Evidence for Decline in Disability and Improved Health Among Persons Aged 55 to 70 Years: The Framingham Heart Study

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ABSTRACT

Objectives. This study detected secular change in disability and health among persons aged 55 to 70 years, the life period when increases in disability and morbidity begin and retirement occurs.

Methods. Cross-sectional comparisons were completed with data from similarly aged members of the original (n = 1760) and offspring (n = 1688) cohorts of the Framingham Heart Study, which represent 2 generations. Analyses were conducted by gender and on chronic disease subgroups by logistic regression.

Results. There was substantially less disability in the offspring cohort than in the original cohort. Thirty-six percent of offspring men were disabled vs 52% of original cohort men ($P = .001$); among women, these proportions were 54% vs 72% ($P = .001$). Fewer offspring perceived their health as fair or poor and fewer had chronic diseases. Offspring were more physically active and less likely to smoke or consume high amounts of alcohol, but their average weight was greater. The secular decline in disability was strongly evident among individuals with chronic diseases.

Conclusions. Our findings depict a secular change toward a less disabled and globally healthier population in the period of life when retirement occurs. (*Am J Public Health*. 1999;89:1678–1683)

Evidence of secular changes in disability and health has been sought as an indication of the effects of disease prevention, health promotion, and health care activities and as an aid to social program planning.[1–4] The life period of 55 through 70 years is particularly appealing for examination of such secular changes, because age-related increases in the prevalence of disability and morbidity begin to occur at this time.[5] These life years are also when people usually retire, so disability and health data about this period relate to an important social program change: the increase in age for full Social Security retirement benefits from 65 to 67 years.[6]

We examined evidence for secular change in disability and health among people aged 55 to 70 years, using data from the Framingham Heart Study (FHS). The FHS offers a unique opportunity to investigate such changes, since similar data from 2 cohorts, representing 2 generations, are available. Further advantages of FHS data are the availability of a measure of disability based on difficulty in functioning rather than need for help and of several measures of health, including general health status, medically defined clinical diseases, and health behaviors.

Since cardiovascular diseases have accounted for a substantial proportion of disability,[7] a contemporaneous decline in their prevalence[2,8] could account for any secular decline in disability, assuming an unchanging prevalence of disability in persons with and without these diseases. Therefore, we also examined evidence for secular change in disability and health status among FHS cohort members with and without chronic diseases. This has not been done in other studies.

Methods

This investigation compared individuals aged 55 to 70 years from the original FHS cohort with those in the same age range in the offspring cohort. In the FHS, clinical data and self-reported health and demographic data are collected at regular intervals; disability data have been collected at selected examinations.

Original Cohort

The FHS was started in 1948 as a prospective investigation of cardiovascular disease. A total of 5209 residents of Framingham, Mass (a town west of Boston) between the ages of 30 and 62 were enrolled in the study between 1948 and 1951.[9] These residents constituted approximately one third of the town's population and are the original study cohort. Almost all subjects were White. Further details about recruitment are described elsewhere.[9]

Offspring Cohort

The second cohort, the Framingham Offspring Study, consists of 3544 children of parents from the original cohort and 1580 spouses of these offspring.[9] The racial/ethnic

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characteristics of this sample are therefore similar to those of the original cohort. In families where both parents were FHS participants (63% of participants), all children were contacted. Where 1 parent was a FHS participant, children of parents with coronary heart disease or abnormal lipoprotein patterns were preferentially recruited. All 5124 individuals were enrolled between 1971 and 1978.

Definition and Construction of Variables

The study variables were grouped under the following headings: (1) disability, (2) health, and (3) demographic characteristics. Many of the same methods of measurement were used in collecting data from both cohorts. The wording of the self-report questions we used was identical to that of the original study, except for the activities of daily living items. Self-reported data were collected by an interviewer in the original cohort and by self-administration in the offspring cohort.

Disability variables. Three components of disability were measured. A physical activity component consisted of 9 activities developed by Nagi: pulling or pushing large objects; stooping, kneeling, and crouching; reaching above shoulder level; reaching below shoulder level; handling small objects; standing longer than 15 minutes; sitting for an hour or more; lifting less than 10 pounds; and lifting more than 10 pounds.[10] Subjects' difficulty in doing each function was indicated as none, a little, some, a lot, unable to do, or don't do under doctor's orders.

A gross motor component contained 3 Rosow-Breslau Functional Health Index functions: walk one half mile, walk up and down stairs to the second floor, and do heavy work around the house.[11] Subjects reported whether they could or could not do these activities without help. Finally, an activity of daily living component consisted of bathing, dressing, eating, and transferring functions taken from the Katz activity of daily living scale.[12] Wording of the transfer item changed from "bed to chair" in the original cohort to "chair to standing" in the offspring cohort. Wording of the response categories changed from "no help, help from special equipment or device, help from another person, or help from both another person and special equipment" in the original cohort to "no help needed, device used, or human assistance needed" in the offspring cohort.

Cumulative disability scales for each of the disability components were constructed by previously developed methods.[13] First, responses to each activity were dichotomized to unlimited (no difficulty or no human help needed) vs limited (any amount of difficulty or any human help needed). Next, scales consisting of all the items in a component were developed. Each scale was then dichotomized into unlimited—that is, no limitation in any of the activities—and limited categories.[13] Finally, we defined 2 levels of disability on the basis of previous work[13]: (1) no limitation in any component vs limitation in any component and (2) no limitation or limitation in the physical activity component only vs limitation in the gross motor and/or activity of daily living components.

Health variables: self-perceived health, chronic diseases, and health behaviors. Self-perceived health was the 4-unit rating of general health status (excellent/good/fair/poor) recognized as a good predictor of mortality among the elderly.[14] Using FHS protocols described in the next paragraph, we ascertained the prevalence of each of these chronic diseases: cardiovascular diseases, including myocardial infarction, angina pectoris, congestive heart failure, stroke, and intermittent claudication; hypertension; diabetes; chronic obstructive pulmonary disease; and arthritis. These diseases were selected because of their association with disability in prior Framingham investigations.[15,16] In addition, a variable specifying chronic disease was constructed to indicate presence of any of these diseases.

Cardiovascular diseases were characterized through standardized published criteria. Such diseases were assigned a diagnosis and date by a panel of 3 physicians.[17] Hypertension was defined as systolic pressure of 140 mm Hg or higher, diastolic pressure of 90 mm Hg or higher, or current use of antihypertension medication. Diabetes was defined as a casual glucose level of 200 mg/dL or higher in the original cohort, a fasting glucose level of 140 mg/dL or higher in the offspring cohort, or—in both cohorts—use of either insulin or oral hypoglycemics. Clinically relevant chronic obstructive pulmonary disease was defined as a forced expiratory volume in 1 second (FEV_1) of less than 65% of predicted value plus an FEV_1–to–forced vital capacity (FVC) ratio of less than 90% of predicted value. Predicted values of FEV_1 and FEV_1-to-FVC ratios were derived from sex-specific regression equations relating each of these variables to height and age among healthy nonsmokers in the cohorts. Because there were no clinical data on arthritis available, we based the arthritis definition on the Framingham examining physician's diagnosis. This was definite arthritis in the original cohort and definite degenerative joint disease or rheumatoid arthritis in the offspring cohort. Chart review of diagnoses of arthritis in the original cohort showed that over 90% of definite arthritis consisted of degenerative joint disease or rheumatoid arthritis.

The health behaviors were physical activity, weight, smoking, and alcohol intake. Physical activity scores were calculated from items assessing amounts of rest and activity in a typical day. These amounts were weighted to reflect metabolic expenditure and summed.[18] Because physical activity data for the original cohort were available only at the examination conducted 4 years before the Disability Study, we used physical activity data collected 4 years earlier for the offspring as well. Current body mass index (BMI)—that is, weight in kilograms divided by height in meters squared—was used to assess secular change in weight.

Questions about the number of drinks of beer, wine, and liquor consumed per week were used to calculate current intake of alcohol in grams. Daily alcohol intake was estimated by the following formula: $[(0.57 \times \text{number of cocktails per week}) + (0.44 \times \text{number of beers per week}) + (0.40 \times \text{number of glasses of wine per week})] \times 28.35/7$. Three categories of alcohol intake were formed: none, light to moderate, and high; US Department of Agriculture dietary guidelines, in which light to moderate is no more than 2 drinks per day for men and no more than 1 drink per day for women, were used. Data on current and past cigarette smoking were used to categorize individuals as never, former, or current smokers.

Demographic characteristics. Demographic variables were age, sex, marital status, education, and employment status. Marital and employment statuses were dichotomized into married or unmarried and employed or unemployed. We divided educational attainment into 2 categories: high school diploma or less education, and education beyond high school.

Analysis

Full cohort sample comparisons were conducted separately for men and women, because there are differences by sex in disability and health.[19] Since age is strongly associated with disability and health, differences in age per sample were examined within each sex group by the Student *t* test. Significant differences in the ages of the cohort samples were found for both sexes (Table 1), so in comparisons of all other variables, the cohort effect (an indicator variable) was examined by logistic regression to adjust for age as a continuous variable. The age distribution of the combined cohort samples was used to calculate percentages standardized by age.

To examine the extent of secular change among persons with and without chronic diseases, we formed 2 subgroups consisting of persons with chronic diseases (n = 2375) and without chronic diseases (n = 946). In each

TABLE 1—Demographic Characteristics of Original Cohort vs Offspring Cohort, Aged 55–70 Years: The Framingham Heart Study

	Men			Women		
	Original Cohort (n = 753)	Offspring Cohort (n = 819)	P	Original Cohort (n = 1007)	Offspring Cohort (n = 869)	P
Mean age, y (SE)	63.1 (0.14)	61.9 (0.16)	<.001	63.6 (0.12)	62.1 (0.15)	<.001
Married,[a] %	89.8	87.0	0.1	64.3	71.3	.01
>High school, %						
Educational attainment[a]	29.4	48.5	<.001	30.6	42.5	<.001
Employed,[a,b] %	65.3	56.5	<.001	38.9	43.8	0.1

[a]Percentages standardized by age.
[b]Full- and part-time employment.

TABLE 2—Disability Status of Original Cohort vs Offspring Cohort, Aged 55–70 Years: The Framingham Heart Study

	Men (n = 1572)			Women (n = 1876)		
	Original Cohort (n = 753)	Offspring Cohort (n = 819)	P	Original Cohort (n = 1007)	Offspring Cohort (n = 869)	P
Limitation in at least 1 function,[a] %	52.4	36.1	<.001	71.6	53.6	<.001
Difficulty with at least 1 physical activity function,[a,b] %	50.8	35.6	<.001	69.1	52.1	<.001
Help needed in at least 1 gross motor function,[a,c] %	16.0	8.8	<.001	29.2	17.2	<.001
Help needed in at least 1 activity of daily living function,[a,d] %	1.3	0.5	.17	1.0	1.1	.86

[a]All percentages standardized by age; limitation is difficulty or need of help.
[b]Nagi activities; i.e., pushing, stooping, reaching, writing, standing, sitting, and lifting.
[c]Rosow-Breslau activities; i.e., heavy household work, walking up and down stairs, and walking one half mile.
[d]Katz activities; i.e., bathing, dressing, eating, and transferring.

subgroup, we used logistic regression to compare outcomes between cohorts, adjusting for both age and sex. The joint distribution of age and sex in the subgroups was used to calculate percentages standardized by age and sex. Because of the known drop in cardiovascular diseases and the importance of these diseases in causing disability, we examined cohort differences in the subset of persons with cardiovascular diseases (n = 466), using the same methods.

Results

An initial Framingham Disability Study was conducted among members of the original cohort between 1976 and 1978; 75% of living members attended this study.[20] Of these living members, 1760 were aged 55 through 70 years, and they constituted the older generation sample. The median birth year of this sample was 1914.

Disability data like those in the Framingham Disability Study were collected during offspring examination 5; 81% of living members attended this cycle. Of these living members, 1688 were aged 55 through 70 years, and they constituted the younger generation sample. The median birth year of this sample was 1931.

In the original cohort sample, the mean age of the men (n = 753) was 63 years, compared with a mean age of 62 years ($P<.001$) among the offspring men (n = 819) (Table 1). A small age difference existed for women also (mean age 64 years among 1007 original cohort women and 62 years among 869 offspring women; $P<.001$). More offspring women were married than original cohort women, while the rates were approximately the same among men. The proportions of offspring men and women who had attained education beyond high school were higher than those in the original cohort. Fewer offspring men (57%) were employed than men in the original cohort (65%; $P<.001$), whereas a modestly higher percentage of offspring women (44%) were employed compared with original cohort women (39%; $P=.10$).

Overall, there was substantially less disability among the offspring cohort than the original cohort (Table 2). Fewer offspring subjects than original subjects were limited in 1 or more of the disability components (men, 36% vs 52% [$P<.001$]; women, 54% vs 72% [$P<.001$]). Secular improvements were also found at the more severe level of disability, that is, limitation in 2 or more components: 7% for offspring men vs 12% for original cohort men ($P=.001$) and 15% for offspring women vs 26% for original cohort women ($P=.001$) (data not shown). Among the 3 disability components, similar declines were seen in the physical activity and gross motor components (Table 2). Little difference was seen in the activity of daily living component, but the proportions of subjects needing help in these functions were small.

There were also indications of improved health among the offspring subjects (Table 3). Fewer offspring subjects perceived their health as fair or poor than in the original cohort (men, 10% vs 15% [$P=.01$]; women, 9% vs 15% [$P=.001$]). The rates of cardiovascular disease, hypertension, chronic obstructive pulmonary disease, and arthritis were lower in both offspring sex groups (Table 3). In contrast, more offspring subjects had diabetes than did original cohort members. Persons in the offspring sample were more physically active than those in the original cohort sample (Table 4); this was true for both sexes, but especially so for women. Other indications of health behavior improvement were lower current smoking rates (men, 15% vs 31% [$P<.001$]; women, 17% vs 34% [$P<.001$]) and lower rates of higher than recommended alcohol intake (men, 20% vs 31% [$P<.001$]; women, 15% vs 20% [$P=.004$]). Offsetting these favorable changes was an increased mean BMI among offspring members of both sexes (men, 28.2 vs 27.2 [$P<.001$]; women, 27.3 vs 26.5 [$P<.001$]).

TABLE 3—Health Status of Original Cohort vs Offspring Cohort, Aged 55–70 Years: The Framingham Heart Study

	Men (n = 1572)			Women (n = 1876)		
	Original Cohort (n = 753)	Offspring Cohort (n = 819)	*P*	Original Cohort (n = 1007)	Offspring Cohort (n = 869)	*P*
Fair or poor health perception,[a] %	14.6	9.6	.01	14.8	9.3	.001
Chronic disease,[a] %	73.6	68.9	.04	76.8	67.9	<.001
Cardiovascular diseases[b]	19.9	13.7	.001	12.8	8.3	.003
Hypertension	58.0	50.5	.004	59.6	46.6	<.001
Diabetes	7.6	11.8	.02	4.5	7.5	.01
Chronic obstructive pulmonary disease[c]	9.9	6.7	.01	6.3	4.9	.21
Arthritis	15.7	14.4	.69	34.3	26.2	<.001

[a]All percentages standardized by age.
[b]Includes myocardial infarction, angina, congestive heart failure, stroke, and intermittent claudication.
[c]Clinically relevant disease; i.e., forced expiratory volume in 1 second (FEV_1) of less than 65% of predicted value plus an FEV_1–to–forced vital capacity (FVC) ratio of less than 90% of predicted value.

TABLE 4—Health Behaviors of Original Cohort vs Offspring Cohort, Aged 55–70 Years: The Framingham Heart Study

	Men (n = 1572)			Women (n = 1876)		
	Original Cohort (n = 753)	Offspring Cohort (n = 819)	*P*	Original Cohort (n = 1007)	Offspring Cohort (n = 869)	*P*
Physical activity index, mean (SE)	35.8 (0.23)	37.4 (0.22)	<.001	33.2 (0.20)	36.4 (0.22)	<.001
Body mass index, mean (SE)	27.2 (0.17)	28.2 (0.16)	<.001	26.5 (0.15)	27.3 (0.16)	<.001
Smoking[a]						
Never smoked, %	26.9	28.8	.55	43.0	43.5	.97
Former smoker, %	41.9	56.3	<.001	23.3	39.5	<.001
Current smoker, %	31.2	15.0	<.001	33.7	17.0	<.001
Alcohol intake						
None, %	24.9	28.4	.18	43.7	40.8	.31
Light to moderate,[b] %	44.3	51.2	.005	36.9	44.7	.001
Heavy, %	30.8	20.4	<.001	19.5	14.5	.004

[a]Cigarettes.
[b]Men up to 2 drinks per day; women up to 1 drink per day.

Overall, the proportions of offspring members having any of the chronic diseases were lower than those of members of the original cohort (men, 69% vs 74% [*P* = .04]; women, 68% vs 77% [*P* = .001]). There was less disability in the offspring cohort than in the original cohort among persons with and without these chronic diseases (Table 5). Fifty-one percent of offspring subjects with chronic disease, vs 66% of the original cohort, were limited in 1 or more disability components (*P* < .001). This difference was even more substantial in the subset of persons with cardiovascular diseases (51% of the offspring cohort vs 79% of the original cohort) (data not shown). Secular improvements in self-perceived health and in physical activity, smoking, and alcohol intake were also seen in the subgroup with chronic diseases. In the subgroup without chronic diseases, the proportion of offspring members viewing their health as fair or poor was only modestly lower, but the same secular improvements in health behaviors were evident. Weight increased in the offspring cohort in both subgroups.

Discussion

We found evidence of secular improvement in disability and health in men and women aged 55 through 70 years, the life period when health typically begins to decline and disability increases.[5] Members of the FHS offspring cohort who were in this life period in 1994 reported less difficulty in doing physical activities and less need for help in carrying out gross motor functions than did similarly aged members of the original cohort in 1977. Small numbers of persons in both cohorts needed help with activity of daily living functions, and there was little evidence of secular improvement in this type of disability. Other studies have not reported consistent secular trends in activity of daily living functioning.[21,22]

Declines in the prevalence of disability among persons 65 years and older have been reported in studies using data from the 1982–1994 National Long-Term Care Survey (NLTCS) and the 1984–1993 Survey of Income and Program Participation (SIPP).[22,23] In the SIPP data, the decline in disability was less evident among persons aged 50 to 64 years.[23] Our finding of a substantial decline in disability in the 55-to-70-year age group differs from SIPP data because of a different age period definition and because of the longer time gap in our study.

Some of the decline in disability that we found can be explained by the lower prevalence of chronic diseases—especially cardiovascular disease, hypertension, and chronic obstructive pulmonary disease—in the offspring sample. Similar declines have been reported in other studies.[4,17,24] The significant decline in arthritis among women that we found was also seen in

TABLE 5—Original Cohort vs Offspring Cohort Subgroups, Aged 55–70 Years, With and Without Chronic Diseases[a]: The Framingham Heart Study

	With Chronic Diseases			Without Chronic Diseases		
	Original Cohort (n = 1318) (75.4%)	Offspring Cohort (n = 1057) (66.2%)	*P*	Original Cohort (n = 407) (24.6%)	Offspring Cohort (n = 539) (33.8%)	*P*
Limitation in at least 1 function,[b] %	65.5	50.5	<.001	55.1	35.3	<.001
Difficulty in at least 1 physical activity function,[b,c] %	62.9	49.1	<.001	54.5	34.8	<.001
Help needed in at least 1 gross motor function,[b,d] %	27.5	16.2	<.001	9.9	5.6	.02
Help needed in at least 1 activity of daily living function,[b,e] %	1.3	1.0	.47	0.6	0.0	1.0
Fair/poor health perception,[b] %	17.5	11.8	<.001	5.4	3.8	0.9
Employed,[b] %	46.4	46.2	.69	62.8	57.7	.05

[a]Cardiovascular diseases, hypertension, diabetes, chronic obstructive pulmonary disease, and arthritis.
[b]All percentages standardized by age and sex; limitation is difficulty or need for help.
[c]Nagi activities; i.e., pushing, stooping, reaching, writing, standing, sitting, and lifting.
[d]Rosow-Breslau activities; i.e., heavy household work, walking up and down stairs, and walking one half mile.
[e]Katz activities; i.e., bathing, dressing, eating, and transferring.

self-reported arthritis data from the National Health Interview Survey[4] and in data on both sexes from the NLTCS.[24] However, the validity of self-reported arthritis is poor,[25] and although in our study we used physician diagnosis, the decrease could be due to change in diagnostic criteria for arthritis. The partial change in the definition of diabetes could explain the increase in the prevalence of diabetes, although small secular increases have been reported in other studies.[4,24] The decline in the numbers of persons reporting their health as fair or poor provides additional evidence of improved health in the offspring generation.

The lower rates of many of the chronic diseases suggest that disease prevention efforts, including promotion of increased physical activity and decreased smoking and alcohol intake, have had an effect.[2] Increasing weight, found in national samples as well,[26] continues to be a problem. The secular improvements in disability and health found in persons with chronic diseases, especially cardiovascular disease, suggest that disease interventions have also had an important beneficial effect.[1,2] Both health promotion and intervention efforts were probably enhanced by the higher educational attainment of the offspring generation.

Evidence of secular improvement in the physical activity component of disability is especially relevant to the life period when retirement usually occurs, as limitation in these activities identifies work-disabled individuals.[27] For Social Security retirement age considerations, the physical work capacity of the offspring generation is improved compared with that of their predecessors. However, offspring men were less likely to be employed than men in the original cohort. A gradual decline in employment among men aged 55 to 65 has occurred since 1970,[28] probably in relation to a decline in the manufacturing segment of the economy.[29] Framingham has experienced a loss of major manufacturing employers.[30]

While the original cohort was a population-based sample of a community, approximately 30% of the offspring of the cohort members were not enrolled in the study.[9] Because of the recruitment strategy used, some offspring not enrolled might be at lower risk for cardiovascular disease, thus creating a bias against finding less disability in the offspring sample. Two characteristics of offspring enrollees, though, suggest that they are a representative sample of original cohort offspring and of White US citizens in their age range. Their cholesterol and lipoprotein(a) levels are similar to the levels of White subjects of the National Health and Nutrition Epidemiology Study of the same age and sex,[31,32] and the proportions of FHS offspring who were current cigarette smokers are similar to those in the National Health Interview Survey (15% vs 18% for men, 17% vs 15% for women).[33]

One advantage of using FHS data sets is that they contain high-quality disability and morbidity measures. The measures of disability used in most national surveys—need for help, for example—may be influenced by changes in programs or in social or physical environments, so findings from these measures may not reflect change in health.[1,4,34] The physical activity items in the FHS ask about amount of difficulty in doing an activity, a measure less apt to be influenced by external changes. Most US population data on the prevalence of diseases are based on self-report and therefore are subject to problems in self-recognition and external changes.[4] Most FHS diagnoses are based on medical criteria.

Another important FHS advantage is that, with the exception of the activity of daily living items, the wording of self-report questions was identical in both cohorts; changes in wording have been shown to influence disability rates.[35] Although self-report data were collected by an interviewer in the original cohort and by self-administration among offspring, several studies have shown that self-administration produces higher rates of disability,[35–37] so a bias favoring greater disability among offspring members existed. A possible limitation to the examination of any self-reported data for secular change is that the social acceptability of answers may change; offspring members may have found it less acceptable to acknowledge limitation than members of the original cohort.

That almost all persons in the FHS cohorts are White suggests that the secular changes we found were not due to racial/ethnic differences. Using subjects from the same families limits any biological heterogeneity that could account for our findings. However, these findings cannot be generalized to other racial or ethnic groups. Although overall level of disability among some of these groups is likely to be higher,[38] in a recent report[39] there was evidence of a secular decline in disability among Black elders in the NLTCS. One reason Framingham was selected for a heart study was its heterogeneity in social class. In our samples, 25% of the original cohort and 30% of the offspring cohort held professional, executive, supervisory, or technical positions, and the remaining members held clerical, sales, craftsmen, operative, service, or labor positions or were housewives.

In conclusion, members of the FHS offspring cohort who were aged 55 to 70 years in 1994 were substantially less disabled than similarly aged members of the original cohort who were born approximately 17 years earlier. We found a striking secular decline in disability among persons with chronic diseases. Our findings depict a secular change toward a less disabled and globally healthier population in the life period when retirement generally occurs. □

Contributors

S. H. Allaire planned the study, analyzed the data, and wrote the paper. M. P. LaValley supervised the data analysis and contributed to the writing of the paper. S. R. Evans carried out the data analysis. G. T. O'Connor defined chronic obstructive pulmonary disease, provided the pulmonary function test data, and contributed to the writing of the paper. M. Kelly-Hayes gave advice about the measurement of disability with the Framingham disability items and contributed to the writing of the paper. R. F. Meenan contributed to the writing of the paper. D. Levy contributed to the writing of the paper. D. T. Felson provided overall project advice and ideas for the paper and contributed to the writing of the paper.

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