortality simulation differs very little from the base simulation. Recall that in this alternative scenario, life expectancy at birth was given a modest five percent increase. Accordingly, under the alternative scenario the proportion of the population over 65 shows a modest increase: from 0.13 to 0.15. Correspondingly slight changes can be found for each of the other indicators shown.

Table 3. Summary of kinship indicators for three alternative simulations.

		Simulation	
Indicator	Base	Low-mortality variant	Low-fertility variant
Proportion of population aged 65+	.13	.15	.23
Proportion of working-aged population without aged parents	.70	.66	.67
Proportion of aged population without working-age offspring	.04	.05	.17
Population-based aged dependency ratio	.13	.13	.21
Family-based aged dependency ratio	.41	.37	.53

In contrast, the reduced-fertility simulation produces dramatic shifts in the age and kinship structure of the population. Again, this simulation assumes fertility rates that are 40 percent lower at all ages than in the base simulation. As a result, the proportion of the population in the age 65+ group rises significantly, from 0.13 to 0.23. As already mentioned, however, the proportion of the working-age population with a living aged mother changes little—a drop from 0.70 to 0.66—while the proportion of the aged population without working-age offspring is greatly increased, from about 0.04 to 0.17.

Both the population-based dependency ratio—the ratio of elders to the working-age population—and the family-based dependency ratio—the ratio of elders with working-age offspring to working-age individuals with a living aged parent—are distinctly higher in the simulated reduced-fertility world. The former exhibits a 62-percent increase, while the latter exhibits a more modest 30-percent increase. Yet within the working-age population, the distribution of *relative* shares of parental support obligations is almost indistinguishable across all three simulations; illustrations of this distribution, analogous to that shown in Figure 6 for the base simulation, are virtually identical in appearance, and hence are not shown.

The most striking contrasts suggested by the three sets of results, then, pertain to the *levels* of dependency burdens, and the gross, overall patterns of potential kin-support linkages between the aged and working-age populations. Reduced fertility not only raises the aged dependency ratio, it raises the proportion of elders with no working-age offspring to call upon (or for the state to turn to); it increases the average number of aged parents per working-age adults with living aged parents, but does not particularly affect the proportion of working-age adults with a living aged parent.

We close this section with a reminder that the simulation model used in the analysis, like all models, omits certain elements of the phenomenon being studied. Since the model used does not incorporate nuptiality, the existence of husbands and fathers cannot be taken into account. Accordingly certain qualifications must be placed on the analysis. Spouses are in fact a leading source of support for the dependent elderly. By omitting spouses, we ignore a potential source of support for the older women in the population. Even more, however, we ignore a potential demand upon the older women: namely, the demands of caregiving to their own aged spouse. Similarly, from the perspective of working-age children our ignoring of fathers means that we overstate the extent of dependency among their mothers. However, we ignore an additional (but empirically minor) claim upon the working-age children: the existence of widowed fathers.

IV. SUMMARY AND CONCLUSIONS

To summarize, this paper has examined the aged dependency burden issue at a microanalytic level, at the level of individual kin-network ties. Aggregate population data for the recent past, and projections for the coming decades, reveal patterns of low fertility and rising life expectancy for the world as a whole, and for the IIASA countries in particular. These trends in vital rates will, in turn, lead to increasingly aged population structures, with a higher ratio of over-65 people to working-age—defined as the 20-64 age group—people.

This paper has presented findings from simulation analyses designed to reveal the pattern of linkages between individuals within the aged and the working-age populations. For the rather simple models used here, the only necessary input data were age-specific schedules of fertility and mortality. Yet the type of information generated by the model is not generally available: for those countries which maintain complete population registry systems, such as the Scandinavian countries, kin-linkage information could be extracted with some effort; in other countries, data on kinship linkages has, on only a few occasions, been obtained in sample surveys.

The principal finding of the analysis was a pronounced lack of overlap of the aged and the working-age populations, with respect to nuclear-family kinship ties. Using data which imply a stable population similar in structure to the Netherlands in 1984, we find that nearly 70 percent of the working-age population does not have a living aged parent, while about 4 percent of the aged population has no offspring in the working-age group. Further reductions in mortality will tend to exacerbate this lack of overlap only slightly, while reductions in fertility on a scale that has actually been observed in some industrialized nations will significantly exacerbate the situation.

A tabulation of the working-age and aged populations according to the existence of living kin in each age group helps to define the extreme bounds for the use of family members as an alternative to collective support of the elderly. Demographic realities preclude the use of the family as the sole source of support for the elderly, since some of the aged population is without working-age family members to turn to for support. Mixed schemes of support for the aged can be used to combine collective and kin-based responsibility for supporting the aged population; the resulting public policy problem involves tradeoffs among the following three factors: the adequacy of support given the worst-off aged, the burden placed on the public budget by the universal component of the aged-support scheme, and the burden placed on those with aged parents by the family-based component of the aged-support scheme. To each possible solution to the policy problem there corresponds two distributional analyses, one pertaining to the support burden borne by the working-age population (illustrated, for example, in Figure 6) and one pertaining to the benefits enjoyed by the aged population.

The analysis presented in this paper is, of course, only a first step. More complicated demographic models can easily be envisioned. However, a more complete analysis must go beyond demography, and take account of the incentive effects of public policies. Attempts to compel a shift of the burden of supporting the aged away from the public budget and onto family members may, in the long run, influence the very behaviors that give rise to kinship patterns in the first place.

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Appendix Table A

Summary of Simulated Kinship Patterns, Variant Simulation: Reduced-Mortality Scenario

Reduced Mortality Regime

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
0- 4	0.09	1.00	29.63	0.	0.	1.00	0.	0.	1.00	0.	0.	1.00
5- 9	0.08	1.00	34.72	0.	0.	1.00	0.	0.	1.00	0.	0.	1.00
10- 14	0.08	1.00	39.80	0.	0.	1.00	0.	0.	1.00	0.	0.	1.00
15- 19	0.07	0.99	44.66	0.01	0.86	0.99	0.01	1.03	0.99	0.03	0.95	0.97
20- 24	0.07	0.98	49.52	0.19	1.74	0.83	0.18	1.70	0.83	0.37	1.72	0.69
25- 29	0.07	0.98	54.46	0.64	3.18	0.51	0.65	3.21	0.52	1.29	3.20	0.24
30- 34	0.06	0.96	59.45	1.08	5.73	0.31	1.10	5.71	0.30	2.19	5.72	0.08
35- 39	0.06	0.92	64.39	1.24	9.51	0.26	1.24	9.53	0.26	2.48	9.52	0.06
40- 44	0.06	0.85	69.20	1.34	14.18	0.23	1.32	14.10	0.24	2.66	14.14	0.05
45- 49	0.06	0.74	73.86	1.33	19.06	0.23	1.35	19.01	0.24	2.68	19.03	0.04
50- 54	0.06	0.59	78.02	1.32	24.09	0.25	1.32	24.24	0.25	2.64	24.17	0.04
55- 59	0.05	0.44	82.58	1.28	28.95	0.26	1.28	29.20	0.26	2.56	29.07	0.04
60- 64	0.05	0.27	86.67	1.27	33.78	0.26	1.36	33.84	0.23	2.63	33.81	0.05
65- 69	0.04	0.11	91.36	1.30	39.12	0.25	1.28	39.15	0.24	2.59	39.14	0.04
70- 74	0.04	0.06	95.17	1.28	44.08	0.26	1.22	44.15	0.25	2.50	44.11	0.06
75- 79	0.03	0.02	100.50	1.32	48.96	0.25	1.19	48.93	0.27	2.51	48.95	0.05
80- 84	0.02	0.01	103.50	1.32	54.20	0.25	1.20	53.61	0.28	2.52	53.92	0.06
85- 89	0.01	0.	0.	1.17	58.77	0.33	1.16	58.40	0.27	2.32	58.59	0.05
90- 94	0.01	0.	0.	1.17	63.47	0.33	1.17	63.61	0.33	2.35	63.54	0.05
95- 99	0.00	0.	0.	1.33	67.80	0.32	0.88	68.16	0.40	2.21	67.94	0.11
100-104	0.00	0.	0.	1.57	72.94	0.13	0.43	73.10	0.61	2.00	72.98	0.13

Key to columns:

- (1) Age group
- (2) Proportion of population in age group
- (3) Proportion in age group with living mother
- (4) Average age of living mothers of those in age group
- (5) Mean number of living daughters of those in age group
- (6) Average age of living daughters of those in age group
- (7) Proportion in age group with no living daughters
- (8) Mean number of living sons of those in age group
- (9) Average age of living sons of those in age group
- (10) Proportion in age group with no living sons
- (11) Mean number of living children of those in age group
- (12) Average age of living children of those in age group
- (13) Proportion in age group with no living children

Appendix Table B

Summary of Simulated Kinship Patterns, Variant Simulation: Reduced-Fertility Scenario

Reduced Fertility Regime

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
0- 4	0.05	1.00	29.92	0.	0.	1.00	0.	0.	1.00	0.	0.	1.00
5- 9	0.05	1.00	35.09	0.	0.	1.00	0.	0.	1.00	0.	0.	1.00
10- 14	0.05	1.00	40.25	0.	0.	1.00	0.	0.	1.00	0.	0.	1.00
15- 19	0.05	0.98	45.12	0.01	1.00	0.99	0.01	1.21	0.99	0.02	1.14	0.98
20- 24	0.06	0.97	50.05	0.13	1.81	0.88	0.10	1.48	0.90	0.23	1.66	0.79
25- 29	0.06	0.96	55.09	0.42	3.19	0.65	0.39	3.07	0.67	0.81	3.13	0.41
30- 34	0.06	0.94	59.82	0.72	5.69	0.48	0.69	5.68	0.49	1.41	5.68	0.21
35- 39	0.06	0.89	64.29	0.80	9.48	0.43	0.80	9.44	0.43	1.59	9.46	0.15
40- 44	0.06	0.79	69.29	0.86	14.25	0.40	0.81	14.45	0.43	1.68	14.35	0.15
45- 49	0.06	0.67	73.78	0.86	19.24	0.40	0.82	18.85	0.42	1.68	19.05	0.15
50- 54	0.06	0.50	78.02	0.85	23.85	0.41	0.81	24.24	0.43	1.65	24.04	0.15
55- 59	0.07	0.30	82.50	0.88	28.97	0.38	0.82	29.05	0.41	1.71	29.01	0.14
60- 64	0.07	0.16	86.16	0.86	34.02	0.40	0.81	34.09	0.43	1.67	34.06	0.15
65- 69	0.06	0.06	90.48	0.83	39.23	0.42	0.80	38.91	0.43	1.64	39.07	0.17
70- 74	0.06	0.02	94.53	0.82	44.15	0.42	0.84	43.98	0.40	1.66	44.06	0.16
75- 79	0.05	0.00	96.80	0.80	49.18	0.42	0.78	48.85	0.44	1.59	49.02	0.16
80- 84	0.03	0.00	103.00	0.83	53.70	0.41	0.75	53.63	0.45	1.58	53.67	0.18
85- 89	0.02	0.	0.	0.79	58.66	0.45	0.68	58.49	0.48	1.47	58.58	0.20
90- 94	0.01	0.	0.	0.82	63.39	0.42	0.62	63.26	0.50	1.44	63.33	0.20
95- 99	0.00	0.	0.	0.57	69.64	0.52	0.57	66.44	0.57	1.14	68.04	0.27
100-104	0.00	0.	0.	0.91	70.30	0.27	0.27	71.00	0.73	1.18	70.46	0.27

Key to columns:
(1) Age group
(2) Proportion of population in age group
(3) Proportion in age group with living mother
(4) Average age of living mothers of those in age group
(5) Mean number of living daughters of those in age group
(6) Average age of living daughters of those in age group
(7) Proportion in age group with no living daughters
(8) Mean number of living sons of those in age group
(9) Average age of living sons of those in age group
(10) Proportion in age group with no living sons
(11) Mean number of living children of those in age group
(12) Average age of living children of those in age group
(13) Proportion in age group with no living children