Rural residents are more likely than urban residents to have behaviors, conditions, and circumstances that challenge health, such as physical inactivity, heavy alcohol consumption, fewer regular dental visits, serious psychological distress, self-reported fair or poor health, and a lower likelihood of having private health insurance. Rural residents are more likely to live in poverty than urban residents; this is associated with less cohesive social networks, limiting support for individuals in need. All these challenges may exacerbate health disparities between older populations in rural and urban areas.

On the other hand, some characteristics of urban areas may contribute to an urban health penalty. These include neighborhood environmental issues such as excessive noise and heavy traffic. Such barriers to physical activity have been associated with loss of physical function. Overcrowding can lead to poor sanitary conditions. Urban air pollution poses many challenges to health: areas with more days of unhealthy air have higher risks of aggravated effects of asthma, congestive heart failure, and chronic obstructive pulmonary disease, including hospitalization and mortality. Thus, rural residence may to some degree serve as a protective factor for health or longevity.

Although morbidity and mortality in rural and urban areas have been studied, little research has
investigated differences in the ways these measures may combine to affect the course of physical impairment in later life, distinguishing between rural and urban areas. “Health expectancy,” an indicator that integrates mortality and morbidity information, has become widely used as a measure of population health.30-32 One aspect of health expectancy is “healthy life expectancy,” sometimes called “active life expectancy,” or “unimpaired life expectancy.” This measures the years an individual can expect to live free of substantial impairment. The second aspect measures the years an individual can expect to live with substantial impairment, often called “inactive life expectancy,” or “impaired life expectancy.” Total life expectancy (TLE) is simply the sum of the healthy and inactive life expectancy measures. Using 1990 data from a diverse set of 23 local rural and urban areas, distinguished by high (or low) poverty rates in the United States, researchers found that women and men in rural areas lived longer lives, with more impairment, than those in urban areas.22 Summarizing results of studies of active life expectancy in Canada, Bebbington and Bajekal29 report that older rural residents live more impaired lives than urban residents. A recent study using data from 6 regions in the UK found notable variation in active life expectancy across the regions, with mixed results for rural and urban areas.30 If rural residents live more years with physical impairment, or a greater proportion of their lives impaired, this would have important implications for our understanding of public health in rural areas and for planning health care and social services. We focused our analysis on a particularly vulnerable group of individuals, those who were impaired at the time of a baseline measurement, and sought to determine whether there are differences between older impaired rural and urban residents in active life expectancy and impaired life expectancy. Life expectancy measures can differ notably among population groups. Thus, we developed separate estimates for important subgroups, distinguished by gender, race, and educational attainment.

**Methods**

**Data.** The data source for this project is the National Long-Term Care Survey (NLTCS), matched with Medicare claims to obtain accurate dates of death. The NLTCS employs a mixed panel and longitudinal design. The first interview was conducted among a sample of Medicare enrollees aged 65 or older in 1982, with follow-up interviews in 1984, 1989, 1994, and 1999. Those included in the detailed NLTCS community interviews, the sample to which this analysis is limited, reported at least some degree of difficulty in performing at least 1 activity of daily living (ADL) or instrumental ADL at the time of the 1982 screening interview. ADLs include eating, getting in or out of bed, getting around inside, dressing, bathing, and getting to the bathroom or using the toilet. Instrumental ADLs include activities such as managing a checkbook or preparing meals. For an individual to be included in the detailed survey, the impairment had to have lasted, or have been expected to last, at least 90 days at the time of the screening interview. Details about the NLTCS have been published.31

Our study focused on ADL impairment, which was ascertained by asking respondents about their ability to perform each of the 6 ADLs. Separately for each ADL, respondents were asked if they “have any problem” performing the ADL “without help of another person or special equipment.” Those requiring such help were considered to be impaired, and they are the subject of this analysis. To follow individuals who would most closely represent older individuals today, we focused the analysis on a cohort aged 65-69 in 1982.

About 36% of the cohort who were alive when the 1989 surveys began were systematically excluded from that year’s survey due to constrained budgets for the NLTCS at that time. This data characteristic affects all longitudinal studies using the NLTCS that span this period. To avoid bias that might be introduced by including the long interval from 1984 to 1994, these individuals were excluded from the analysis. Respondents were considered to be rural residents if they lived in any of the following area types: “open country/not farm,” “farm,” or “city/town/village (under 50,000).” Of those in these area types, 33% lived in the first, 60% in the second, and 7% in the third. Thus, individuals designated as rural residents predominantly lived in areas that were likely to have been quite rural. Residents of all other area types were classified as residents of urban areas. About 26% of respondents could not be identified as either rural or urban residents in 1982. Those excluded due to missing values for this measure were notably more likely to have 12 or more years of education, and modestly more likely to be women. We addressed the exclusion of observations due to these reasons by reweighting the data, using established procedures.32 These procedures use logistic regression to identify probabilities associated with a number of variables, including those used in our model, that are associated with an observation being excluded. These probabilities are then used to reweight the data. Few cohort members were Hispanic (n = 36), or in other race/ethnicity groups (n = 19) other than white or African American. We used only those data representing whites and African Americans.
The unweighted analytic sample represented 2,939 individuals; 47% were rural residents.

All but 5 US states (Alaska, Nevada, New Mexico, South Dakota, and Vermont) were included in the analytic sample. Missouri had a disproportionately large representation (n = 127), equivalent to that of Ohio, a state with a notably larger population. Aside from this anomaly, all states contributed observations to the analytic sample roughly in proportion to their population sizes.

Statistical Analysis. We first conducted descriptive analyses of characteristics of the rural and urban samples, including an examination of the residence areas (rural or urban) of the cohort in all survey waves. We also conducted descriptive and standard logistic analyses of factors associated with the exclusion of observations due to missing data for area of residence.

The principal study method combined interpolated Markov modeling and microsimulation. Laditka and Wolf introduced the use of this method for estimating active life expectancy. It has since been used for this purpose by a number of researchers. The method accounts for unequal measurement periods (eg, the 2 years from 1982 to 1984, compared with the 5 years from 1984 to 1989) and for missing functional status information for a given survey wave, when it is followed by another survey with nonmissing data. The data for a given individual were right censored at the time of the last completed interview, or at the month of death. Although a number of NLTCS respondents may remain alive at the end of the study period, those who died during the study provided adequate power for estimating parameters associated with transitions to death. This approach is consistent with previous studies of active life expectancy, including those that use the present method, and also those that have used the more common life table methods. Details of the methods used in the present analysis have been published.

In brief, the method uses a maximum likelihood approach that expresses the probability of individual-level transitions as underlying model parameters in a logistic regression. The dependent variable was multichotomous, representing 4 pairs of functional status transitions from 1 month to the next: unimpaired to impaired, unimpaired to dead, impaired to impaired, and impaired to dead. The reference category for the transitions beginning with unimpaired months was the transition from unimpaired to unimpaired. The reference category for the transitions beginning impaired months was the transition from impaired to unimpaired. Several factors that have been shown by previous research to influence changes in functional status among older people were included as independent variables: age, gender, race, and education. Also included was a covariate representing rural or urban residence at baseline. The multinomial estimation procedure produced parameters of functional status transitions. The models estimated a constant (ie, intercept) for each transition type. They also estimated 1 parameter for each independent variable, including the covariate representing rural residence and the 4 control covariates, for each of the transition types. Thus, a total of 24 parameters were estimated. As with standard logistic regression, the reference categories were represented in the model implicitly; the estimated model parameters were measured in comparison to the reference categories. The model focused on month-to-month transitions. At any given month $t$, the probability of having a particular functional status the next month ($t + 1$) depended on functional status in month $t$, age in month $t$, baseline rural or urban residence, and the individual’s gender, race, and level of education. The assumption that functional status in a given month was dependent in part on functional status in the preceding month, with no “memory” of functional status in earlier months, is known as the Markov assumption. Use of this assumption is consistent with previous related research. The model created matrices that provided probabilities for each transition type, for each configuration of the covariate values, and for each month of life beginning at age 65. These matrices, which were summarized by the estimated parameters of the logistic analysis, were the foundation for the microsimulations. Further details of this estimation procedure have been previously published.

The probability matrices were then used to simulate individual monthly functional status histories for populations of 100,000, for each group defined by gender, race, education, and rural or urban residence. For an individual with functional status value $i$ and covariate values $X_j$ in month $t$, the model used the estimated parameters to generate the 3 transition probabilities, $p_{i1}(t + 1)$, $p_{i2}(t + 1)$, and $p_{i3}(t + 1)$, corresponding to the possible functional status states occupied the next month (unimpaired, impaired, or dead). These 3 probabilities were then mapped onto corresponding subregions of the interval ranging from 0 to 1: subregion 1 was the interval from 0 to $p_{i1}(t + 1)$, while subregion 2 was the interval from $p_{i1}(t + 1)$ to $[p_{i1}(t + 1) + p_{i2}(t + 1)]$, and so on. Next a computer-generated random number was drawn from the uniform (0,1) distribution. Finally, a value for the next month’s functional status was assigned, depending on the subregion into which the random number fell. This process was repeated for each simulated individual until death.
The impairment profile for each population starting a microsimulation, as well as the population profile of gender, race, education, and rural or urban baseline residence, matched the corresponding profile of the actual population at ages 65-69 living in the community with the same combination of characteristics. These profiles were identified through weighted analysis of the 1982 NLTCS. Ages 65-69 were combined for this purpose to ensure an adequate unweighted number of persons for estimating the weighted impairment profile of each subgroup. Although it may be expected that older individuals in this age range would be modestly more impaired than those at age 65, previous research and our analyses for this study suggest that microsimulation is not highly sensitive to the impairment profiles of the starting populations; the simulations are governed primarily by the monthly transition probabilities specific to each group studied.

Individual monthly functional status histories were created for 16 simulated populations, 8 groups of women and 8 groups of men, defined by race category, education level, and baseline rural or urban residence. The data produced by the microsimulation procedure were treated as longitudinal survey data, analyzed using standard statistical methods. For example, TLE for a given simulated population was simply the average age at death. TLE estimates from our microsimulations are generally very similar to those provided by the Census Bureau for life expectancy at age 65. What is not provided in Census data are expectancies for years lived with and without impairment, and also expectancies associated with population subgroups such as individuals with high or low education, or those who have lived in rural areas.

Thus, for example, the older life course experience of impairment was simulated for 2 populations of 100,000 white women with a low level of education. One of these simulations identified life and health expectancies for the population in rural areas. In this instance, 14.3% of the population began the simulation impaired, matching the weighted proportion of the corresponding actual population identified from the NLTCS. The second of the 2 simulations in this example was for a population in urban areas, 8% of which began the simulation impaired. To examine the sensitivity of the simulations to sample size, analogous simulations representing 1,000,000 individuals were also conducted. The results of these simulations did not differ meaningfully from those presented.

To examine the reasonableness of the results, we compared them to life expectancy estimates at age 65 for the US population in 1982. We estimated the 1982 expectancy by interpolating a value using those provided for 1980 and 1985. These estimates do not separately measure effects of rural residence or of low educational attainment. We calculated a summary estimate of TLE at age 65, using the results for the groups in this study weighted by the proportions of these groups in the 1982 United States’ population. We recognized that the life expectancy estimates from the simulations might be modestly shorter than those from the Census Bureau, given that the 1982 NLTCS excluded older individuals who reported no problems of any sort with any ADL or instrumental ADL. On the other hand, the baseline data did not sample those who resided in institutions; this characteristic of the data should tend to increase the life expectancy estimates from this analysis, compared with Census estimates. Nonetheless, our expectation was that the results from these 2 sources should be similar.

Results

Descriptive information for the weighted sample follows: among impaired rural residents, 6.1% were African Americans, 61.8% were women, and 16.9% had low education. The mean baseline age in the rural sample was 67.1 years. Among impaired urban residents, 7.6% were African Americans, 61.8% were women, and 4.8% had low education. The mean baseline age in the urban sample was 67.2 years. Thus, the urban and rural samples were similar, excepting the larger proportion of the rural sample with low education.

Of NLTCS respondents who lived in rural areas in 1982 and survived to 1989, 84% lived in rural areas in 1989; of those who survived to 1999, 82% were in rural areas. Thus, there is evidence that most impaired rural residents at baseline continued to reside in rural areas throughout the study period. Of the 18% of surviving baseline impaired rural residents who were no longer in rural areas at the end of the study, 51% lived in the same state throughout the study period. Although it is possible that these individuals moved within state to urban areas, some may have lived in areas in which the population grew to surpass the urban definition threshold. Of impaired individuals in urban areas in 1982 who survived to 1989, 82% lived in urban areas in 1989; of those who survived to 1999, 100% were in urban areas.

The estimated coefficients for the model of functional status transitions (not shown in tabular form) suggested that, among our sample of individuals who reported impairment at baseline, members of the rural sample were more likely than members of the urban sample to be unimpaired in a given month and impaired the next (b = 0.694, P < .001). They were also
less likely to be unimpaired in a given month and dead the next \((b = -1.124, P < .001)\). There was some evidence that they may have been less likely to be impaired in a given month and dead the next \((b = -0.287, P < .1)\), although this estimate was not statistically significant at conventional levels. Only 1 estimate representing African Americans was individually statistically significant. However, including the covariates representing African Americans in the model significantly improved the model fit \((P < .001)\). This result and previous research suggest the usefulness of including these covariates in the model.20-23 Most other covariates were individually statistically significant. Likelihood ratio tests indicated that each covariate set introduced into the model was significant at \(P < .001\).

The life course patterns of impairment beginning at age 65 are shown in Figures 1 and 2. The results for women are shown in Figure 1. The upper panels show the results for white and African American women with high education. The lower panels show analogous results for women with low education. The differences between the estimates for all rural/urban pairs, such as the unimpaired life expectancy for rural and urban African American women with more education, are statistically significant at \(P < .001\), with the exception of unimpaired life expectancy for African American women with low education, for which the rural/urban difference is not statistically significant. For African American women with more education, those in rural areas had a total remaining life expectancy at age 65 of 22.5 years, compared with 19.5 years for comparable urban residents. In this group, women in rural areas had more years of life without impairment (unimpaired life expectancy) than did urban women (18.2 and 17.4, respectively) and notably more with impairment (impaired life expectancy, 4.3 and 2.1, respectively). Rural/urban differences were similar for African American women with less education, although those with less education lived substantially fewer years and a notably larger proportion of life with impairment. The remaining panels of Figure 1, and those representing men in Figure 2, are interpreted analogously. With few exceptions, these figures show that rural residents lived longer than urban residents and also had more years of impairment. With the exception of white women with low education, results suggest that rural residents live a notably larger

Figure 1. **Total Life Expectancy (TLE), Unimpaired Life Expectancy (ULE), and Impaired Life Expectancy (ILE) at age 65, for African American and White Women.**

![Figure 1: Total Life Expectancy (TLE), Unimpaired Life Expectancy (ULE), and Impaired Life Expectancy (ILE) at age 65, for African American and White Women.](image-url)
The proportion of remaining life with impairment. The consistently large effects of educational attainment should be noted. For example, comparing the panels representing African American men with high and low education, those with high education spent 14.7% of remaining life with impairment, compared with 51.3% for those with low education.

Average life expectancy for all individuals at age 65 in 1982 estimated from Census data was 16.50 years. The comparable summary estimate in this study was 16.66 years. The results from these 2 sources are reasonably consistent. Analogous comparisons found similar results specific to African Americans and whites.

**Discussion**

We conducted a 20-year retrospective cohort study, following individuals at ages 65-69 in 1982, all of whom lived in the community but reported some level of impairment at the time of the baseline interview. Among these individuals, rural residents lived longer than urban residents in every group studied. However, in all but 1 instance rural residents lived more years with impairment and, in most cases, a greater proportion of life with impairment. These findings are consistent with a previous study of several small areas of the United States and also with a study using data from Canada. In addition to the greater health burden implied by these results, they suggest the possibility that service needs associated with impairment may be greater in rural areas. They also suggest that family caregivers may provide care over longer periods in rural areas. Caregiving in the home challenges physical and emotional health. Thus, the findings imply a notable public health impact of active life disparities in rural areas, both for the directly affected individuals, and possibly for their families or other informal care providers. The greater burden of impairment among rural residents means that many rural communities are doubly disadvantaged, with higher impairment rates and fewer health care and other resources, and additional barriers stemming from isolation and lack of public transportation. These results suggest that, at least on a per capita basis, rural areas may have greater needs than urban areas for health care, social services, environmental modifications, and other resources required to address the needs of older persons with physical disabilities.

Consistent with previous research, the results also show that those with less education live substantially shorter lives with more impairment. Also consistent with previous research, African Americans generally lived shorter and more impaired lives than whites, although effects of education on...
expectancies for life and health were much greater than those of race. It would be useful to know how much of the variability in the data under analysis was accounted for by the estimated model. Unfortunately, such measures are not well defined by logistic regression. We note, however, that the estimated –2 log likelihood value was greatly reduced by the addition to the model of the covariate representing education. This result suggests that education contributed importantly to the variation within these data. The notable results for education also underscore the usefulness of controlling for educational attainment in studies that examine active life expectancy in rural and urban areas.

Several considerations should be weighed when interpreting these findings. Preliminary investigations found that the NLTCS data, although widely used for analyses of physical impairment and disability, were inadequate for modeling multistate disability dynamics (eg, unimpaired, moderately impaired, severely impaired, dead) specifically of the rural and urban samples we studied. We therefore chose an approach that is commonly used to measure impairment, in which the outcome is defined as impairment in “1 or more” ADLs. It should further be noted that we modeled the transition from independence to any ADL impairment. Individuals were considered to be impaired if they were unable to perform an ADL, or if they received help to perform it or used an assistive device. This is consistent with the definition of disability used in the NLTCS screening interview. However, studies of disability sometimes use a higher threshold to indicate disability, where an individual cannot perform an ADL without substantial assistance from another person. The threshold chosen to define impairment and disability can have notable consequences for understanding impairment and disability.

The baseline (1982) NLTCS did not include individuals who were institutionalized and therefore omitted the most impaired individuals. However, individuals who thereafter became institutionalized were included in follow-up surveys and are represented in our data until death. We noted that we addressed the exclusion of data by reweighting. Although we believe this reweighting was appropriate, the simulations were not sensitive to such weights. It should also be noted that the model used in this analysis did not separately control for effects of income or wealth. Rural populations are poorer than urban populations. Lack of specific controls for wealth or income may have introduced bias into the results. However, wealth and income are notably correlated with education, which was controlled in the analysis.

Results of this study can be generalized to older individuals who share characteristics with those represented in the analytic sample. These are individuals aged 65-69 in 1982, with at least some difficulty performing at least 1 instrumental ADL or ADL at baseline (although many of these individuals may later recover). They also reside in the community, as does a large majority of older Americans. When weighted to provide nationally representative estimates, only a small proportion of this cohort was impaired in 1982, as defined for this research (authors’ calculation using the full NLTCS sample at ages 65-69 in 1982, not restricted to the impaired urban/rural subsample of this analysis). For example, 7% of the cohort reported impairment in bathing and 6% in getting around inside; only 1% reported needing help or special equipment to eat.

Because the NLTCS included few Hispanics, Asians, or other minorities, the analytic data were limited to non-Hispanic whites and African Americans; inferences are limited to those groups. The results may also to some degree represent a cohort effect, which might not represent more recent cohorts at the same ages. Census estimates consistently suggest that TLE has increased with each passing decade. Greater educational attainment and other life experiences of more recent cohorts may contribute to longer lives. There is evidence that these longer lives may be lived with less impairment, although scientists have recently speculated that an increasing prevalence of diabetes, physical inactivity, and obesity may slow or reverse active life expectancy gains for future cohorts of older persons. If such trends emerge, and particularly if they affect rural and urban areas differentially, the results from this analysis may not represent current or future cohorts. This research focused on functional status as an indicator of physical impairment. Cognitive status is another valuable indicator of health and impairment. It may be useful for future research to include a measure of cognitive status in the impairment indicator.

Some of the individuals who no longer lived in rural areas in 1999 may have moved to urban areas. Others may have lived in areas in which populations grew, exceeding the threshold that defined rural areas. These 2 circumstances cannot be separately identified in the NTLCS data. Despite the common impression that we live in an increasingly mobile society, persons aged 65 and older in the United States rarely move. Moving is also relatively rare among those at ages 45-64. Thus, a majority of the rural sample in 1982 may have lived in the same rural areas for many years. Further, life course effects of rural or urban residence may continue to affect individuals’ profiles of
impairment and longevity even after they move from one area type to another, at least among those who have lived a notable number of years in a given area type.

It is also possible that moves to or from rural areas, or permanent residence in either area type, may be associated with health profiles or other characteristics of individuals that affect life expectancy measures. That is, the rural effects we found may be associated with characteristics of rural residents (such as lack of insurance, or physical inactivity), rather than characteristics of rural areas (such as fewer health care resources, or risks of agricultural employment). In either case, the results highlight greater burdens of physical impairment among rural residents. It is also possible that the threshold defining rural and urban areas may have influenced the results. In that regard, it is useful to note that not all studies have found unambiguous gradients of health from rural to urban areas. In some studies, the most rural and the most urban areas are found to be disadvantaged compared with suburban areas. Rural-suburban health disparities have been well documented. The data available for this research did not contain an adequate number of observations from suburban areas to examine this possibility. Readers should interpret the results of this analysis with caution as the simple dichotomous definition of rural and urban areas masks considerable heterogeneity among areas, unmeasured differences that may notably influence impairment dynamics.

Our results highlight opportunities to promote research and policies focused on reducing physical impairment. Our findings suggest that impaired rural residents enjoy longer lives but live more years with impairment. People with more education had strikingly longer lives and lived a notably greater percentage of those years without impairment. Previous research has demonstrated that individuals with more education are more likely to adopt healthy behaviors. Risks of physical impairment may be reduced by behavioral change. It is also well established that physical activity and other healthy behaviors can notably increase the likelihood of recovery from impairments, and slow the progression of impairment for those already affected by many conditions, such as arthritis, diabetes, and lower body functional limitations. Thus, practitioners should focus on strategies to enhance physical activity and other healthy lifestyles among impaired individuals. Although healthy behaviors should be promoted, this strategy may not address all the disparities suggested by our results. For many groups affected by health disparities, environmental and other hazards that can exert strong effects on health throughout the life course are difficult to avoid. Established national priorities aim to reduce disparities in health status among older Americans. It seems likely that large public policy initiatives may be required to begin to realize this goal. Thus, in addition to promoting individual healthy choices, it would be useful to promote changes at the community level that would address risks to health.

References


