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Quality-Adjusted Life Years Lost to Arthritis: Effects of Gender, Race, and Social Class

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Objective. *To estimate the public health impact of self-reported arthritis in terms of Quality-Adjusted Life Years.*

Method. *The Quality of Well-Being Scale (QWB) is a general measure of health-related quality of life that scores levels of wellness on a continuum between death (0.0) and optimum functioning (1.0). Values for the QWB were imputed for the National Health Interview Survey. These estimates were adjusted for mortality based on the life tables. Age-specific estimates were obtained for those reporting arthritis and compared to estimators for the population not reporting arthritis. These estimates were broken down by race (white versus nonwhite), gender, and socioeconomic status.*

Results. *The expected life years lost because of arthritis were 1.86 (95% confidence interval 1.40–2.32 years). Arthritis was reported more often among those of lower income, those living in rural areas, those of lower educational attainment, and older respondents. Men and women did not differ in rates of reporting arthritis, but men with arthritis had lower QWB scores than women with arthritis.*

Conclusion. *Arthritis has a significant public health impact.*

Key words. *Quality of life; Arthritis; Race; Gender; Socioeconomic status.*

INTRODUCTION

The public health effects of musculoskeletal diseases have been difficult to estimate. Traditional outcomes in public health include life expectancy, infant mortality, and disability days. Because most musculoskeletal diseases do not cause premature death, arthritis is poorly represented by measures of life expectancy and infant mortality. Many studies have documented the impact of arthritis on disability (1,2). However, disability data are not easily compared with other public health indicators. Although it is clear that musculoskeletal diseases are associated with disability, evaluating the societal impact has been difficult. For example, it has been argued that arthritis or other musculoskeletal diseases are not taken as seriously as diseases that cause early death. This occurs, in part, because the impact of some diseases is measured in terms of life expectancy, while the effect of other diseases is represented by self-reported measures of dysfunction and disability (3).

Methods in outcomes research provide quantitative expressions that combine morbidity and mortality into a single unit (4,5). These methods are similar to traditional survival analysis. However, in survival analysis each individual is scored using a dichotomous scale for each year in his or her life expectancy. Those alive are scored as 1.0, while those who are dead are scored as 0. Quality-Adjusted Life Expectancy quantifies levels of wellness between 0 and 1.0. These numbers are then used to adjust life expectancy for diminished quality of life. The purpose of this system is to provide a single quantitative expression of wellness. Using these index numbers, it is possible to make direct

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comparisons between illnesses causing shortened life expectancy and those having their primary impact on quality of life. The purpose of this paper is to estimate the societal impact of arthritis using data from the National Health Interview Surveys (NHIS).

PATIENTS AND METHODS

Measures. Over the last 20 years, a group of investigators at the University of California, San Diego School of Medicine has worked toward the development of a General Health Policy Model. The purpose of the model is to estimate the costs, risks, and benefits of health care using a standardized unit known as the well-year of life. This is also referred to as the Quality-Adjusted Life Year (QALY), defined as the average duration or quantity of life adjusted for quality of life. Conceptually, a QALY is equivalent to one year of completely well life with no disabilities or symptoms. Well-years summarize health benefits by combining mortality (quantity of life) with morbidity (quality of life) into a single measure. Well-years are similar to estimates of life expectancy because both describe the experience of all persons in a population, regardless of age.

The calculation of well-years uses 2 different types of data. First, life tables are used to describe the proportion of people living and dying in each age category. The most common forms of arthritis and musculoskeletal diseases may have relatively little impact on these measures of mortality. However, the model also requires estimates of health-related quality of life at each phase of the life expectancy. The measures of well-being are general and include aspects of individual functioning, mental, physical, and social health. Social functioning, for example, describes limitations in performing activities of daily living including work, school, or housework. Physical functioning describes ambulation, limitations in walking, confinement to bed, couch, or chair, etc. Measures are also included to describe mobility and symptoms. The specific measure used in this research is the Quality of Well-Being Scale (QWB).

The QWB is one of several different approaches for obtaining QALYs (5). Using this method, patients are classified according to objective levels of functioning. These levels are represented by scales of mobility, physical activity, and social activity. In addition to classification into these observable levels of function, individuals are also classified by the most undesirable symptom or problem. The addition of a symptom assessment is important. On any particular day, nearly 80% of the general population is optimally functional. However, fewer than one-half of the population experience no symptoms. Symptoms or problems may be severe, such as serious chest pain, or minor, such as taking medication or following a prescribed diet for health reasons. Human value studies have been conducted to place the observable states of health and functioning onto a preference continuum for the desirability of various conditions, giving a "quality" rating between 0.0 for death and 1.0 for completely well.

The QWB has 3 function scales: Mobility, Physical Activity, and Social Activity. In order find the preference for each combination of functioning level and symptom/problem complex along the death–wellness continuum, judgments were obtained from representative peers in the community. These weights are used to place each state on a continuum that ranges from 0.0 for death to 1.0 for optimal functioning with no symptoms. Experimental studies have been used to estimate a model of preference for health states (6,7). The model assigns the preference weights to symptom/problem complexes and to components of functioning. These are recorded in Tables 1 and 2. For example, the "Weights" column in Table 1 shows how much each symptom or problem reduces the score from the initial value of 1.0. It is important to emphasize that only one symptom or problem is used in the scoring. The single-day QWB calculating formula is also shown in Table 2 (formula 1). In the General Health Policy Model, QWB inputs are integrated with terms for the number of people affected and the duration of time affected to produce the output measure, which is known as the well-year (formula 2).

The QWB has been used in population studies (8). In addition, the methods have been used in clinical trials and studies to evaluate therapeutic interventions for medical and surgical conditions. These include chronic obstructive pulmonary disease (9), acquired immune deficiency syndrome (10,11), cystic fibrosis (12), diabetes mellitus (13), atrial fibrillation (14), lung transplantation (15), arthritis (3), cancer (16), depression (17), schizophrenia (18), and several other conditions (19). Further, the method has been used for health resource allocation modeling and has served as the basis for an innovative experiment on rationing of health care by the state of Oregon (19).

National Health Interview Surveys. This study is based on data from the NHIS. This series of surveys is designed to assemble data on a national probability sample of noninstitutionalized civilians. During most years, the sample is composed of about 42,000 households, which typically include about 135,000 persons. The study used the same sampling design between its inception and 1984. The purpose of the study is to

Table 1. List of Quality of Well-Being Scale symptom/problem complexes (CPX) with calculating weights

CPX no.	CPX description	Weights
1	Death (not on respondent's card)	−0.727
2	Loss of consciousness such as seizure (fits), fainting, or coma (out cold or knocked out)	−0.407
3	Burn over large areas of face, body, arms, or legs	−0.367
4	Pain, bleeding, itching, or discharge (drainage) from sexual organs—does not include normal menstrual (monthly) bleeding	−0.349
5	Trouble learning, remembering, or thinking clearly	−0.340
6	Any combination of one or more hands, feet, arms, or legs either missing, deformed (crooked), paralyzed (unable to move), or broken—includes wearing artificial limbs or braces	−0.333
7	Pain, stiffness, weakness, numbness, or other discomfort in chest, stomach (including hernia or rupture), side, neck, back, hips, or any joints of hands, feet, arms, or legs	−0.299
8	Pain, burning, bleeding, itching, or other difficulty with rectum, bowel movements, or urination (passing water)	−0.292
9	Sick or upset stomach, vomiting or loose bowel movements, with or without fever, chills, or aching all over	−0.290
10	General tiredness, weakness, or weight loss	−0.259
11	Cough, wheezing, or shortness of breath with or without fever, chills, or aching all over	−0.257
12	Spells of feeling upset, being depressed, or of crying	−0.257
13	Headache, or dizziness, or ringing in ears, or spells of feeling hot, or nervous, or shaky	−0.244
14	Burning or itching rash on large areas of face, body, arms, or legs	−0.240
15	Trouble talking, such as lisp, stuttering, hoarseness, or inability to speak	−0.237
16	Pain or discomfort in one or both eyes (such as burning or itching) or any trouble seeing after correction	−0.230
17	Overweight or underweight for age and height, or skin defect of face, body, arms or legs, such as scars, pimples, warts, bruises, or changes in color	−0.186
18	Pain in ear, tooth, jaw, throat, lips, tongue, missing or crooked permanent teeth—includes wearing bridges or false teeth, stuffy, runny nose, any trouble hearing—includes wearing a hearing aid	−0.170
19	Taking medication or staying on a prescribed diet for health reasons	−0.144
20	Wore eyeglasses or contact lenses	−0.101
21	Breathing smog or unpleasant air	−0.101
22	No symptoms or problem (not on respondent's card)	−0.000
23	Standard symptom/problem (respondent reported a symptom on card)	−0.257
24	Trouble sleeping	−0.257
25	Intoxication	−0.257
26	Problems with sexual interest or performance	−0.257
27	Excessive worry or anxiety	−0.257

provide unbiased estimates of the noninstitutionalized population residing in the United States. The primary sampling unit covers the 50 states and the District of Columbia. The survey uses a multistage probability sampling design. The samples that are obtained each week are independent, and the weekly samples are additive over time. Some groups, for example the nonwhite population, are oversampled instead of using probabilities for selection. The study continues throughout the year with about 800 households sampled per week. Because the samples are random and independent, seasonal bias is eliminated.

The purpose of the health interview survey is to provide point estimates about the health status of the civilian noninstitutionalized population. The study is based on 4 sampling characteristics. First, there is a probability of selection inflation. This is accomplished by multiplying the reciprocal of the probabilities of selection in each step in the design. This is done for the primary sampling unit, the unit segment, and household. The second operation is an adjustment for nonresponse. A multiplication factor is applied as an adjustment for interviews that are not obtained. Third, there is a first-stage ratio adjustment so that the sample can be adjusted to the latest census data with regard to ethnicitiy and geographic location. Finally, there is a post-stratification adjustment by age, sex, and ethnicity. The survey does not include calculations for

Table 2. Quality of Well-Being Scale elements and calculating formulas

Scale, step no.	Step definition	Weight
Mobility Scale (MOB)		
5	No limitations for health reasons	−0.000
4	Did not drive a car, health-related; did not ride in a car as usual for age (younger than 16), and/or did not use public transportation, health-related; or had or would have used more help than usual for age to use public transportation, health-related	−0.062
2	In hospital, health-related	−0.090
Physical Activity Scale (PAC)		
4	No limitations for health reasons	−0.000
3	In wheelchair, moved or controlled movement of wheelchair without help from someone else; or had trouble or did not try to lift, stoop, bend over, or use stairs or inclines, health-related, and/or limped, used a cane, crutches or walker, health-related; and/or had any other physical limitation in walking, or did not try to walk as far or as fast as others the same age are able, health-related	−0.060
1	In wheelchair, did not move or control the movement of wheelchair without help from someone else, or in bed, chair, or couch for most or all of the day, health-related	−0.077
Social Activity Scale (SAC)		
5	No limitations for health reasons	−0.000
4	Limited in one other role activity, health-related	−0.061
3	Limited in major (primary) role activity, health-related	−0.061
2	Performed no major role activity, health-related, but did perform self-care activities	−0.061
1	Performed no major role activity, health-related, and did not perform or had more help than usual in performance of one or more self-care activities, health-related	−0.106

Calculating formulas

Formula 1*

Point-in-time well-being score for individual W:

$$W = 1 + CPXwt + MOBwt + PACwt + SACwt$$

Formula 2

General Health Policy Model formula for well-years (WY) as an output measure:

$$WY = [\text{no. of persons} \times (CPXwt + MOBwt + PACwt + SACwt)] \times \text{time}$$

* wt = preference-weighted measure for each factor; CPX = symptom/problem complex. With this formula, for example, the W score for a person with the following profile—CPX-11 (cough, wheezing, or shortness of breath, with or without fever, chill, or aching all over) with a weight of −0.257, MOB-5 (no limitation) with a weight of −0.000, PAC-1 (in bed, chair, or couch for most or all of the day, health-related) with a weight of −0.077, and SAC-2 (performed no major role activity, health-related, but did perform self-care activities) with a weight of −0.61—can be calculated for one day as follows: W = 1 + −0.257 + −0.000 + −0.077 + −0.061 = 0.605.

social class, but does include information on education and income. Typically, there are 686 ethnicity-unique cells and adjustments are made in order to weight data properly for representation in the population. These weights are available in public use tapes.

Although the survey does not provide detailed diagnostic information, the interview does include lists of conditions, including arthritis, that are classified using the international classification of diseases.

QWB imputation. The NHIS does not include the QWB measure. However, under a contract to Social and Scientific Systems (Bethesda, MD), the National Center for Health Statistics imputed the QWB for 4 years of the NHIS (1977, 1979, 1980, and 1984). The first step in developing the imputation methodology was to match questions on the NHIS questionnaires to those asked as part of the QWB instrument. Each QWB item was rated for definite agreement, reasonable agreement, or no agreement with NHIS items.

Each item was also evaluated for recall period. Several methodologic studies by the QWB group have demonstrated that the wording of items can have a significant impact on reported level of disability. For example, items requiring greater recall have larger biases. For items with no or only reasonable agreement, strategies were developed for imputing missing information. This was most difficult for symptom/problem complex classifications. The NHIS has not previously asked about symptoms; instead, it uses 100 self-reported health conditions that are derived from 6 different lists. In order to infer symptoms from health

conditions, an experienced clinician reviewed the condition lists and estimated the most probable symptoms.

Another technical problem was the estimation of duration. The calculation of well-years requires an assignment of duration of condition. Using social activity limitations as an anchor, we initially assumed that symptoms would persist for at least 2 days longer than they would disrupt social activity. Analysis of the imputed tapes suggests that the QWB content can be well estimated from the NHIS. Further, the imputed QWB shows greater sensitivity to minor variations in wellness than do the traditional NHIS items (8,20,21).

Estimation of QWB from the NHIS. The analyses reported here used 2 data sets: one consisting of all reported persons with arthritis (n = 2,019) from the 1980 NHIS survey, and the other consisting of a 5% random sample (n = 5,186) from the same survey. Ninety-two cases appeared in both data sets; these were dropped from the arthritis data set, leaving n = 1,927. A statistical test for differences in QWB between the 92 cases dropped from the arthritis data set and the 1,927 remaining was nonsignificant, $P = 0.3667$.

Life tables. In order to estimate life expectancy, we used "Expectation of Life and Expected Deaths, by Race, Sex and Age: 1988," from *Vital Statistics of the United States* to compute a life table for the general US population (22). The column "Expected deaths per 1,000 alive at specified age: Total" was entered into an Excel spreadsheet, along with the corresponding ages. For example, out of every 1,000 people who reach their fiftieth birthday, the table indicates that 4.98 will die before reaching their fifty-first birthday. Expected survivors per 1,000 alive at a specified age were estimated from the table.

A life table was also computed for each of the 4 combinations of gender (male, female) and race (white, black), using the appropriate columns from the *Vital Statistics* table.

Weighting factors to account for deceased respondents. Cases in both data sets were broken down into 19 age categories. Because the oldest respondents were age 96, we split the "91 years and up" category into a "91–96 years" group and an empty "97 years and up" group. This made for graphic completeness by allowing the QWB curves to meet at 0 when age approached 97 years.

By definition, the weighting factor for the QWBs in each age category was the proportion of the birth cohort still alive within that age category. Using the life table, the weighting factor was set to equal the survival proportion at the midpoint of each age category. For example, "51–55 years" was 5 years in length (ages 51 exactly to 56 minus one day), making the midpoint 53.5. Linear interpolation was used when necessary. The "97 years and up" category was treated differently and in the obvious manner; it had a survival proportion of 0 and a QWB of 0.

Because of limitations at the high end of the source table from which the survival proportions were computed, extrapolations were performed to estimate the weighting factors within the age categories "86–90 years" and "91–96 years." The computation went as follows: the conditional probability, p(x), that a person will die in the next 5 years, given that he/she reaches age x, was determined for x = 0, 5, 10, . . . , 80. The logit transformation of p(x) was computed. Curiously, after a steady rise in logit from x = 5 to x = 60, the logit dropped at x = 65 and rose after that. Thus, using SPSS, the logit at ages 65, 70, 75, and 80 were regressed on age. The fitting had an adjusted R^2 of 99.931%, and the fitted equation was used to extrapolate logits for ages 85 and 90. These values were then used to estimate the required weighting factors.

When the arthritis population was split by gender, race, and age category, empty cells were created in which QWB could not be estimated. To resolve this problem, for our gender–race analysis, we analyzed only the adults and broadened the age categories. The new age categories used were 21–35, 36–45, 46–55, 56–65, 66–75, 76–96, and 97 and up. Computation of the weighting factors went as described above, but rather than extrapolate the survival proportions at the true midpoint of the 76–96 interval, the values derived in the gender–race life tables for age 85 were used. (One difficulty in this analysis was the n of 1 child with arthritis in the 0–5 age category. It was necessary to estimate the variance in this age category by methods other than the usual. We used SPSS to regress the variances from all the other age categories [except "97 years and up"] on means for those with and without arthritis and the variance, and to predict the needed quantity from the fitted equation. The adjusted R^2 of the regression was 0.88%.)

The QWB curves and computation of total years lost. The following computational steps were taken within each age category, and separately for the persons with arthritis and the general population: 1) the mean of the QWB observations was calculated; 2) the variance of mean QWB was obtained; 3) the mean QWB scores were adjusted for deaths in the birth cohort; and 4) the variance of the adjusted mean QWB was computed. The computations were then used in a variety of analyses.

Table 3. Comparisons between arthritis reporters and the general population for males and females*

	Males			Females		
	Arthritis, %	Population, %	*P*	Arthritis, %	Population, %	*P*
Rural residence	41.6	31.9	0.01	36.3	32.8	0.280
<12 years education†	50.9	28.6	0.001	44.2	30.0	0.195
Income < $10,000	38.3	20.5	0.001	44.2	28.3	0.014
White race	88.7	87.4	0.267	89.7	86.7	0.553

* All significance tests used Mantel-Haenszel method with adjustment for age.
† Analysis of education excluded all subjects less than age 20.

RESULTS

A variety of analyses considered simple comparisons between those with self-reported arthritis and the general population. In comparison to the general population, those self-reporting arthritis were more likely to be women (63.7% versus 51.6%: age-adjusted Mantel-Haenszel test $P < 0.001$) and older. A comparison of the 2 age distributions by Kolmogorov-Smirnov (K-S) test showed the difference to be significant ($P < 0.001$). Women in the general population had a median age of 29, while the median age in the arthritis group was 61 years (K-S test, $P < 0.001$).

Table 3 summarizes characteristics of those reporting arthritis in comparison to the general population. The table offers these comparisons separately for males and females. In comparison to the general population, men reporting arthritis were significantly more likely to live in rural areas, to have less than 12 years of formal education, and to have annual incomes less than $10,000. These same trends were apparent for women, although only the income difference was statistically significant. The proportion of respondents reporting white race did not differ between the arthritis reporters and the general population for either men or women.

Computation of average QWB lost. Average QWB was estimated for each population (general population and self-reported persons with arthritis) as a weighted average of the adjusted mean QWBs across all age categories. The weights were people-years, or number of respondents in each age interval (adjusted for deaths in the birth cohort), multiplied by length of interval. The difference in average QWB between those with self-reported arthritis and the general population was 0.205. A 95% confidence interval for the average QWB lost to arthritis is 0.202 to 0.209. Table 4 summarizes these estimates broken down by gender. The table also estimates the lifetime expected QALYs lost for individuals affected by arthritis, unadjusted by the age of

Table 4. Total Quality-Adjusted Life Years (QALYs) lost and adjusted years lost pairwise comparisons*

	QALYs lost		QWB lost	
	Total	SE	Average	SE
Groups				
White males	5.816	0.313	0.178	0.004
White females	4.760	0.256	0.123	0.003
Nonwhite males	5.325	0.869	0.215	0.010
Nonwhite females	6.382	0.944	0.205	0.009
Pairwise tests				
Gender comparisons				
White: male versus female	$Z = 2.607$	$P = 0.009$	$Z = 11.316$	$P < 0.001$
Nonwhite: male versus female	$Z = -0.824$	$P = 0.410$	$Z = 0.696$	$P = 0.486$
Race comparisons				
Male: white versus nonwhite	$Z = 0.531$	$P = 0.595$	$Z = -3.393$	$P = 0.001$
Female: white versus nonwhite	$Z = -1.659$	$P = 0.097$	$Z = -8.847$	$P < 0.001$

* QALYs lost are calculated from differences between persons with self-reported arthritis and the general population multiplied by duration. QWB (Quality of Well-Being) lost considers only differences between persons with self-reported arthritis and the general population unadjusted by duration.

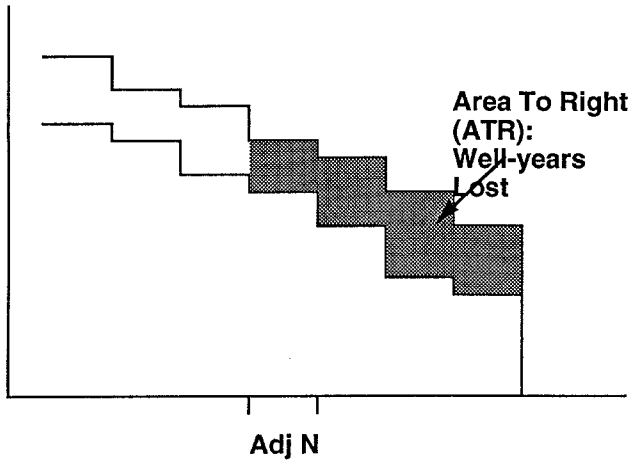

Figure 1. Hypothetical summary of Quality-Adjusted Life Years (QALYs) lost by age group in general population. The shaded area begins at age of onset. The upper curve is the general population and the lower curve is those with arthritis. The area between the curves in the shaded portion is QALYs lost.

onset. For nonwhite females, for example, the diagnosis of arthritis is associated with a loss of 6.38 QALYs. This would be equivalent to dying 6.38 years prematurely.

Computation of expected total years lost. The foregoing analysis calculates the area under the curve to estimate the lifetime total loss of well-years due to arthritis. However, it makes the assumption that arthritis begins early in life. The figures presented above assumed that a person has arthritis from birth (or, in the case of the gender–race analyses, from age 21). Similarly, we may compute lost years for persons with arthritis starting from any age category; it is simply the sum of the areas of the current age category and all those to the right (Figure 1). For example, if the condition begins on average at age 55, then QALYs lost would be calculated by finding the differences between those self-reporting arthritis and the general population each year beginning at age 55 and summing these differences through the end of the life expectancy (78 years for women and 71 years for men). (That is, if A_i = Block$_i$ is the area-between-the-curves for the ith age category (higher i corresponds to older age), $1 \leq i \leq k$, say, then for a person with arthritis starting in age category j, total years lost would equal $Y_j = A_j + A_{j+1} + A_{j+2} + \ldots + A_k$. The frequency distribution of the Y_j's is that of the arthritis population in the various age categories. Thus, if N_j = AdjN_j is the *adjusted* number of persons with arthritis (accounting for "dead" respondents) in the jth age category, and $N = N_1 + N_2 + \ldots + N_k$, then the expected total years lost for a person with arthritis—or a weighted average of total years lost—equals $\text{ExpTYL} = (N_1Y_1 + N_2Y_2 + \ldots + N_kY_k)/N$. Substituting the definition of Y_j and rearranging gives $\text{ExpTYL} = [N_1A_1 + (N_1 + N_2)A_2 + \ldots + (N_1 + N_2 + \ldots + N_k)A_k]/N$, which is easier to work with because it allows easy computation of Var(ExpTYL).) The method makes adjustments for age prevalence in the population. Overall, without regard to demographic variables, the expected total years lost for a person with arthritis, adjusted for average age of onset, is 1.86 (95% confidence interval = 1.40, 2.32). This implies that, on average, having arthritis is equivalent to having the life expectancy shortened by 1.86 years.

Table 5. Well-years lost, by subgroup

Subgroup	Expected total years lost	95% confidence interval
Male		
Urban < high school	2.17	(1.45, 2.89)
Urban high school graduate	2.65	(1.59, 3.70)
Rural < high school	1.27	(0.41, 2.12)
Rural high school graduate	2.90	(1.68, 4.12)
Female		
Urban < high school	1.38	(0.71, 2.05)
Urban high school graduate	3.00	(2.27, 3.74)
Rural < high school	0.53	(−0.20, 1.26)
Rural high school graduate	1.62	(0.70, 2.54)

Subgroup analyses. Because of the various demographic differences between the arthritis group and the general population, and because of the possible effects of these variables on QWB, the data were split along 3 dimensions into several subgroups, and a separate expected total years lost because of arthritis was computed for each subgroup. The 3 dimensions were gender, residence, and education (Table 5). Because family income was most likely to change over a lifetime, it was not used.

Pairwise gender/race comparisons. Pairwise comparisons by gender and race were made to look for differences among the groups with respect to total years lost or average QWB lost as a function of arthritis. These findings are summarized in Table 4.

The listed P values are all 2-tailed. With respect to total QALYs lost, among whites, the loss of well-years was significantly greater for men with arthritis than for women with arthritis. No statistically significant difference could be detected between male and female nonwhites, nor between white and nonwhite males. The difference between white and nonwhite females was marginally significant, with the loss of well-years

attributable to arthritis being greater for nonwhite than for white females.

With respect to average QWB lost, the only nonsignificant difference was between male and female nonwhites. Quality of Well-Being lost to arthritis was significantly greater for 1) male than for female whites, 2) nonwhite than for white males, and 3) nonwhite than for white females.

Socioeconomic status effects on QWB. Socioeconomic status (SES) is typically measured by education, income, and work status. Although the NHIS does not include an index of SES, we considered 3 variables relevant to social class: income, rural residence, and education. A series of analyses compared differences in QWB when respondents were grouped by *pairs* of demographic variables. Because the sample sizes were inadequate for an analysis of nonwhite populations, only white subjects (age 21 years and older) were analyzed. The analyses used an analysis of variance of QWB, in which several 2-factor interactions were significant. Because the education variable was included, only respondents older than 30 years were considered for the analyses.

Gender by family income. Among respondents with annual family income less than $10,000, males had a significantly lower QWB scores than females, 0.633 (± 0.109) versus 0.659 (± 0.089), $P < 0.001$. The reverse was true among respondents with annual family income greater than $10,000: in this group, females had a lower QWB than males, 0.706 (± 0.100) versus 0.715 (± 0.111), $P = 0.026$. Thus, the common finding that low income is associated with lower health status was moderated by gender.

Residence by reported arthritis. In the general population, rural residents had lower QWB scores than urban-dwellers, 0.714 (± 0.107) versus 0.735 (± 0.114), $P < 0.001$. The same was true in persons with arthritis, but to a lesser degree, 0.633 (± 0.070) versus 0.640 (± 0.068), $P = 0.035$.

Education by age. Among respondents younger than 40 years, no significant difference in QWB between those with and those without a high school diploma could be detected, 0.755 (± 0.120) versus 0.751 (± 0.131), respectively, $P = 0.722$. Among respondents 40 years and older, those without a high school diploma had a lower QWB than those with a diploma, 0.654 (± 0.097) versus 0.692 (± 0.091), $P < 0.001$.

Other gender and age effects. *Gender by reported arthritis.* In the general population, no significant difference in QWB between men and women was detected, 0.731 (± 0.116) versus 0.725 (± 0.108), respectively, $P = 0.229$. On the other hand, men who reported arthritis had a lower QWB than women reporting arthritis, 0.627 (± 0.075) versus 0.644 (± 0.064), $P < 0.001$.

Age by reported arthritis. In the general population, respondents 40 years and older had a lower QWB than those younger than 40, 0.711 (± 0.103) versus 0.776 (± 0.123), $P < 0.001$. The same was true in respondents with arthritis, but to a lesser degree, 0.636 (± 0.069) versus 0.658 (± 0.058), $P < 0.001$.

DISCUSSION

The public health impact of musculoskeletal diseases has been difficult to estimate. Traditional public health statistics often fail to represent the impact of these conditions. For example, public health measures often focus on life expectancy, infant mortality, and disability days. Arthritis rarely causes early mortality; thus, its impact is minimized if only life expectancy and infant mortality indicators are used. Disability days do capture the effects of arthritis. However, these measures are insensitive to much of the variation in musculoskeletal diseases. Further, it is difficult to make a direct comparison between diseases that affect disability and those that cause early mortality. One of the advantages of the well-years or QALY approach is that it can be used to quantify the effects of very different conditions and compare them using the same units (19,23). The analysis suggests that the impact of self-reported arthritis is substantial. For the average person, the diagnosis of arthritis is equivalent to losing 1.86 years from life expectancy. Among those diagnosed before mid-life, the loss is equivalent to losing over 5 years.

Our data are consistent with several related analyses. For example, Reynolds and colleagues modeled the impact of musculoskeletal disease and arthritis in Canada. Using a similar methodology, they estimated that the unadjusted current life expectancy for 15-year-olds was about 65 years (total life expectancy of about 80 years) for women and about 59 years (total about 74 years) for men (24). Adjustments for quality of life loss associated with arthritis produced a net loss of about 3.3 years for women and about 1.6 years for men. Our results are quite similar, but show less discrepancy between the genders. Our results on gender differences are consistent with Reynolds et al for nonwhites, but they are inconsistent for white respondents. One explanation for these differences is that the Canadian data were not directly estimated. In other words, prevalence data were estimated from the US National Health and Nutrition Examination Survey and extrapolated to the Canadian population. Estimates of disability were low-

er than for the NHIS sample. It is also important to emphasize that the total QALYs lost in all analyses will be greater for women than for men. The reason for the greater total loss to society among women is that musculoskeletal diseases are more common among women than among men. Thus, the average QALYs lost will be multiplied by a larger number for women than for men.

Results from this study suggest that arthritis is more common among those who are nonwhite, those who live in rural areas, women, and those with fewer economic resources. These findings are consistent with a wide variety of analyses showing that health status is inversely correlated with socioeconomic variables (25). Although the direction of causation can not be determined from our data, it is likely to be bidirectional (26). Arthritis may cause disability and loss of income, and, conversely, the stress associated with the loss of income may exacerbate the illness. Arthritis may have a greater impact on those with less education because they are more dependent on physical skills than those with more education.

We must recognize the many limitations of our analysis. For example, the study depends on self-reported arthritis and we have no verification that people who self-identify arthritis actually have the disease. A second major limitation is that the NHIS tapes available to us coded racial background only as white and nonwhite. The nonwhite category is very heterogeneous and probably includes a wide variety of ethnic and racial groups. A third significant problem is that the data are old. These analyses are based on a 1980 survey. We used data from 1980 tape because it was the best available public tape that allowed the calculations of QALYs. Although the data are older, there is reason to believe that the impact of arthritis on quality of life has not changed significantly over the past 16 years.

The method of imputing QWB from the NHIS may involve considerable error. The QWB measure was not actually included in the NHIS, rather it was estimated on the basis of other responses to the survey. The problems with this methodology have been discussed elsewhere (8). Suffice it to say that difficult assumptions are required in order to proceed with this type of analysis. However, the same data set and the same imputed QWB values were used to provide preliminary estimates of the quality-adjusted life expectancy of the US population for the *Healthy People 2000 Report.*

Despite these limitations, our data suggest that the public health impact of arthritis is substantial. Because of its high prevalence, even minor improvements for the average arthritis patient will result in substantial public health benefits.

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