
Modeling AIDS Cases in Non-Metropolitan Areas of the United States, 1993-2010

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Abstract

Annual AIDS surveillance data provided by the CDC showed that, from 1993 through 2003, AIDS cases in rural areas of the U.S. increased by 202%, compared to an increase of only 147% in large U.S. cities. A change in the Office of Management and Budget's use of the term "non-metropolitan" in 2004 resulted in a decrease in rural AIDS cases from the end of 2003 (i.e., 55,343) to 2004 (i.e., 47,742). Forecasts portend that, through the year 2010, 56,756 people will have been residents of rural areas in the U.S. when they were diagnosed with AIDS. The estimated annual cost of HIV/AIDS-related medical care for persons living with HIV in rural areas has increased to approximately \$500 million in recent years.

Ever since its initial appearance 25 years ago, AIDS in the United States has been viewed primarily as a disease confined largely to urban centers. However, epidemiologic data demonstrate that AIDS has unequivocally arrived in non-urban areas, with approximately five to seven percent of all AIDS cases in the U.S. diagnosed in small towns and rural areas (Hall, Li, & McKenna, 2005). HIV entered into rural communities of the U.S. via two "waves" (Lansky et al., 2000). The first wave involved the migration of HIV-infected persons (primarily gay men) from urban centers to rural communities when their HIV disease worsened and they sought assistance from family members and friends. A second (and current) wave involves an increasing number of "native infections" (i.e., persons who were born, raised, and infected in their current place of rural residence; Lansky et al., 2000; Steinberg & Fleming, 2000).

The number of AIDS cases in rural areas of the U.S. will continue to increase for two reasons. First, because of improved clinical care and increasingly efficacious regimens of antiretroviral therapy (Palella, et al., 1998), many rural people living with HIV/AIDS will live for longer periods of time. Second, many rural persons (both HIV-seropositive and seronegative) continue to engage in high HIV-transmission risk behaviors. Indeed, 33 to 50% of sexually active HIV-infected rural persons continue to engage in unsafe sex (Beltrami, Fann, & Toomey, 2000; Heckman, Silverthorn, Waltje, Meyers, & Yarber, 2003; Crosby, Yarber, DiClemente, Wingood, & Meyerson, 2002).

Historically, the South has accounted for approximately

50% of all AIDS cases diagnosed in rural areas of the U.S. (Centers for Disease Control [CDC], 1998). However, more recent epidemiologic data suggest that this already high proportion may be increasing. For example, of the 3,317 AIDS cases diagnosed in rural areas of the U.S. in 2003, 68% were diagnosed in the South (CDC, 2005). Moreover, the AIDS case rate in the South (9.4 / 100,000) is greater than those observed in rural areas of the Northeast (7.2 / 100,000), the West (4.2 / 100,000), and the Midwest (2.9 / 100,000) (CDC, 2005).

In 2005, African Americans accounted for 48% of the AIDS cases diagnosed in rural areas of the U.S. and Whites comprised 40% (CDC, 2005). This represents a significant change from 1996, when African Americans accounted for only 41% of all AIDS diagnoses in U.S. rural areas (Steinberg & Fleming, 2000). A comparison of AIDS case data collected in 1996 and 2005 also shows that women in rural areas are at elevated risk for HIV/AIDS. In 1996, there were 3.88 men diagnosed with AIDS in rural areas for each woman; however, in 2005, this ratio had decreased to 2.98 rural men for each rural woman diagnosed with AIDS (CDC, 2005).

In response to the concern that AIDS will increasingly impact rural areas of the United States, this research documented the number of persons who were diagnosed with AIDS in rural areas of the U.S. between December 1993 and December 2005. The study also compared the number of AIDS cases diagnosed in rural areas to those observed in metropolitan statistical areas, forecasted the number of persons who were expected to be diagnosed with AIDS in rural areas through December 2010, and estimated AIDS-related health care costs incurred by rural areas between 1996 and 2006.

Materials and Method

Data Sources

Data analyzed in this study were obtained from *HIV/AIDS Surveillance Reports* published each December for the years 1993 through 2005.⁴ The 13 surveillance reports analyzed in

⁴The data for the 13 reporting periods analyzed in the current study are available on the CDC's website (<http://www.cdc.gov/hiv/stats/hasrlink.htm>) under the Main Topic of "HIV/AIDS Surveillance Reports."

this study contained data that documented: (1) the number of persons who were diagnosed with AIDS while living in *metropolitan statistical areas* (MSAs; i.e., cities with populations exceeding 500,000) and *non-metropolitan areas* (communities of 50,000 or fewer residents)^b between December 1993 and December 2005,^c and (2) the total number of persons *living with AIDS* (PLWAs) in the U.S. through 2005.^d This study analyzed data only for those individuals whose place of residence was known at the time of their AIDS diagnosis. Because the CDC revised the case definition of AIDS in 1993 (after which a person could be diagnosed with AIDS based on their CD4+ T-lymphocyte count or a diagnosis of pulmonary tuberculosis, invasive cervical cancer, or recurrent pneumonia), this study focused only on data published after December 1993.

Data Analysis Procedures

Study data were analyzed using the following procedures. First, descriptive statistics characterized the number of persons who were residents of MSAs and rural areas at the time of their AIDS diagnosis between December 1993 and December 2005. Second, regression analyses were conducted to identify the regression model(s) that provided the best fit to observed rural AIDS diagnoses between 1993 and 2003 (using the OMB's previous definition of "non-metropolitan") and between 2004 and 2004 (using the OMB's revised operational definition of "non-metropolitan"). Third, time series and regression analyses were used to forecast the number of persons who were expected to be residents of rural areas at the time of their AIDS diagnosis through December 2010.

For each year between 1993 and 2005 the number of persons living with AIDS in rural areas at year end was estimated by multiplying the total number of PLWA in the U.S. by the ratio of the cumulative number of rural AIDS cases to the cumulative total for the U.S.: $PLWA_{Rural} = PLWA_{U.S.} * (Cases_{Rural} / Cases_{U.S.})$. The corresponding cost of HIV/AIDS-

related medical care *during the following year* then was estimated by multiplying the number of rural PLWA by the annual cost of medical care for a person with AIDS -- \$21,204, 1996 dollars^e (Bozzette, et al. 2001). Similar procedures were used to estimate the number of PLWA, and corresponding medical care costs, in metropolitan areas.

Results

AIDS Cases Diagnosed by Area, 1993-2001

Cumulative numbers of AIDS diagnoses between 1993 and 2005 for MSAs and rural areas are shown in Table 1 ("Cases"). As shown in Table 1 (Case Ratio), between 1993 and 2003, the ratio of MSA to rural area AIDS diagnoses decreased steadily. At the end of 1993, approximately 16.8 persons were living in MSAs at the time of their AIDS diagnosis for each person diagnosed with AIDS in rural areas. However, by the end of 2003, the MSA to rural AIDS case ratio had decreased to 13.6 to 1. Moreover, whereas the proportion of cumulative AIDS cases diagnosed in MSAs of the United States *decreased* between 1993 and 2005 (from 85.4% in December 1993 to 85.1% in December 2005; data not shown), a slight *increase* was observed in rural areas during this interval (from 5.1% in 1993 to 5.3% in 2005).

In 2004, the Office of Management and Budget published revised standards for defining metropolitan statistical areas for use in federal statistical activities (Office of Management and Budget, 2005). This revision, among other things, reclassified some cities that had previously been classified as "non-metropolitan" into "micropolitan" or "metropolitan statistical areas." This revision resulted in a *decrease* in the number of AIDS cases diagnosed in rural areas. Specifically, and as shown in Table 1, in 2003 there were 55,343 persons living in small towns and rural areas when they were diagnosed with AIDS; however, in 2004, this number decreased to 47,742 rural AIDS diagnoses (a decrease of 7,601 cases).

For each of the 11 annual CDC data reporting periods, proportional increases in AIDS diagnoses—relative to the 1993 baseline year—were calculated separately for MSAs and non-metropolitan areas. As shown in Figure 1, AIDS diagnoses increased at relatively similar rates in the two areas through approximately 1997. However, by 1998, the proportional increases in AIDS diagnoses in rural areas began to diverge from those in MSAs. For example, in 1993, 18,308 persons were living in rural areas at the time of their AIDS diagnosis; this number increased to 39,856 persons in 1998, for an increase of 118% (see Figure 1). During this same period, AIDS diagnoses increased in MSAs by 88%. This pattern is even more evident between 1993 and 2003, when proportional increases in AIDS diagnoses in rural

^b For sake of simplicity, and because many people diagnosed with AIDS in "non-metropolitan" areas live in small towns and rural and frontier areas, the term "rural" will be used throughout the remainder of the article.

^c All physicians who make a diagnosis of AIDS must contact their local, state, or federal health department. These agencies then notify the CDC regarding numbers of AIDS diagnoses made within a particular region. The current study focused exclusively on AIDS diagnoses because several U.S. states have just begun to report new HIV infections to state or local health departments, thereby complicating efforts to examine the number of persons living with HIV infection in various geographical regions.

^d The phrase "persons living with AIDS" is frequently used to refer to the larger population of persons living with, or having been diagnosed with, HIV or AIDS. However, in this study, this phrase is intended to quantify the total number of persons in the United States who have progressed to AIDS and who were literally *still alive* at each reporting period.

^e Cost estimates were not calculated for 1994 and 1995, because these years pre-date HAART.

Table 1. Cumulative AIDS Diagnoses, Persons Living with AIDS, and Cost Estimates for Metropolitan and Non-Metropolitan Areas

Reporting Period	Metropolitan Statistical Areas			Non-Metropolitan (Rural) Areas			Case Ratio
	Cases	PLWAs	Cost (\$)	Cases	PLWAs	Cost (\$)	
Observed Values (1993 – 2003; Original CDC Definitions)							
1993	306,998	117,423	-----	18,308	7,003	-----	16.8
1994	374,533	142,996	-----	22,866	8,730	-----	16.4
1995	433,628	161,815	3,431M	27,504	10,264	217.6M	15.8
1996	488,310	182,854	3,877M	32,043	11,999	254.4M	15.2
1997	539,590	208,930	4,430M	36,436	14,108	299.1M	14.8
1998	578,010	231,750	4,914M	39,856	15,980	338.8M	14.5
1999	615,812	253,118	5,367M	43,221	17,765	376.7M	14.2
2000	649,759	272,441	5,777M	45,643	19,138	405.8M	14.2
2001	684,468	290,164	6,153M	49,375	20,931	443.8M	13.9
2002	719,566	324,296	6,876M	51,994	23,433	496.9M	13.8
2003	757,588	342,777	7,268M	55,343	25,040	530.9M	13.6
Observed Values (2004 – 2005; Revised Definitions)#							
2004	776,809	353,545	7,497M	47,742	21,729	460.7M	16.3
2005	807,169	369,326	7,831M	50,040	22,896	485.5M	16.1
Forecasted Values (2006 – 2010; Revised Definition)							
2006				51,779			
2007				53,384			
2008				54,748			
2009				55,872			
2010				56,756			

Cases = Cumulative AIDS cases reported through end of reporting period; PLWAs = Number of persons living with AIDS at end of reporting period; Cost = Cost of AIDS-related medical care during the following year (1996 dollars); Proportion Alive = Proportion of persons previously diagnosed with AIDS who were alive at the end of the reporting period; Case Ratio = Ratio of metropolitan to non-metropolitan AIDS cases.

#: Classification system used to categorize communities into "metropolitan" and "non-metropolitan" areas revised.

areas and MSAs increased by 202% and 147%, respectively.

Modeling AIDS Diagnoses in Metropolitan and Non-Metropolitan Areas

This study also identified the regression models that most accurately characterized increases in AIDS diagnoses in each area. Because it was possible that the relationship between AIDS cases and "Time" was non-linear, polynomial terms and a robust estimator of variance were evaluated in addition to traditional linear techniques.

Initial analyses considered a straight line model for the number of AIDS diagnoses in each area over time. While the predictor variable "Time" explained 99% of the variability in the number of AIDS diagnoses in non-metropolitan areas and 98% in MSAs in linear models, the distribution of residual terms in these analyses evidenced parabolic patterns (i.e., the residuals in both models were shaped as inverted "U"s) indicating violations of assumptions germane to linear regression analyses.

The second set of analyses tested whether the models for each area were improved by increasing the complexity of

Figure 1. Proportional Increases in Number of AIDS Diagnoses in MSAs and Non-Metropolitan Areas Through 2003 (1993 Value Used as Referent); Previous OMB Definition.

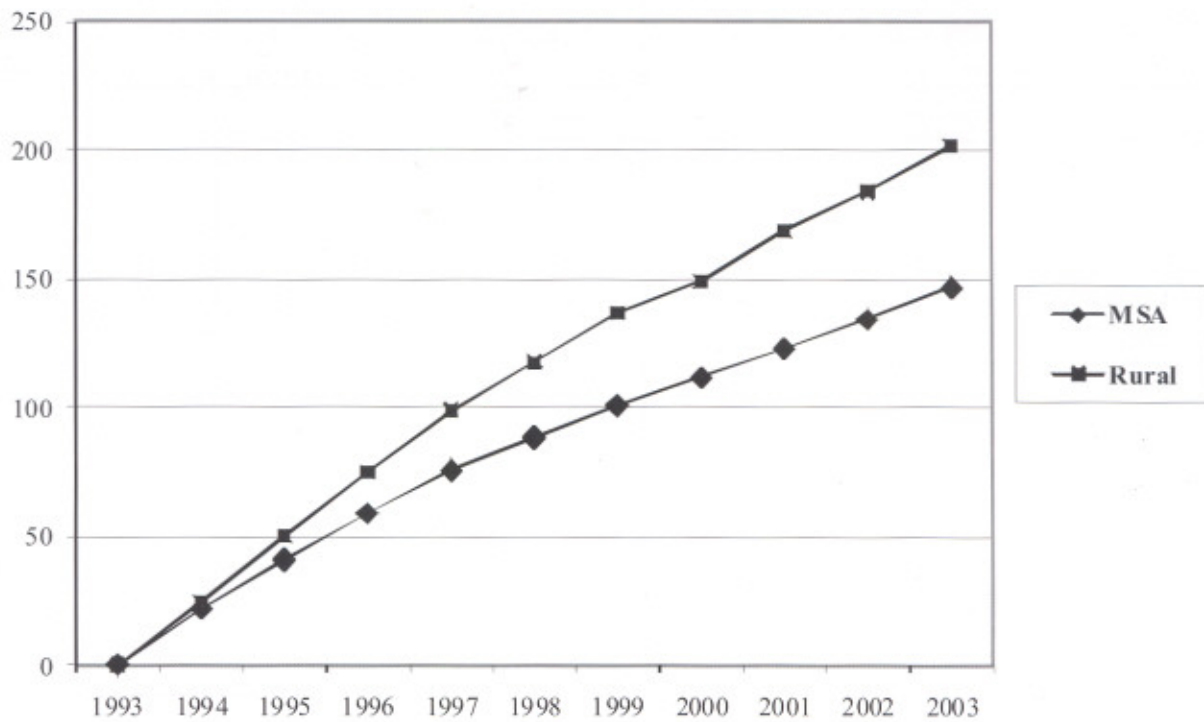
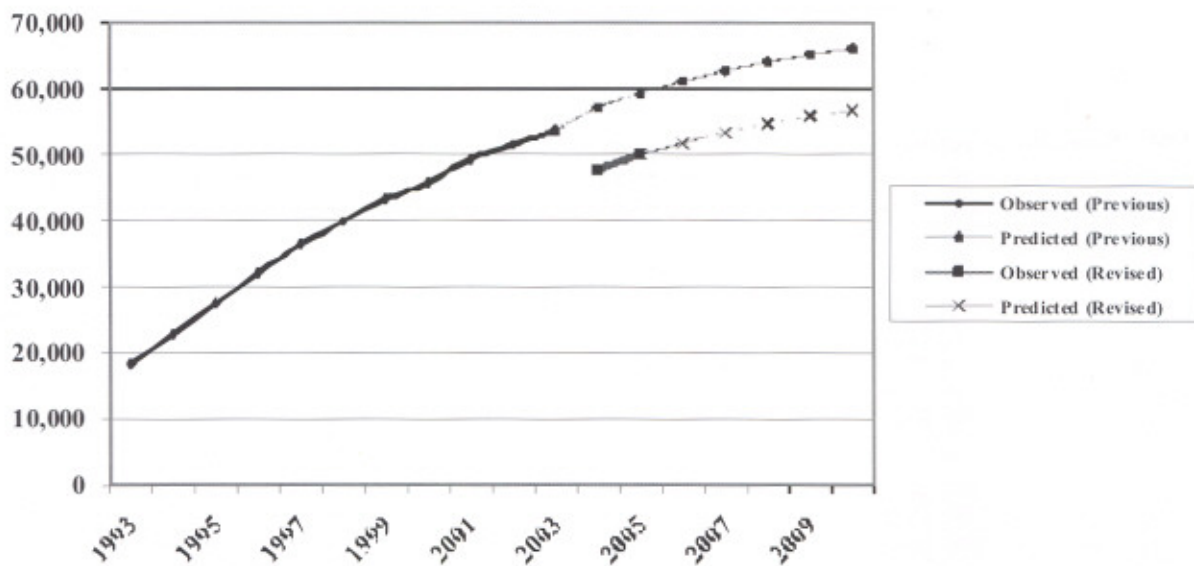


Figure 2. Observed and Projected Number of Persons Living in Non-Metropolitan Areas at the Time of Their AIDS Diagnosis (1993-2010); Previous and Revised OMB Definitions.



each fitted curve. The extension of the straight-line model to the second-order polynomial (i.e., a quadratic model) improved the model in each area: non-metropolitan areas ($r^2=99.95\%$) and MSAs ($r^2=99.73\%$) and the distributions of residuals in each analysis were non-systematically centered around zero. Accordingly, the most appropriate model to explain increases in AIDS diagnoses in both areas between 1993 and 2003 involves a second-order term (i.e., Time^2) in addition to the "Time" variable. The inclusion of this second-order term implies that while the number of rural AIDS cases is increasing each year, the rate of this increase is slowing over time. Figure 2 provides a visual characterization of AIDS cases observed in non-metropolitan areas between 1993 and 2003 (see dark, solid line from 1993 through 2003). The shorter dark, solid line shows the increase in rural AIDS cases from 2004 through 2005 using the revised OMB definition of "non-metropolitan."

Forecasting Future AIDS Diagnoses in Rural Areas

The quadratic regression model discussed above was used to forecast future numbers of total AIDS diagnoses in rural areas from December 2006 through December 2010. Two separate forecasts were calculated for these periods (see Figure 2). The first (shown in the dotted line with black circles) forecasts the number of rural AIDS diagnoses that would have been expected under the previous OMB definition of "non-metropolitan." Under the previous OMB classification scheme (used prior to 1994), small towns and rural areas of the U.S. would have accounted for approximately 66,093 AIDS cases in the U.S. in 2010. The second forecast (shown in the dotted line with small "x's") shows the expected number of rural AIDS diagnoses using the revised/current OMB definition of "non-metropolitan" that is used by the CDC. Using the revised/current definition of "non-metropolitan," Table 1 and Figure 1 show that the number of AIDS cases diagnosed in rural areas will increase steadily in the future, reaching 56,756 in December 2010.

Persons Living with AIDS and Associated Health Care Costs

As shown in Table 1, the number of persons with AIDS living in rural areas increased from approximately 10,000 at the end of 1995 to nearly 23,000 at the end of 2005, and estimated expenditures for HIV/AIDS medical care grew from approximately \$218 million in 1996 to more than \$485 million in 2006. Altogether, between 1996 and 2006, the U.S. spent an estimated \$4.3 billion to care for persons living with AIDS in small towns and rural areas of the United States.

Discussion

This research documents AIDS considerable impact on rural areas of the United States. From 1993 through 2003, the

number of persons diagnosed with AIDS in rural areas increased by more than 200%. The current study also shows that AIDS has had a significant economic impact on rural areas. In recent years the estimated annual cost of HIV/AIDS-related medical care for persons living with HIV in rural areas increased to approximately \$500 million. Importantly, this estimate does not include costs incurred by rural areas for the provision of care to HIV-infected persons who have not yet progressed to AIDS.

The current study shows that rural areas must intensify their efforts to meet the social and economic challenges created by AIDS. Issues such as access to care, treatment adherence, and mental health intervention approaches in rural areas of the U.S. have not been evaluated sufficiently to date. Unfortunately, the scant amount of research that has examined these issues paints a very bleak picture for many rural persons living with HIV/AIDS. For example, in the area of medication adherence, research shows that approximately 50% of HIV-infected rural persons fail to adhere consistently to life-sustaining HAART regimens (Heckman, Catz, Heckman, Miller, & Kalichman, 2004). This non-adherence rate is alarming and is one of the highest rates of medication non-adherence found in the AIDS care literature. Research also portends that the mental health needs of HIV-infected rural persons are considerable. Indeed, more than one-third of HIV-infected rural persons think about committing suicide (Heckman, Miller, Kochman, Kalichman, Carlson, & Silverthorn, 2002) and rates of depressive disorder as high as 60% have been observed in this group (Heckman, et al., 2004). In the area of sexual risk reduction, approximately 50% of sexually active HIV-infected rural persons fail to use condoms consistently (Crosby et al., 2002; Heckman et al., 2003).

Given the growing number of rural AIDS cases, innovative interventions are urgently needed to: (1) facilitate the adjustment efforts of this group; and (2) reduce the continued practice of unsafe sex that transmits HIV from HIV-seropositive rural persons to their seronegative partners. Given the unique life circumstances of HIV-infected rural persons (e.g., geographic isolation, confidentiality concerns), it is unlikely that mental health and sexual risk reduction interventions that have been effective in urban areas (e.g., face-to-face support groups, community-level risk reduction interventions) will generalize easily to rural areas. Interventions aimed at improving quality of life and reducing risky sexual behaviors in HIV-infected rural persons will need to utilize more innovative technologies, such as telephone and videophone technologies and/or the Internet.

Complicating the challenges of developing sexual risk reduction and AIDS mental health interventions for HIV-infected rural persons is the fact that rural areas of the U.S. are remarkably heterogeneous. For example, the medical and mental health care needs of HIV-infected individuals in remote areas of Mississippi are likely to be different than those

of infected persons in remote regions of Alaska. To this end, rural-based health care and social service organizations must monitor the evolving needs of their clients and be innovative in their efforts to develop culturally-contextualized interventions to reduce patterns of continued risky behavior and improve the life circumstances of persons living with HIV/AIDS in geographically-isolated areas of the United States.

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