To study the epidemiology of rural populations in the context of contemporary issues in public health, a population laboratory (Health Census '89) was established in Otsego County, New York, by the Research Institute of the M. I. Bassett Hospital, affiliated with the Columbia University School of Public Health. Such a laboratory is needed because of an apparent lag in positive health indices in rural populations across the United States, resulting in rates of chronic diseases, such as coronary heart disease, for which rural areas now exceed urban ones. This was confirmed for Otsego County by the survey Health Census '89, the foundation of a rural population laboratory, in which all residents were enumerated and characterized as to their prevalent diseases, health behaviors, use of preventive services, and environmental exposures. Heart disease, cancer, and diabetes mellitus rates were found to exceed average rates for US urban areas, while the data on preventive health behaviors suggest this is a population of "late adopters." The survey, conducted in 1989, had an 86.6% response rate, and enumerated 17,147 households and 44,406 persons. The authors discuss adults aged 17–64 years, 58 percent of the total census (n = 25,614). Sharp gradients in disease prevalence, risk factors, and utilization of preventive services were observed across educational strata. Data from Health Census '89 were used as the basis for a successful community intervention program, which targeted identified high risk groups. Rural populations are excellent settings for community interventions, offering laboratories where new strategies of risk reduction and provision of preventive services might be tested. Am J Epidemiol 1998;148:949–57.

coronary disease; epidemiologic methods; rural health services

BACKGROUND

Over the last several decades, interest has developed in utilizing geographically defined communities as units for epidemiologic study, especially of chronic diseases (1–4). Ideally, these are relatively stable communities with little migration and with self-contained medical care systems. Often, however, considerations in the selection of communities have been pragmatic or administrative, rather than theoretical and methodological. The Commission on Chronic Illness, funded by The Commonwealth Fund in 1959, published one of a four-volume report, Chronic Illness in a Rural Area: Hunterdon County, New Jersey (5), an effort not only to compare urban and rural communities in terms of chronic disease (the urban area was Baltimore, Maryland), but to suggest methods as to how communities could conduct less costly but useful chronic disease surveys. Less than 30 years ago, the first systematic presentation of community studies from an epidemiologic viewpoint was published, encompassing medical, social, and psychiatric studies (6). This casebook introduced the phrase “the community as an epidemiologic laboratory,” implying the existence of a system for the registration of denominator data (population figures) and numerator data (vital events) (7).

Many population laboratories were not established until the 1970s, and only a few have included, at least in part, rural populations. In the 1930s and 1940s, a series of classic health-related censuses were conducted in the Eastern Health District of Baltimore, Maryland (1933–1947); although these censuses were not carried out in a rural area, these surveys were methodologically important to all subsequent censuses (8). The first census for general health research on a
county-wide basis was conducted in 1946 in Musco-gee County, Georgia (9). In 1963, a non-official cen-sus of semi-rural Washington County, Maryland, was conducted, in large part, to provide a major resource for training at the Johns Hopkins School of Hygiene and Public Health (10).

Why study rural populations?

Rurality is defined in various ways by different agencies and investigators. The US Census Bureau defines “rural” as places with 2,500 or fewer population (11). Using this definition, 26.3 percent of the 1990 US population resided in rural areas. The Office of Management and Budget uses the definition of a metropolitan statistical area (MSA), which encom-passes an urban population and adjacent communities (12); rural is then defined as “nonmetro,” i.e., every place else. Using this definition, 23.4 percent of the 1990 US population resided in rural areas. Thus, rural populations constitute about a quarter of the population of the United States.

Several types of health problems have traditionally shown higher morbidity and mortality rates in rural areas. One such example is accidental injury and death, including pediatric trauma (13), farm machinery injuries, and motor vehicle accidents (14). However, in terms of chronic diseases, rural populations often have been considered to live in a healthy way, and to enjoy a health advantage over crowded urban populations. Certainly, cardiovascular disease has been considered an urban problem, with studies in the 1960s and 1970s in the southern United States (15) and Puerto Rico (16) documenting higher rates of cardiovascular mortality in urban groups when compared with rural groups. The same trends have been shown in vital statistical data, in which cardiovascular disease death rates were higher in urban populations well into the late 1960s. However, more recent analyses have correlated age-adjusted death rates in the 48 continental states of the United States with the percent of their populations classified as rural (17). By 1979–1981, a striking reversal in cardiovascular disease and to-tal mortality was being seen for white men and, for cardiovascular disease, in white women. Since that time, cardiovascular disease mortality has correlated directly with rurality.

This reversal of urban/rural predominance in cardio-vascular disease may be explained by the relative trends in coronary disease mortality in the second half of the twentieth century. Coronary disease mortality rose in the United States as a whole until approximately 1968, after which there has been a nationwide decline in age-adjusted coronary disease death rates (18). However, data from the National Center for Health Statistics suggest that the decline in rural populations was somewhat slower than in metropolitan populations from 1968 to 1978, with the gap between rural and urban populations widening between 1979 and 1985 in every region of the United States (19). Thus, rural populations have not benefited as much as urban populations from the striking declines in coro-nary disease mortality, for reasons not well under-stood.

This delayed downward trend of coronary disease mortality in rural areas may be explained by the character-ization of rural communities as “slow adopter” communities (20). In this instance, slow adopter communi-ties first would be delayed in their adoption of those unhealthy life-styles (such as cigarette smoking, high fat diets, and sedentarism) which characterize urbanization. Therefore, at one point in time, rural populations would have lower rates of coronary disease than urban populations (as was the case in the 1960s). Then urban populations would gradually identify the ways to prevent coronary disease through reductions in smoking, diet modification, and exercise, leading to a rapid decline in coronary disease mortal-ity. Rural populations would again lag in their adop-tion of such healthy behaviors, manifesting a continued increase (or slower decline) in coronary disease mortality and, over a period of time, have higher coronary disease mortality rates than urban populations.

Therefore, in order to confirm or deny such an hypothesis, it is meaningful to study rural populations in order to identify those characteristics which may have contributed to this delay in the decline in coro-nary disease mortality, in the form of a case study of broader health problems found in rural populations. This formed our rationale for the development of a rural population laboratory, to study further the phe-nomena of contemporary rural epidemiology, using an intact social group. The concept of the community as a laboratory formed the basis of Health Census ’89 in Otsego County, New York. It was to the Washington County census and to its principal investigator, Dr. George W. Comstock, that we turned when the Otsego County census was planned. Although there were some important methodological differences between the two studies, and Otsego County is more rural, study similarities included the relative stability of the population, a largely centripetal pattern of medical care, and the affiliation with an academic medical center, in this case the Mary Imogene Bassett Hospital, its Research Institute, and the Columbia University School of Public Health.
Development of a rural population laboratory: Health Census '89

In 1989, the Research Institute of The Mary Imogene Bassett Hospital set out to establish a rural population laboratory through the performance of a health census of all permanent residents of Otsego County, a county in central New York state that encompasses 1,000 sq mi (1,613 sq km) north of the Catskill Mountains. The county is largely rural, with over 76 percent of inhabitants living in places with populations of less than 2,500 people, and it is officially designated part of Appalachia by the Appalachian Regional Commission. Few large companies operate in Otsego County, and the most common occupations are involved with small businesses and agriculture.

The prestated goal of Health Census '89 was to describe the health status of this rural population with regard to prevalent disease, health behaviors, environmental exposures, and the use of preventive services. Health Census '89 was initially planned and implemented with the assistance of Survey Research Associates of Baltimore, Maryland. The first task was to enumerate the entire population residing in Otsego County. Beginning early in the year, two local residents and a professional cartographer were sent out to map all residences in the county, and to determine if they were inhabited by one or more permanent residents of the county. Criteria for exclusion of residents were: residence in Otsego County <6 months a year (the area is a summer resort); institutionalization (e.g., nursing homes, etc.); or living in noninstitutional quarters containing >10 unrelated persons (e.g., dormitories). A total of 25,022 households was identified, of which 5,222 were documented as not being inhabited for ≥6 months per year. Each eligible household was then identified on detailed maps in which the county was divided into census tracts (n = 11), and smaller enumeration districts (n = 1,103).

Standardized questionnaires were then mailed to each of the 19,800 eligible residences. Each questionnaire contained a page in which all household members who considered that household as their permanent (not summer) residence were enumerated, including age, sex, race, marital status, and relationship to head of household. For each adult in the household (aged 17 years or older), a one-page questionnaire inquired about prevalent chronic diseases (coronary disease, diabetes mellitus, cancer), the use of preventive services (cholesterol and blood pressure screenings, cervical smears and mammograms for women, and colon cancer screenings), health behaviors (cigarette smoking, exercise), and demographic data (occupation, education). A final page described the households in terms of duration of residence at that site; number of rooms; type of heat, plumbing, and basement; use of specific local media (television, radio); type of health care and health insurance for household; and frequency of use of the health care system. The head of the household was asked to complete the questionnaire, consulting with family members about their individual information. An ongoing campaign in the local media, explaining the census, coincided with the questionnaire mailing and collection. A large staff of trained field workers collected the questionnaires at the homes. The field workers wore identification badges and answered any questions that the participants raised. Questionnaires were reviewed on site and incomplete responses were completed on the spot whenever possible. All data were dual-entered and verified. Range and validity checks were performed routinely. A media campaign to thank the community for its participation and present summary information was carried out at the end of field operations. All procedures were approved by the Institutional Review Board of the Mary Imogene Bassett Hospital.

Of the 19,800 eligible households, 17,147 participated, for an 86.6 percent response rate. Only 8.5 percent of households declined to participate. For approximately 4.9 percent of households, the occupants could not be contacted or stated that they had completed the questionnaire elsewhere. The population enumerated consisted of 44,406 persons, of whom 33,428 were adults for whom individual data (although not always complete) were available.

SELECTED RESULTS

The successful field operation of Health Census '89 allowed the enumeration and description of this rural population. The age and sex distribution of the population to be discussed in this paper is shown in Table 1, showing 25,614 persons (58 percent of total census) between ages 17 and 64 years. In addition, 17 percent of the population was 65 years and older, and 25
percent was under age 17 years (on the latter, no individual data were collected). The population was 98.7 percent white and, among adults ages 17 years and older, 49 percent were married. In terms of educational attainment (used as a measure of socioeconomic status), only 20.3 percent of adults had a college degree and 18.7 percent had not finished high school. Of adults, 11.4 percent were unemployed at the time of the census. The stability of the population was described by the finding that the average duration of residence in the current home was 13 years, with a median of 9 years and a range of <1 year to 89 years.

The self-reported prevalence of chronic diseases, such as coronary disease, diabetes mellitus, and cancer was determined by levels of educational attainment to examine socioeconomic gradients in disease. For both men and women over age 29 years, striking gradients in self-reported prevalence of coronary disease as diagnosed by a physician were observed, with persons with less than a high school education having much higher prevalences of coronary disease than persons with higher levels of education (figure 1). Similar gradients were observed for cancer and diabetes mellitus among persons aged 30–64 years (data not shown).

To understand further the origins of this gradient between educational attainment and chronic disease, a variety of health risk behaviors were examined by level of education. One of the most important risk behaviors is cigarette smoking. In Otsego County, a striking gradient in cigarette smoking exists for both men and women by level of education (figure 2).
About half of adult men and women under age 50 years who did not finish high school reported that they were smokers; college graduates had smoking rates less than 15 percent.

Similar findings were documented for exercise behaviors (table 2) (21). Persons who did not have a high school diploma were considerably more likely to be classified as sedentary (with the exception of college-educated women), defined as a negative response to the question validated by Paffenbarger et al. (22): "At least once a week, do you engage in any regular activity like brisk walking, jogging, bicycling, etc., long enough to work up a sweat?" Among the persons who did exercise, most did not do heavy aerobic exercise. There were no large differences in these rates when individuals who listed their occupations as farmers or laborers were removed from the analysis. Walking was by far the most prevalent form of exercise in all age and sex groups.

Space limitations did not allow extensive questions about caloric intake and other dietary behaviors. However, the prevalence of obesity was estimated by self-reported height and weight, both known, by subsequent work in this geographic area, to be somewhat under-reported (23). The prevalence of obesity (not just overweight), as defined by body mass index (weight (kg)/height (m)\(^2\)) of >27.8 for men and 27.3 for women, exceeded 20 percent (figure 3). Interestingly, when the population of Otsego County was stratified by persons who lived in the one small city in the county (population 13,900) versus the rest of the county, all of which consisted of towns of ≤2,500, a gradient could also be seen by educational attainment; persons who had not completed high school and who lived in town had high rates of obesity, but those who lived in rural areas and who had not completed high school had still higher rates, regardless of educational attainment (24). Thus, within Otsego County, rural obesity looms as a major health risk.

Another possible explanation for the socioeconomic gradient in coronary disease may be the differential use of preventive services. Health Census '89 specifically inquired about most of the screenings recommended by the US Preventive Services Task Force (25). In general, high proportions of adults (87.5 percent) had been screened for high blood pressure in the previous 2 years. However, rates of screenings for

### TABLE 2. Percent of the Otsego County, New York, population aged 17–64 years, classified as sedentary, by sex and level of education, in Health Census '89*

| Level of education | Males | | Females | |
|-------------------|-------|----------------|---------|
| S8th grade        | 247   | 54.8           | 126     | 49.8 |
| 9th–11th grade    | 574   | 42.5           | 516     | 45.6 |
| High school graduate | 1,727 | 39.8          | 1,559   | 42.8 |
| Some college      | 948   | 33.5           | 1,271   | 35.8 |
| College graduate  | 721   | 29.3           | 1,257   | 43.6 |
| Total             | 4,217 |               | 5,129   |      |

* Source: Eaton et al. (21).
cancers were low, with only 36 percent of eligible adults having ever had a rectal examination or stool test for occult blood for colon cancer screening. Only 38.7 percent of women had ever had a mammogram. While most women had at least one cervical smear (83 percent), many had not received this screening on a regular basis. The socioeconomic and urban-rural gradient in preventive services is especially evident for cholesterol screening (figure 4) (24). Men and women with less than a high school education had low levels of cholesterol screening, and in each sex and at each level of education, rural residents had lower levels of screening than persons who lived in the one small city. The relation between cholesterol screening and education remained after multivariate adjustment for age, health insurance status, regular source of health care, smoking, marital status, and sex (data not shown).

Another potential reason for higher chronic disease rates in rural areas may be lack of access to health care. The average distance of the household to its source of regular health care was 10.0 mi (16 km), and 12.6 percent of households had no regular source of health care other than an emergency room. Most health care insurance was provided by private or group plans, with 63 percent of children being in households with this type of insurance. However, 5.3 percent of children were in households on Medicaid and 9.4 percent of households with children had no health insurance. Only 7.4 percent of households were enrolled in health maintenance organizations in 1989.

Receipt of preventive services varied markedly by type of health insurance. Residents in households with no health insurance and/or that received Medicaid had markedly lower utilization rates of recommended screening tests, such as mammograms (26). Residents in households who were uninsured or enrolled in Medicaid also had strikingly increased rates of cigarette smoking and obesity, which suggests that the persons who most need the screening are the least likely to get it (26).

Application of Health Census '89 data to public health problems

The Otsego County Health Census '89 provided the empiric data supporting the rationale for community interventions in rural populations. Since 1989, a community intervention has been ongoing in Otsego and a neighboring county. Many of the community intervention strategies developed by the large, federally funded community intervention programs (34–36) were obviously not applicable to the 92,000 population who resided in the 1,700 sq mi (2,742 sq km) target region of rural, agricultural, central New York. Therefore, low-cost, innovative strategies were implemented between 1989 and 1996 to change cardiovascular disease risk behaviors in this population, where little coronary disease education had previously occurred. The strategy was to target the high risk groups identified in Health Census '89, taking advantage of close-knit rural villages and school districts, local health committees, and local media to organize and promote work site and community health screenings, community-
wide fitness hikes, and low fat suppers at churches and voluntary agencies. Schools were also sites for educational demonstrations and interventions at several grade levels. All materials specifically targeted persons of low educational attainment. After 5 years, an evaluation of the program effectiveness, in comparison to a control community, showed reduced tobacco use and lower predicted 10-year prevalence of coronary disease (by Framingham equation). In addition, census data were used in preparing numerous proposals for rural public health initiatives, many of them successfully funded.

DISCUSSION
Can pathways be identified to account for an excess of coronary disease in rural populations?

Evidence of the excess of coronary disease in rural areas emerging in the late 1970s and 1980s (17, 19) may be supported at least in part by several observations in Health Census '89, which serve to further define this rural population as a "late adopter" community (20). First, a strong inverse gradient between socioeconomic status and coronary disease has been documented in the United States as a whole (27, 28) and is increasing (29). This inverse gradient was certainly present in Otsego County. A likely way in which rural populations would have higher rates of coronary disease (and other chronic diseases) would be if rurality was in turn related to low socioeconomic status. This in fact appears to be so. Rural populations in the United States have higher rates of poverty than urban populations, as measured in any of several ways, in all regions of the country, and in all age and sex groups (30). Although 23.4 percent of the US population in 1990 resided in rural areas, 29 percent of poor people resided in rural areas. Trends in the 1980s suggested that this gap is widening, with poverty rates between 1980 and 1987 rising in rural inhabitants aged 61 years or less from 13.5 to 18.3 percent, while in urban areas during the same period they rose only from 11.1 to 12.6 percent (17). The same is true if educational attainment is used as a marker of socioeconomic status. For each racial/ethnic group in the United States have higher rates of poverty than urban populations, as measured in any of several ways, in all regions of the country, and in all age and sex groups (30). Although 23.4 percent of the US population in 1990 resided in rural areas, 29 percent of poor people resided in rural areas. Trends in the 1980s suggested that this gap is widening, with poverty rates between 1980 and 1987 rising in rural inhabitants aged 61 years or less from 13.5 to 18.3 percent, while in urban areas during the same period they rose only from 11.1 to 12.6 percent (17). The same is true if educational attainment is used as a marker of socioeconomic status. For each racial/ethnic group in the United States, educational attainment was lower in rural than in urban populations. The slow adopter status in rural populations may be in part explained by this higher rate of poverty and lower rate of educational attainment.

Low socioeconomic status is not the only risk factor present in rural areas. Traditionally, agriculturally-based rural families have consumed a high-fat, high-calorie diet, that often included food grown at home. Dairy farmers, for example, typically consume their own whole-fat milk. While the high caloric intake was in the past counterbalanced by an equally high caloric expenditure during intense physical labor required for farming, logging, and other activities, mechanization of rural occupations has reduced these levels of caloric expenditure, with resulting high levels of obesity. For instance, in Health Census '89, high levels of obesity were observed, including in young adults (figure 3). The strong gradient of obesity by education level suggests that persons of low economic status were especially prone to caloric imbalance. (Moreover, a comparison of obesity rates between residents of the small city [13,900 people] and residents of more rural areas indicated that obesity rates were even higher among the latter.)

The most prominent contributors to mortality in the United States in 1990 were behavioral; about half of all deaths were attributed to tobacco, diet and activity patterns, alcohol, firearms, sexual behavior, motor vehicles, and illicit use of drugs (31). However, isolated rural populations with poor educational attainment and limited literacy skills may have a very different level both of exposure to and receptivity to the health messages in video, audio, and print media that bombard urban dwellers. Health-promotion organizations, including county health departments, voluntary organizations such as the American Heart Association, and health care providers, are less visible and are sometimes absent in rural than in urban settings. The extent of health education programming in schools, community organizations, and other venues may also be lower. The small and single-family businesses that characterize rural areas rarely have work site health promotion programs.

Another important barrier to primary and preventive health services in rural areas is the lack of health care providers. Rural residents are overrepresented among persons who reside in areas with health personnel shortages, are more likely to have no usual source of care, more frequently have to travel more than 30 minutes to their health care provider, and have fewer physician visits per year than the general population (32). For instance, in Health Census '89, the average distance to a regular source of health care was 10 mi (16 km). Long waiting periods for appointments and the extended distances needed for travel to providers affect all aspects of health care, particularly the provision of preventive care (e.g., the detection and management of high blood pressure and hypercholesterolemia).

Rural health care providers, limited by heavy patient loads, travel times, and lack of accessible continuing medical education, may also be considered "late adopters." The poor economic viability of rural hos-
pitals and their frequent closure have also added to the
distances rural patients must travel to receive either
primary or specialty care (33). From 1980 to 1987, of
364 hospitals in the United States which closed, 45
percent of them were in rural areas (34).

The role of rural poverty in this health care crisis has
been studied extensively. The economic viability of a
rural community is an important determinant of its
ability to attract physicians. Rural hospitals face a
variety of economic disadvantages, including a much
higher rate of charity care due to high rates of uninsured
patients (34). In addition, the rural poor, through
lack of access, knowledge, or pride, often do not
request (or receive) public assistance such as heating
bill assistance, food stamps, and Medicaid (32). Lack
of health insurance not only serves as a barrier to their
seeking care but also decreases their ability to reim-
burse providers and hospitals for any care received. By
way of illustration, Health Census '89 identified low
rates of preventive services, such as cholesterol
screening and cancer screening, for persons without
insurance or with Medicaid only. A chain of causality
can be hypothesized in which rural poverty leads to
reduced access to primary care and hospital services,
which in turn leads to reduced ability to prevent and
treat chronic conditions and their sequelae.

Rurality also impacts negatively on acute condi-
tions. For example, the importance of early identifica-
tion of symptoms and prompt transport to a medical
facility and intervention (e.g., defibrillation, thrombol-
sis) to improve the natural history of acute coronary
disease has been well described. The closure of rural
hospitals increases the distance to an acute care facility
for many residents and can add significantly to delays
in intervention. Possible additional barriers to prompt
treatment include lower awareness of symptoms in
rural populations (again, a public education deficien-
cy), the lack of emergency (911) telephone systems,
out-of-date equipment, poor roads, and frequently hos-
tile weather conditions (35). Moreover, emergency
personnel in rural areas are most often volunteers with
minimal training in acute care and infrequent oppor-
tunities to use their skills. Community hospital emer-
gency personnel likewise may have less than optimal
training for the management of acute (e.g., cardiac)
emergencies. Little is known about strategies to im-
prove the promptness and effectiveness of emergency
treatment in rural areas.

In summary, rurality can be seen as a risk factor for
coronary disease and other chronic diseases. First, the
association between rural residence and low socioeco-
nomic status is established. The large number of rural
poor in the United States underscores their importance
as a high-risk subgroup. Second, a dramatic reversal in
the association between rural residence and coronary
disease occurred between the 1950s and 1980s. Third,
the most obvious pathway through which rurality may
be related to coronary disease and other chronic dis-
eses is its association with low socioeconomic status;
that is, the increasing poverty of rural areas is leading
to increasing rates of chronic diseases. Detrimental
trends in health behaviors, a lack of effective health
promotion messages and services, a crisis in access to
rural primary health care, and limitations in rural
emergency medical systems are all potential pathways
that explain the recent excess of coronary disease and
other chronic disease morbidity and mortality in rural
areas.

Because of societal changes and different channels
of communication, rural communities appear to be late
adopters of positive health behaviors. They have not
caught up in health indices with their urban brethren.
They are clearly the last to recover from the coronary
disease epidemic. In these and other late adopter com-
munities, there may be cause for optimism about the
possible effectiveness of community interventions. In
the Stanford (36), Pawtucket (37), and Minnesota (38)
community interventions, extensive efforts to acceler-
ate an already rapid secular trend in decline of coro-
nary disease risk were largely unsuccessful. In late
adopter rural communities, the task may be fundamen-
tally different. In these communities, it may suffice to
try to catch up to the secular trends seen in other parts
of the country. Thus, the goal is to converge the
coronary disease rates of the late adopter communities
with those of the secular trends of the early adopter
communities, in essence converting the rural popula-
tion into an early adopter community through health
education programs, improved preventive services,
and better access to medical care.

We conclude that rural populations may provide
rewarding targets for community interventions di-
rected at risk reduction, prevention, and enhanced
quality of life and health, and that they offer labora-
tories where new models of social marketing and
provision of preventive services may be tested.

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