Housing and Population Health: A 30 Year Study

Qualitative Investigation of Related Trends in Health and Housing and Potential Explanations

MDLHH0154-06: Task 5 Deliverable

Prepared for HUD Office of Healthy Housing and Lead Hazard Control

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December 2007

Introduction

In November 2006, the National Center for Healthy Housing (NCHH) undertook a study to address the lack of a comprehensive evidence base connecting housing conditions to general and specific health outcomes. The overall goal of this study is to identify housing trends from approximately 1970-2000 that are related to changes in population health, especially children and other at-risk subpopulations, by synthesizing data from existing sources. We have combined historical data from the American Housing Survey (AHS) and the National Health and Nutrition Examination Survey (NHANES) to identify changes in housing that could explain secular changes in health status. Previous deliverables of this study have identified changes over the past 30 years in housing related to (but not limited to) type of construction, tenure, density, size, age, moisture, pest prevalence, lighting, ventilation (Task 4a) and have identified changes in the physical health status of the population, such as respiratory health, obesity/diabetes, lead poisoning, cardiovascular disease, and general health (Task 4b).

With this deliverable, NCHH has examined the data to identify trends in housing that track trends in population health. As an ecological study where data are reported for populations and not for individuals, the research team recognized that it would not be possible to correlate the trends statistically. Instead, our hope is that by shedding light qualitatively on possible associations between housing and health factors, this study may encourage further research into the housing-health connection.

The main purpose of this deliverable is to set forth hypotheses of how housing factors may be related to health conditions and challenge the reader to concur or disagree with the observed associations. This report serves as the last deliverable to HUD before the research team begins drafting a manuscript for scientific publication. NCHH is especially interested in the readers' reactions to two elements of this report:

- Do you concur that the trends suggest an association between the housing and health factors?
- Do you concur with the hypotheses of why each housing trend may be related to a health trend?

The potential housing and health relationships that are considered the most ground-breaking and defensible will become the focus of the manuscript.

Methodology

The analyses in this report examine six broad areas of health that can reasonably be expected to be associated with housing. In the Task 4b deliverable, we identified 21 variables within these areas of interest that had sufficient data across the waves of NHANES surveys to examine trends. Four variables examined trends in the use of medicines and were considered less closely related to housing than the prevalence of the health condition itself, so they are not considered here. Six other variables (cough, wheeze, bronchitis, emphysema, emphysema/bronchitis, and cadmium level) had no apparent change with time, so they were not considered for the comparative analysis with the housing factors. Finally, we dropped two health factors (back pain, ever had asthma) from further analysis because these conditions were better measured by other factors (general health status and current asthma, respectively). This left eight health outcomes in NHANES that can be expected to be related to housing and neighborhood quality and for which data are available between approximately 1971 and 2002 (Table 1).

Table 1. Selected NHANES Health Outcomes Linked to Housing and Neighborhood Quality

Category	NHANES Health Outcome
General Health	Excellent or Very Good General Health Status (Compared to Good, Fair or Poor)
Infectious	Toxoplasma IgG (IU/mL)
Lead Poisoning	Blood Lead Concentration (μg/dL)
Respiratory Health	Currently Have Asthma
	Cotinine (ng/mL)
Obesity	Body Mass Index (kg/m^2)
Diabetes	Diagnosed with Diabetes
Cardiovascular Health	Hypertension - Blood Pressure measurement - Ever diagnosed by doctor with hypertension

The CDC analytic guidelines recommend age-adjustment for comparisons of health outcomes between waves of NHANES. For all health outcomes except blood lead, age-adjusted estimates for 20-74 year old adults based on the 2000 census were used. For blood lead, results are presented for children < 13 years old. For general health status, the unadjusted results are also presented.

We compared the trends in NHANES to selected housing and neighborhood variables in the AHS over the same time period. As with health variables, housing factors that displayed little or no change over time were not considered. Housing factors that displayed increasing, decreasing or changing (up-down) trends were then compared to the health outcomes listed on Table 1. If a reasonable hypothesis could be formulated for how the housing factor trend is related to the trend of the health outcome, then the association is included in this report. Thirty-nine housing factors met this requirement.

Findings

The remainder of this report presents a qualitative analysis of the potentially related housing and health trends. For each potential relationship, an explanation for why the housing factor may be associated with the health outcome is hypothesized. Figures with the trend lines for the factors are presented for all of the health outcomes of interest. On the figures, the center year of the particular NHANES waves is plotted.

Because a change in a given housing characteristic does not necessarily result in an instantaneous change in health status, differing "lag periods" might be defined to determine the best fit in the two trends. A lag period is defined as the time period beginning from when an observed change in a housing variable has been identified and ending when a corresponding change in a health variable has been found. In some cases, possible lagged effects are noted in the report. Additional lagged effects may be present but could not be observed because of the limited number of health surveys available during the analysis period,

At the end of this report, we provide tables that include the summary statistics for each variable in these analyses. Table 2 presents summary statistics for the health outcomes considered. Tables 3, 4 and 5 present summary statistics for the housing and neighborhood variables of interest.

As previously discussed in the Task 4a deliverable, there was a major change in the way certain AHS data were collected in 1997. For 1997 and succeeding years, certain AHS data were collected by interview from the respondent, instead of by direct observation by a survey worker. This may mean that changes observed were due to methodological differences, instead of actual changes in housing or neighborhood condition. The wording changes and modifications to the definitions of some variables are described in the Task 4a deliverable. The affected variables are noted on Tables 4 and 5.

Trends in Population Health Status Potentially Related to Housing Trends

Factors that contribute to population health are known to be multifactorial. Nutrition, access to both preventive and secondary medical care, education, employment, clothing, potable drinking water and access to recreational facilities are only a few of the factors that contribute to both physical and mental health status. Safe and healthful housing factors are also an important contributor to health and are the focus of this discussion. In addition, we examine certain indicators of neighborhood quality, because housing and neighborhood quality are often highly correlated with each other. Clearly, there are important interactions among these various factors. For example, without adequate employment opportunities or financial support, access to adequate housing and medical care can be compromised. Without proper nutrition, health status can be compromised and neighborhood quality often limits access to healthful food supplies.

Lead Poisoning

Among the six general categories, the association between lead poisoning and housing condition is perhaps the most robust given the large body of evidence showing that exposure to residential lead-based paint hazards causes increased blood lead levels. From 1976 to 2002, NHANES data show that blood lead levels declined from 13.2 μg/dL to 1.4 μg/dL in children under 13 years of age. Of course, over this time period, there were reductions in other sources of lead, such as gasoline, food canning, industrial emissions and other sources that contributed to this overall decrease.

A recent analysis showed that the decrease in blood lead level is associated with trends in housing demolition and substantial rehabilitation.[1] The former is associated with trends in housing age, because older units are more likely to be demolished. As the number of older housing units decline (as reported in AHS), the prevalence of lead-based paint can also be expected to decline, because older housing is more likely to have deteriorated paint and that paint is more likely to be lead-based paint. AHS data showed that the percent of pre-1950 housing units decreased from 47% to 25% between 1973 and 2001, respectively (Figure R-1).

Those housing conditions that affect interior moisture can also be expected to be associated with paint film condition, because lower moisture levels improve paint film durability (Figure R-2). Moisture is known to be perhaps the leading cause of premature paint failure. In short, the reduced water leakage from both the interior and the exterior, as reported in AHS, can be expected to positively affect paint quality, which in turn is linked to the reduction in both child and adult blood lead levels seen in NHANES. Interior water leaks declined from 12.2% to 9.5% and leaks from the exterior declined from 17.1% to 12.0% between 1989 and 2001, respectively. Similarly, the large decrease in homes without central air conditioning from approximately 83% in 1973 to 43.4% in

[1] Jacobs DE and Nevin R. *Validation of a Twenty-Year Forecast of U.S. Childhood Lead Poisoning: Updated Prospects for 2010*, Environ Res 102(3) 352-364, Nov 2006.

2002 can also be expected to decrease interior moisture levels, thus increasing paint film durability and reducing exposures from lead-based paint hazards.

Water leaks from both the inside and outside decreased significantly from 1989 to 2001 (Figure R-2), as did peeling paint or plaster, which decreased from 4.7% in 1973 to 2.6% in 2001. Finally, the availability of smooth and cleanable floors is known to be related to lead-contaminated dust, which is the most important route of exposure to children. The prevalence of holes in floors is likely to be a good indicator of the overall cleanability of surfaces. AHS reported a 50% reduction in the presence of large holes in floors, from 2.0% in 1973 to 1.1% in 2001 (Figure R-2).

Reductions in the number of pre-1950 housing units, the number of houses with interior and exterior leaks, and holes in floors, together with increases in the number of housing units with central conditioning (and thus better dehumidification) all can help to explain the large reduction in blood lead levels reported by NHANES.

Asthma

Asthma is a group of diseases for which the causal agents remain unclear. Several studies have suggested that housing conditions can contribute to either exacerbation or possibly on-set of this disease. NHANES reports that among adults aged 20-74, asthma increased from 3.4% in 1973 to 7.9% in 2001 (Figure R-3). Those housing factors that might explain this large historic increase in asthma include, among other things, the large increase in forced air furnaces. AHS reported that such furnaces increased from 49.2% in 1973 to 71.8% in 2001, including heat pumps (Figure R-3). The increased air velocities in living spaces offered by such furnaces could be expected to increase the concentration of airborne particulate matter as well as airborne allergens. Even though such furnaces are typically equipped with filtration systems, they can be expected to result in higher airborne particulate due to resuspension of dust particles that otherwise would settle out of the air onto surfaces where inhalation exposures would be lower. Furthermore, in single family housing, such systems typically do not provide for fresh air introduction, relying instead on building leakage for fresh air supply. Reduced fresh air introduction can be expected to increase exposure to allergens, oxides of nitrogen and other airborne asthma triggers because they will not be diluted as well as systems that provide more fresh air.

The increase in central air conditioning quantified in the blood lead section above might also be expected to contribute to asthma (Figure R-3), because such systems will reduce fresh air infiltration, even as they improve thermal comfort at the same time. Reduced fresh air infiltration means that exposure to oxides of nitrogen and other by-products of combustion from cooking stoves and other sources of combustion are also more likely to increase; exposure to oxides of nitrogen exacerbates asthma. Windows that would otherwise be open in the warm months are more likely to be kept closed in the presence of central air conditioning. Central air will also increase air velocities and re-suspension of particulate matter.

AHS reported changes in buildings where common area lights were working, from a low of 59.9% in 1973 to an improvement to 93.3% in 1993, before declining again to 87.9% in 2001. Poor lighting can be expected to increase stress and depression, both of which have been linked to asthma increases. The early trends in asthma and common area lighting are in general agreement, but not after 1993 (Figure R-3).

Neighborhoods with crime as reported by AHS respondents increased from 13.2% in 1973 to 23.8% in 1993, before declining to 15.3% in 2001. This increase in the perception of crime could increase stress levels and stress has been linked to asthma. Because the perception of crime declined after the mid-1990's, this trend line does not follow the asthma trend line (Figure R-3), although it is possible that asthma could "lag" the trend in crime. On the other hand, the prevalence of bars on windows, while perhaps reducing injuries from falls, might also be an indicator of fear and insecurity, which in turn could be expected to heighten stress-related asthma. Bars on window could at the same time lead to a reduction in perception of the threat of crime (Figure R-4).

Similarly, AHS reported an increase in broken windows from 1% in 1989 to 4.4% in 2001, although much of this change and the change in bars on windows could be associated with a change in the way the data were acquired after 1997 (Figure R-4). If there was an increase in the prevalence of broken windows, one could expect to see an increase in asthma due to the increased stress associated with deteriorated neighborhoods and units, for which broken windows are a good indicator.

The percent of units with working fireplaces increased from 31% in 1989 to 33% in 2001 (Figure R-4). Fireplaces could increase the levels of combustion by-products in living spaces, such as oxides of nitrogen, which has been linked to asthma.

Other studies have suggested that occupancy in pre-1950 housing is associated with asthma, but this analysis suggests that the increase in newer housing tracks the trend in asthma (Figure R-4). It is not known why the decrease in pre-1950 housing units is associated with an increase in asthma in this study.

Cotinine

NHANES reports that geometric mean cotinine levels have declined from 3.07 in 1989 to 0.74 ng/ml in 2001 among adults aged 20-74 (Figure R-5). Those housing conditions that might lead to a reduction in exposure to tobacco smoke indoors include the increased size of houses (Figure R-6), because the higher volume associated with larger houses could reduce the amount of second-hand tobacco smoke inhaled. The reduction in neighborhood bad smells could also encourage more people to smoke outdoors instead of indoors (Figure R-5). The increase in bars on windows, which could contribute to the perception of a reduction in crime, also appears to track the trend in cotinine, suggesting that such a reduction could also lead to people smoking outdoors more often (Figure R-5).

AHS reported an increase in units with nearby open space within a half block of the housing unit. In 1989, 21.5% of units had such nearby open spaces, but in 1997, this had increased to 41.1% before dropping to 36.7% in 2001, although some of this change could be due to changes from direct observation to resident report (Figure R-6). These nearby open spaces could be expected to make it easier for smokers to do their smoking outside the housing unit and building.

The decline in homes without central air conditioning also appears to track the trend in cotinine, suggesting that this could contribute to a decrease in exposure to second-hand tobacco smoke (Figure R-6). While central air conditioning might cause reduced fresh air infiltration, it could also be expected to increase air velocities within the living space, which could serve to dilute second hand tobacco smoke.

Finally, the increase in cost burden associated with housing tracks the decline in cotinine (Figure R-6). This could mean that residents have fewer financial resources to purchase tobacco products, because more of their money goes to secure housing.

Obesity and Diabetes

Although not always the case, diabetes has been linked to obesity and NHANES data show that the two conditions track each other quite closely (Figure R-7). NHANES reports that age-adjusted body mass index for adults aged 20-74 increased from 24.9% in 1971 to 27.7% in 2001 (Figure R-7). NHANES also reported that diabetes in adults aged 20-74 increased from 2.1% in 1973 to 4.5% in 2001 (Figure R-7). Factors related to the rise in these two conditions generally involve caloric intake and exercise.

Some of the AHS trends quantified previously could explain the increase in these two health conditions. The increase in central air conditioning and its associated improved thermal comfort could provide an incentive for people to remain indoors and thus exercise less (Figure R-8). The increase in cost burden for housing can be expected to increase stress and depression, which could contribute to eating disorders and reduced exercise (Figure R-8). The increase in the size of houses suggests that more activities can occur within the home, thus reducing the need to leave the home; this would also lead to a reduction in opportunities for exercise (Figure R-9).

Cardiovascular Health Trends

NHANES reports hypertension in several different ways. Figure R-10 shows the long-term trend for the following three metrics:

1). Those with high measured blood pressure who reported their physician had previously diagnosed them with hypertension or high blood pressure (Line H). This trend shows a decrease from 77% in 1973 to 37% in 2001.

2). Those with high measured blood pressure whose physician had *not* previously provided a diagnosis of high blood pressure (Line N). This trend shows a decrease from 33% in 1973 to 10% in 2001.

3). Those who stated that their physician had diagnosed high blood pressure. This trend shows an *increase* from 14% in 1973 to 17% in 2001.

While these metrics differ somewhat, some of the housing trends that could be associated with cardiovascular health include the slight increase in fireplaces, which could also cause higher exposures to carbon monoxide and other by-products of combustion, which in turn could negatively impact cardiovascular health. On the other hand, the increase in nearby open spaces could improve cardiovascular health, due to the increased opportunity for exercise. Similarly, AHS reported that the presence of commercial buildings in residential areas increased from 13.5% in 1973 to 16.5% in 1989, to 28.0% in 1997, before declining slightly to 27.5% in 2001. The presence of such buildings in residential areas could be associated with greater access to medical services and reduced stress due to greater diversity. All these trends are shown in Figure R-10 for the three different measures of hypertension.

General Health

NHANES has collected information on self-reported health status using a 5-point scale from 1973 to 2002 (excellent, very good, good, fair, or poor).

Those adults between 20-74 years of age whose self-reported general health status was either "excellent" or "very good" increased from 47.8% in 1973 to 54.8% in 2001. If one corrects for age, the improvement was far smaller (55.6% to 55.9% in 1973 and 2001, respectively, with larger variations in the intervening years (Figures R-11 through R-15)). For adults aged 40-60, the increase in excellent or very good general health was from 43.4 % in 1971 to 53.6% in 2002. Among those between 13 and 20 years of age, there was a large decrease in "excellent" or "very good" health, from 69.5% in 1975 to 50.5% in 1991, but then a large increase to 69.2% in 2002. While the increase in lifespan is often associated with improved population health, it is possible that the overall trend in general health differs across age groups. If there was indeed an overall improvement in general health (unadjusted for age), it could be attributed to many factors. It is possible that some housing factors could contribute to general health improvement, but at the same time contribute to specific health problems. The following housing factors can logically be linked to changes in general health.

- The size of the average dwelling unit reported by AHS increased from 1633 square feet to 1774 square feet in 1989 and 2001, respectively (Figure R-11). This increase in size can be expected to reflect a reduction in crowding and thus a reduction in communicable disease, as well as stress-induced mental disease related to confinement in small living spaces. On the other hand, this increase in housing size could also lead to declines in other health measures, e.g. obesity, which is discussed further below. The increase in housing size

has also been accompanied by an increase in housing cost burden (Figure R-15), which could be expected to increase overall stress.

- Improvements in moisture from reduced interior and exterior leaks (Figure R-14) and the increased presence of central air conditioning (Figure R-15) can be expected to reduce mold-induced illnesses, as well as reduce the stress associated with thermal discomfort.
- The reduction in older units (Figure R-15) could be expected to improve general health, because they tend to have higher maintenance requirements, are more likely to include antiquated designs for high-injury related factors, and also have more surfaces that are not cleanable leading to a greater possibility of communicable disease. Examples include stairways designed without hand railings and inadequate electrical system designs. For example, the prevalence of blown fuses reported by AHS decreased from 15.7% in 1973 to 11.0% in 2001 (Figure R-14). AHS also reported a slight increase in the prevalence of each room having a working electrical outlet, from 94.7% in 1973 to 98.8% in 2001 (Figure R-11), which can be expected to improve general health due to reduction in electrical hazards and fires associated with overloaded circuits.
- Residence in an urban area, which increased from 36.5% in 1973 to 41.4% in 2001 as reported by AHS (Figure R-15), can be expected to improve access to medical care, improve nutritional status due to greater access to larger supermarkets with greater food variety and quality, and perhaps improve the prospects of larger social networks, reducing stress-induced illnesses associated with loneliness and depression. Residence in an urban area, with its higher degree of zoning, could also lead to a reduction in neighborhood street noise. AHS respondents reported a decline from 33.9% in 1973 to 28.5% in 2001 in street noise (Figure R-15). Rural areas and central cities might both be expected to have more heavy duty commercial truck traffic. Such zoning might also have a beneficial effect on general health due to a reduction in exposures from industrial emissions; neighborhood “bad smells” declined from 11.6% in 1973 to 6.2% in 2001 (Figure R-14). Urban areas also are much more likely to have satisfactory public transportation (Figure R-12); AHS reported an increase in public transportation satisfaction from 32.4% in 1973 to 56.9% in 2001. It is important to note that the term “urban areas” as used in AHS does not include central cities and rural areas, both of which declined over the time frame of interest here. For all these reasons, living in an urban area can be expected to improve general health.
- The increase in fireplaces, which increased slightly from 31.0% to 33.0% from 1989 to 2001 (Figure R-15), can be expected to improve general health due to reduced stress associated with greater thermal comfort and recreational use. At the same time, fireplaces might give off more particulate matter and combustion by-products, which could negatively affect respiratory health.
- The increase in bars on windows, which increased slightly from 0.9% to 4.6%, could improve general health through an increased sense of security as well as reduced injuries from falls from windows, although some of this change may be due to the methodological change in 1997 (Figure R-13).

- The reduction in houses with basements and garages can be expected to improve general health due to improved air quality from lower exposures to soil gases and automobile emissions, such as carbon monoxide and hydrocarbons. AHS reported that basements declined from 49.1% in 1973 to 45.2% in 2001 and that garages declined from 70.1% in 1973 to 60.9% in 2001 (Figure R-12).
- Decreases in use of private drinking water wells can be expected to improve general health due to reduced water-borne diseases (Figure R-14). Similarly, the reduction in the percentage of houses with flush toilets not working (from 5.3% in 1973 to 2.9% in 2001) can be expected to improve general health through improved sanitation and reduced exposures to communicable diseases (Figure R-13).
- The slight increase in the number of adequate housing units (the decline in the number of severely inadequate housing units was 3.37% in 1989 to 2.01 in 2001) reported by AHS can be expected to improve general health due to reduced communicable disease attributed to inadequate sanitation and overcrowding, reduced injury due to fall and trip hazards, reduced food borne illnesses due to inadequate food storage, reduced disease associated with exposure to the elements and other factors (Figures R-11 and R-13).
- The slight decline in the prevalence of mice or rats seen recently, which AHS reported declined from 10.6% in 1989 to 7.3% in 2001 can be expected to improve general health due to reduced exposure to communicable diseases transmitted through mice and rats, as well as reduced injuries and infections associated with rat and mouse bites (Figure R-14).

Because the impact of housing conditions on general health status is the most ambiguous of the relationships presented, additional housing variables are also presented on Figures R-11 to R-15 for the reader's benefit. Other factors not reported above may also be plausibly associated with general health status. Alternatively, upon further scrutiny, some of the potential relationships described here may not warrant inclusion in a manuscript.

Toxoplasma IgG

Geometric mean Toxoplasma IgG decreased from 0.67 IU/mL in 1989 to 0.3 IU/mL in 2001 (Figure R-16). This NHANES variable could be considered to be a biomarker of housing sanitation, because it is linked with exposure to cat feces, contaminated food or food preparation surfaces and/or utensils, or contaminated drinking water. The housing variables that could be associated with Toxoplasma IgG include severely inadequate housing quality, which can include an absence of adequate food storage and preparation facilities. Incomplete plumbing facilities also can result in poor sanitation. Inside and outside water leaks can also contribute to food preparation surfaces that are not smooth and cleanable, also resulting in poor sanitation. All of these housing variables declined over the period of interest here.

Summary

The analyses in this report looked at housing and health relationships that have been previously explored in depth such as the effect of housing on lead poisoning and other potential relationships that have gotten little attention, like housing and obesity/diabetes. The analyses revealed associations like reductions in peeling paint and water leaks and reductions in blood lead levels that have been documented in prior research. Such findings offer credence to this study design as method to begin exploring other potential housing and health relationships. As one example of a potential relationship deserving further research, the results suggest that the increasing size of American housing and growth in central air conditioning may be contributing to the increase in obesity and diabetes. Alternatively, there could be no relationship between these health and housing outcomes. We believe that this report identifies a number of other potential housing-health relationships that should be documented in a manuscript and highlighted for future study.

In preparing this report, the research team considered the possibility that subsets of the population may display different trends. We conducted preliminary analyses exploring the health and housing trends of families in the lowest decile of income and trends of different racial/ethic subpopulations. The analyses generated a large volume of results, but the results rarely identified differences in trends between the subpopulations and the population as a whole. Lower income populations and some racial groups tended to live in poorer quality housing and their health outcomes were poorer than the general population. However, the subgroups basically displayed the same changes over time (e.g., lower blood lead levels, higher rates of obesity/diabetes, improvement in housing quality) as the trends presented above. Further analysis of subpopulations is possible, but we do not anticipate it will add much to the overall results.

The associations presented here are not necessarily causal, but they can help to inform the development of indicators of secular trends in housing and population health. While controlled trials can randomize interventions and perhaps identify specific causes and effects, they are of limited size and duration, the recruitment of control groups poses special ethical issues and they are unlikely to be representative of the general population due to study effects. In short, the study design used here has the unique advantage of a much larger dataset, covering many more housing variables and subjects over a much longer time period. It should serve as an important first step toward a better understanding of how housing conditions and population health is related.

Figure R−1: GM Blood Lead (ug/dL) and Housing Variables, Part 1 of 2
Children < 13 Years

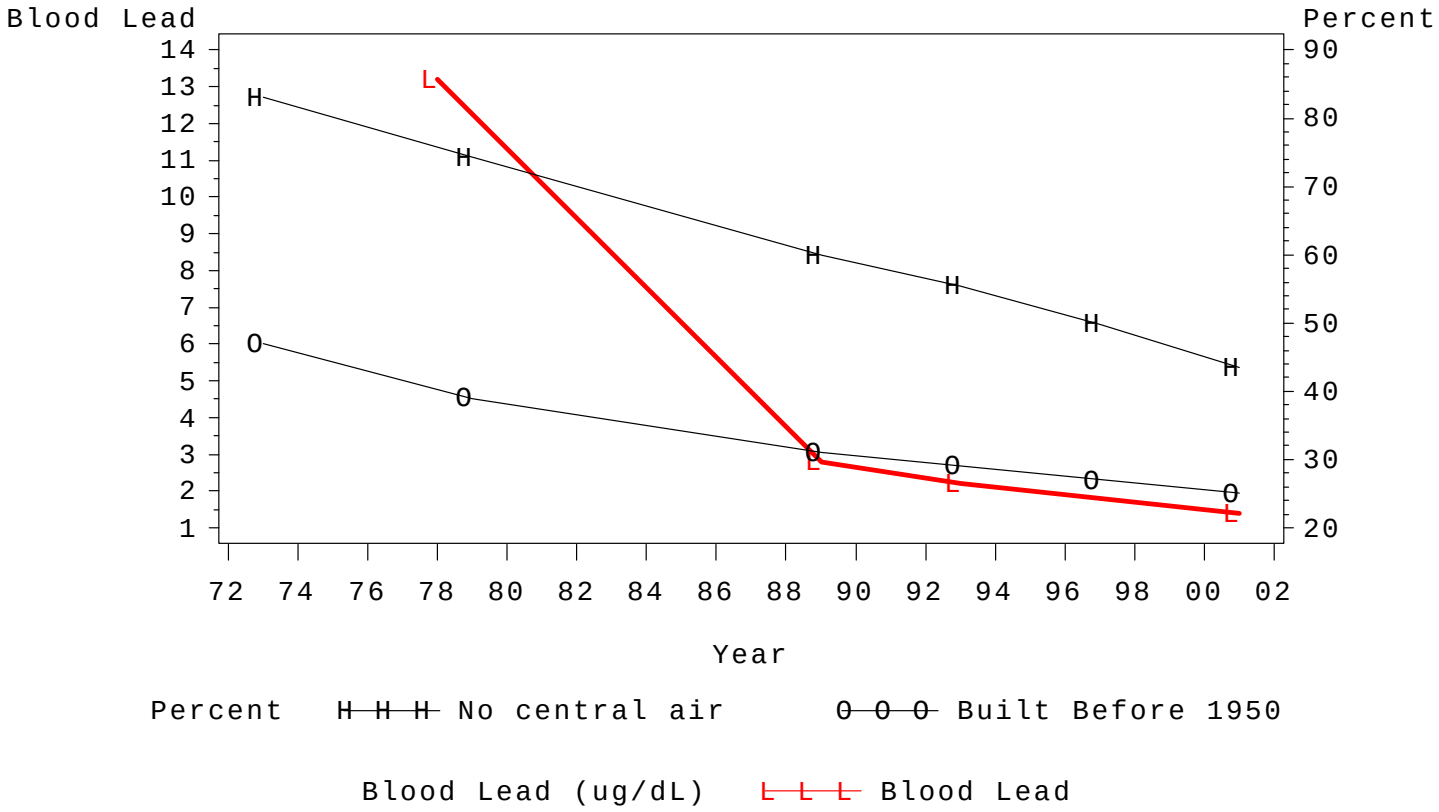


Figure R–2: GM Blood Lead (ug/dL) and Housing Variables, Part 2 of 2
Children < 13 Years

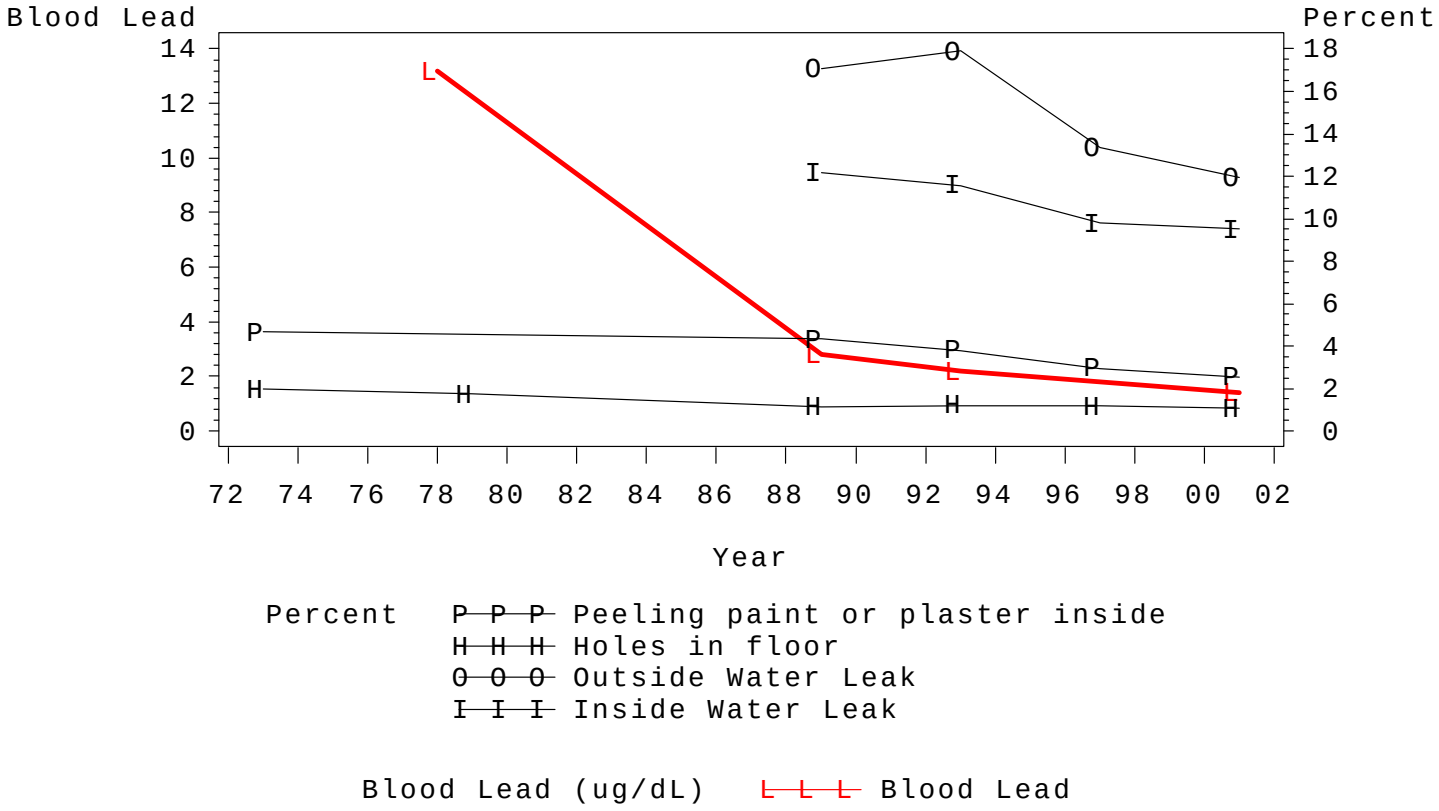
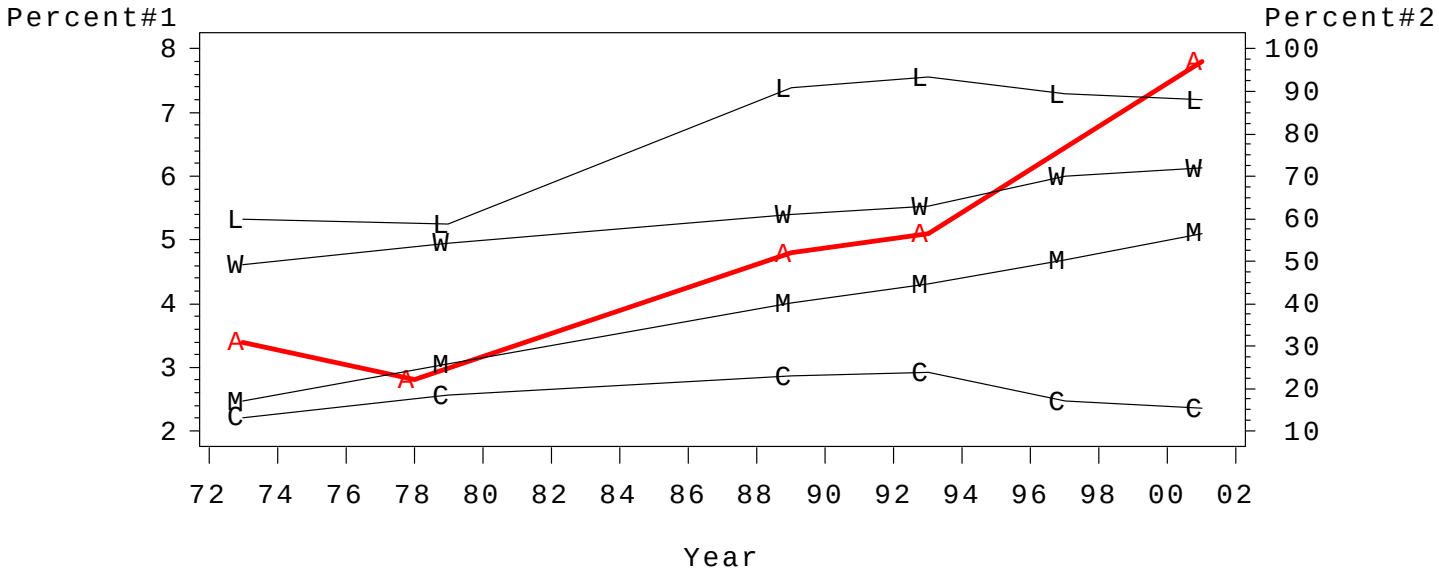


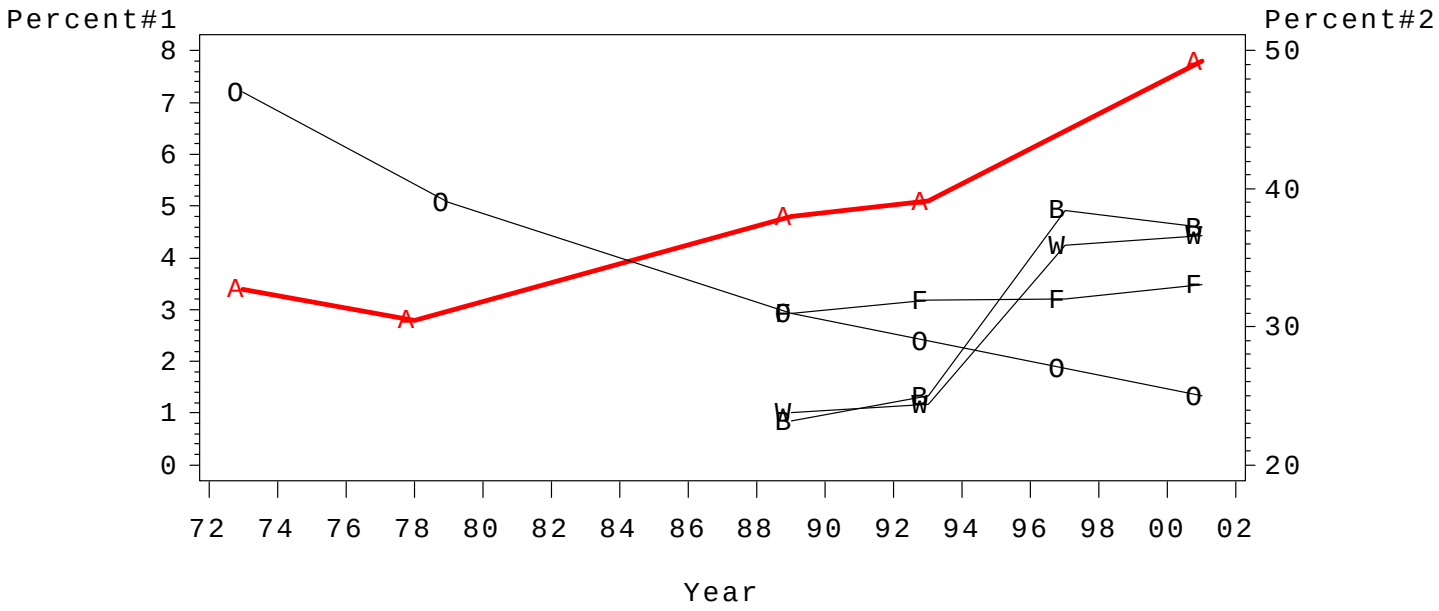
Figure R–3: Percent Currently Have Asthma and Housing Variables, Part 1 of 2
(Adults 20–74 age–adjusted)



Percent#2
C C C Neighborhood has crime
M M M Central air conditioning
W W W Warm (forced air) furnaces
L L L Common hallway lights working

Percent#1
A A A Asthma

Figure R–4: Percent Currently Have Asthma and Housing Variables, Part 2 of 2
(Adults 20–74 age–adjusted)



Percent#2 F F F Unit has useable fireplace
O O O Built Before 1950

Percent#1 A A A Asthma
W W W Broken windows in home
B B B Bars on Windows in home

Figure R–5: GM Cotinine and Housing Variables, Part 1 of 2
(Adults 20–74 age–adjusted)

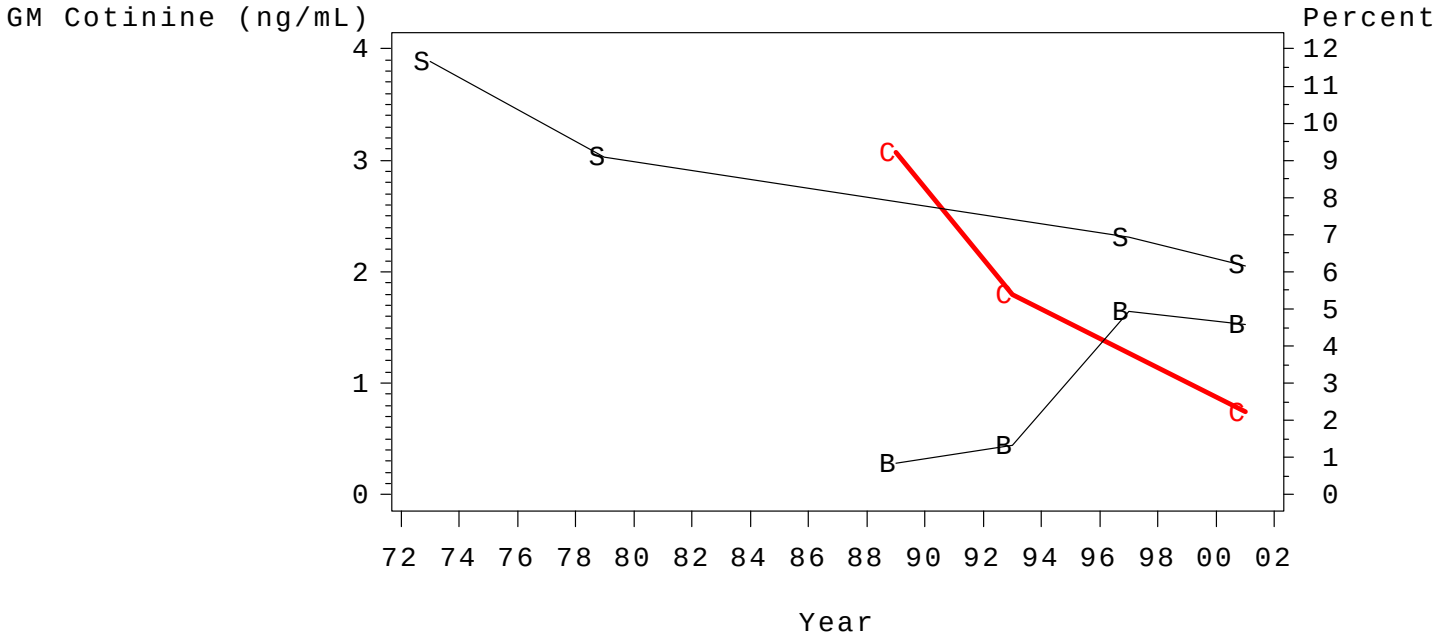


Figure R–6: GM Cotinine and Housing Variables, Part 2 of 2
(Adults 20–74 age–adjusted)

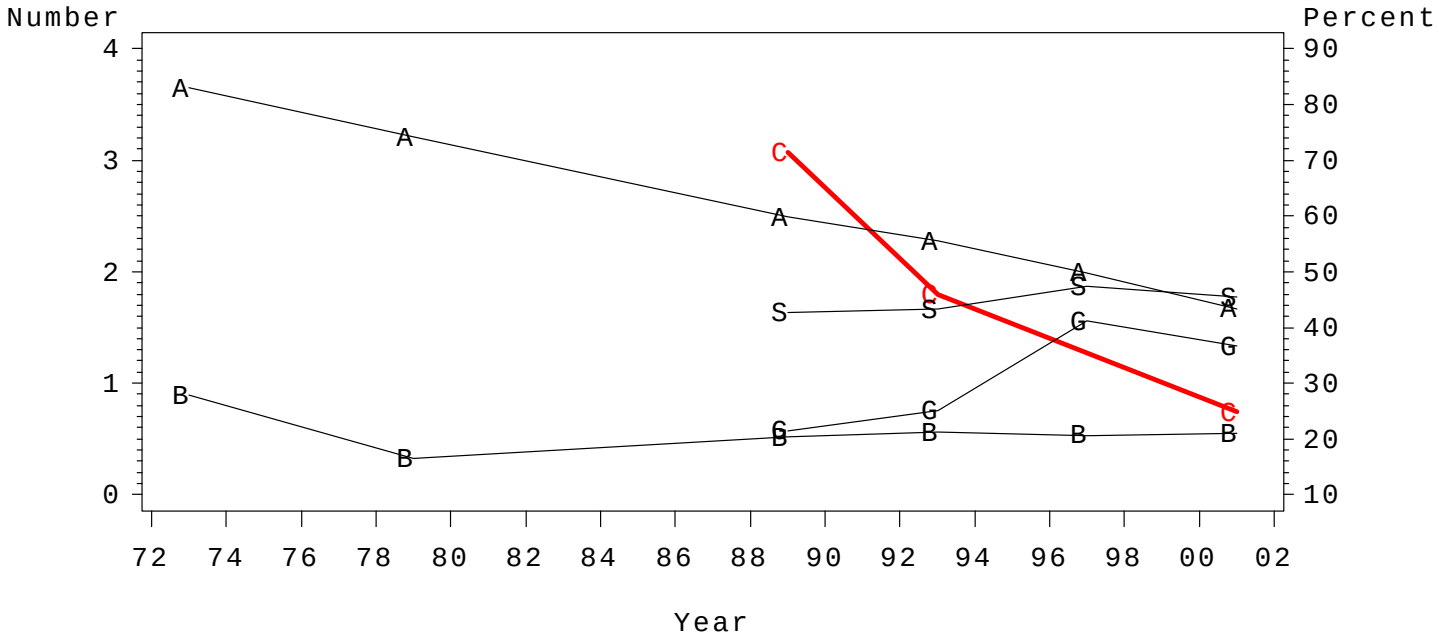


Figure R–7: Mean Body Mass Index and Percent Doctor Diagnosed Diabetes
(Adults 20–74 age–adjusted)

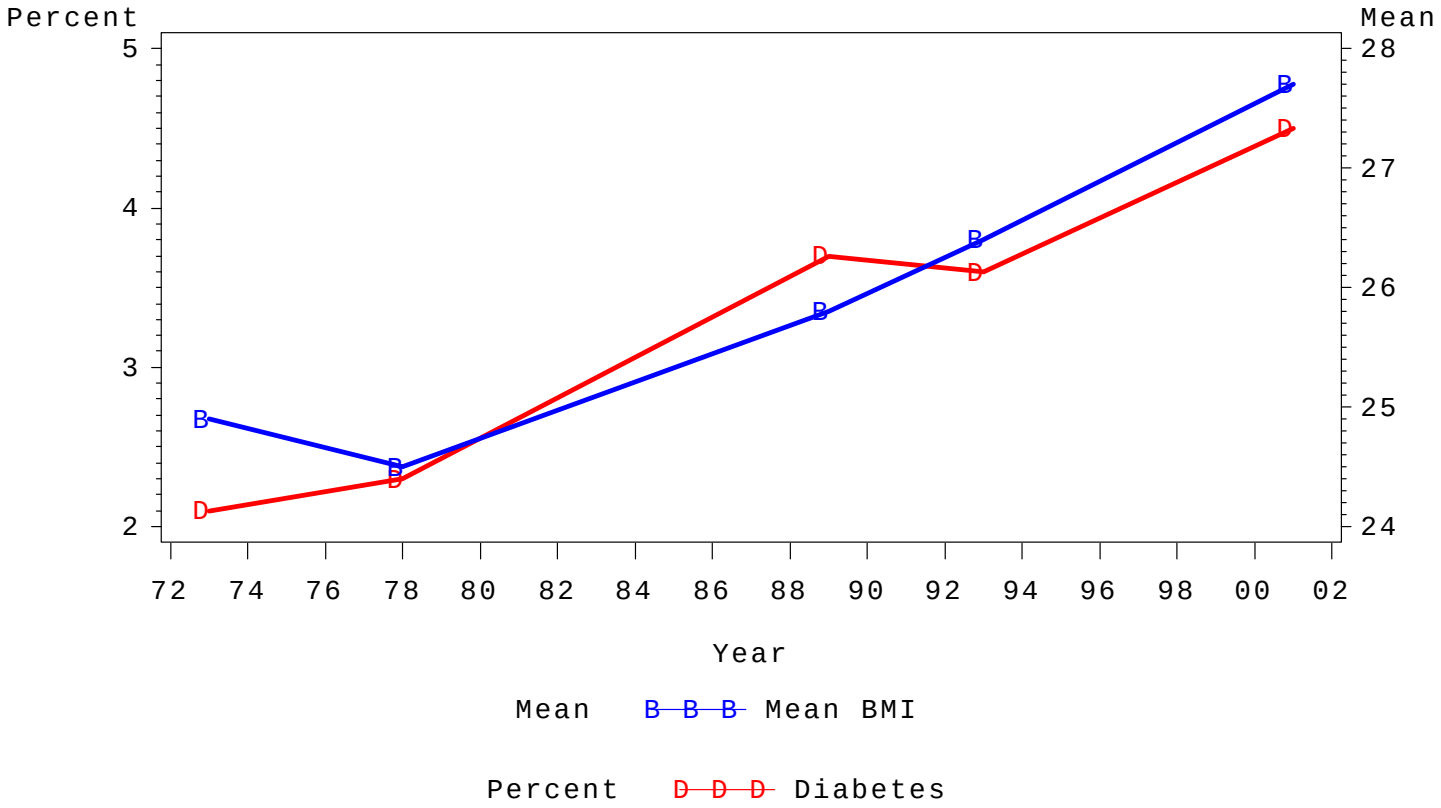


Figure R–8: Mean Body Mass Index and Housing Variables
(Adults 20–74 age–adjusted)

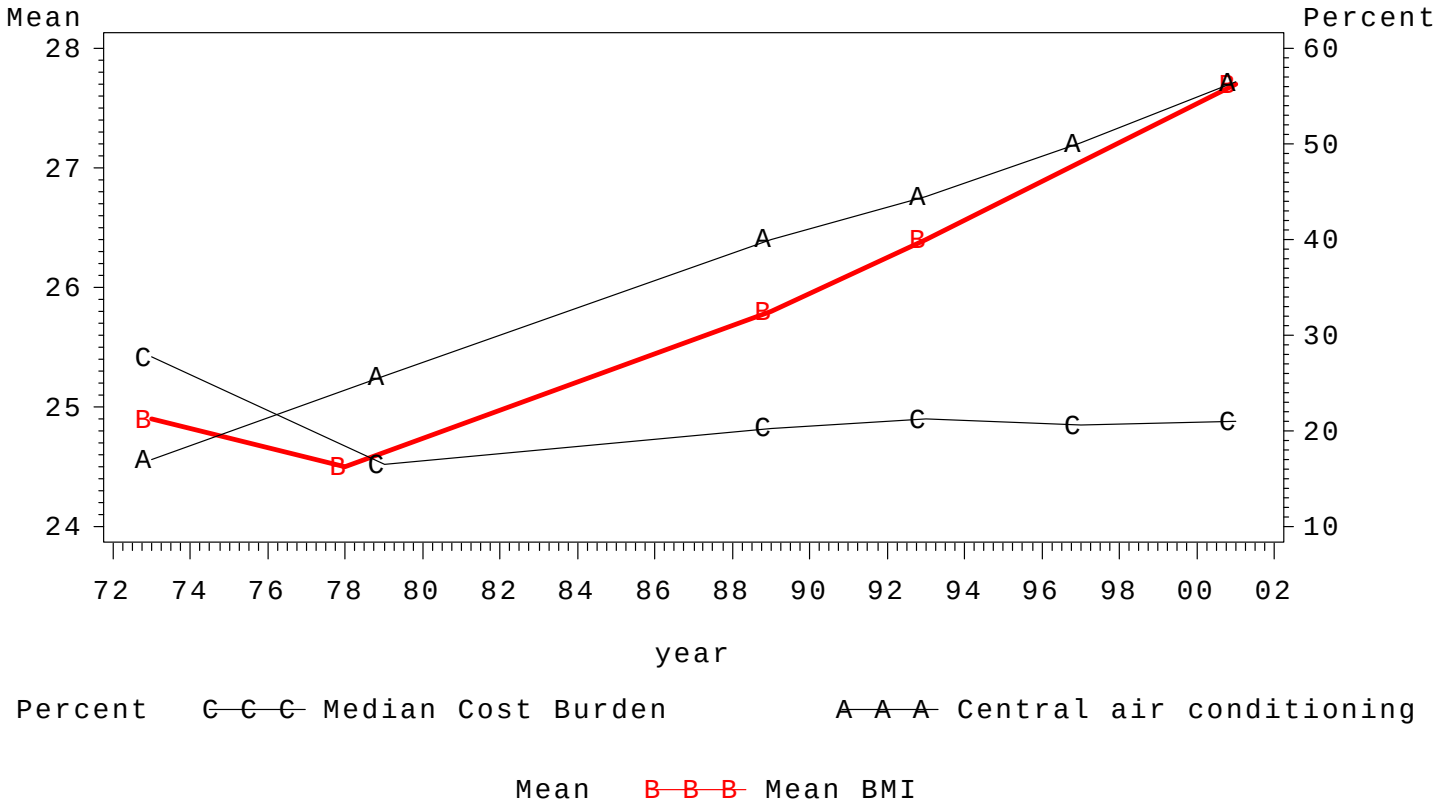


Figure R–9: Mean Body Mass Index and Housing Variables
(Adults 20–74 age–adjusted)

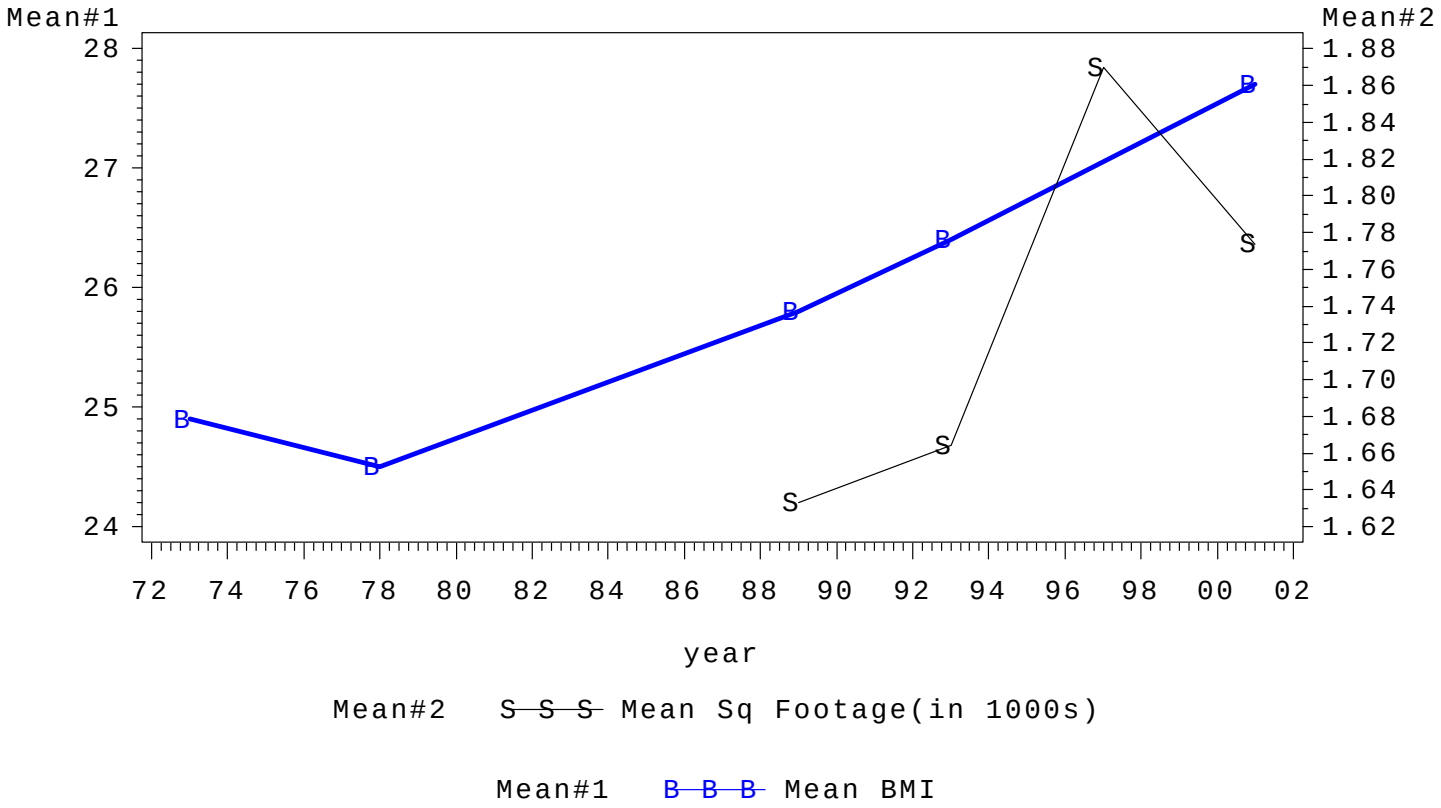


Figure R−10: Percent with Diagnosed Hypertension, amd Measured High BP by Diagnosed and Housing Variables (Adults 20−74 age−adjusted)

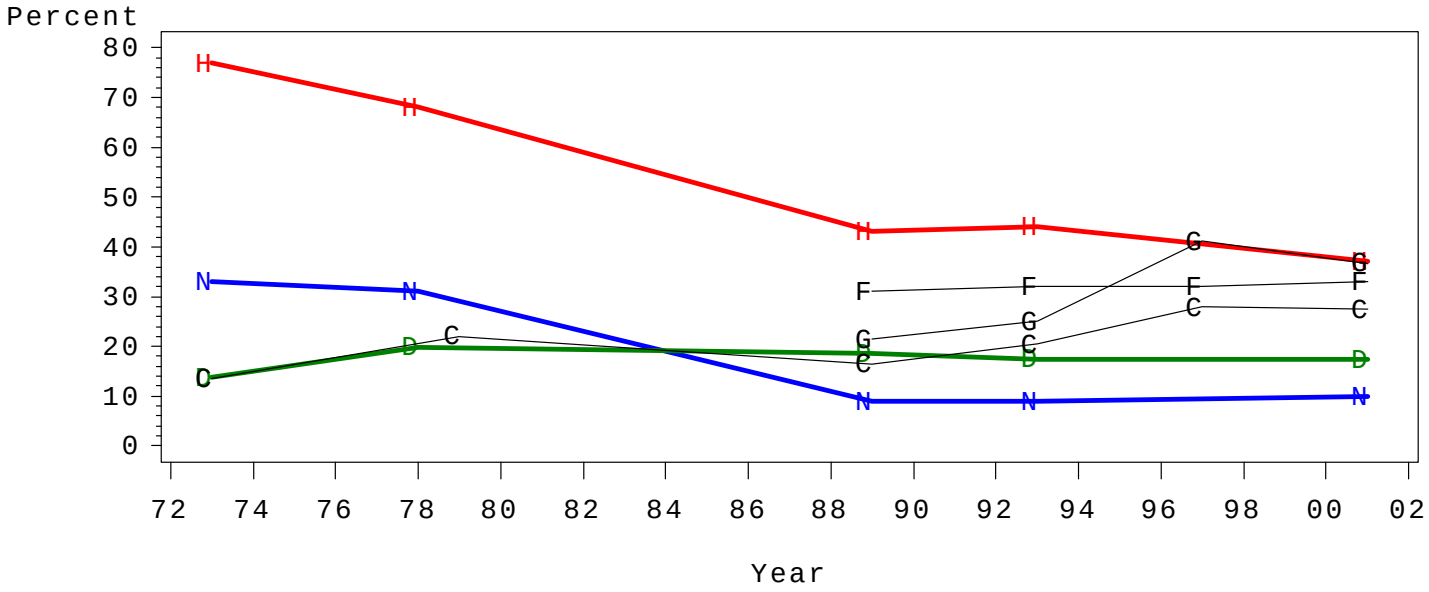
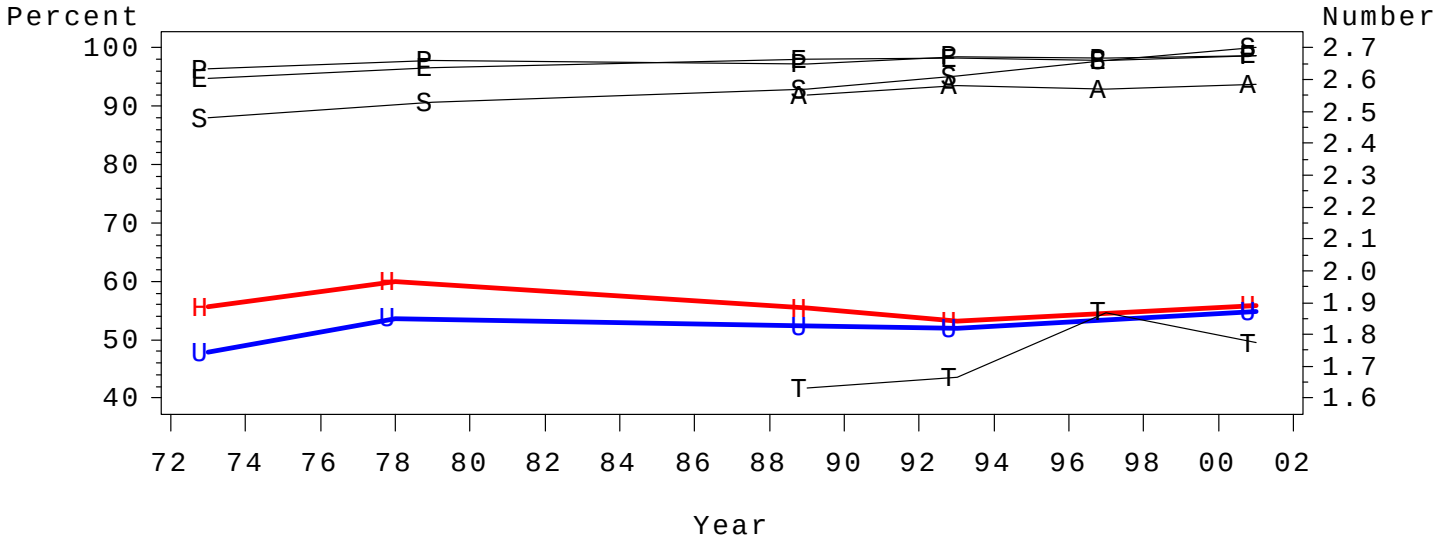


Figure R–11: Percent Excellent/Very Good Health and Housing Variables, Part 1 of 5
(Adults 20–74 age–adjusted and unadjusted)



Number T T T Mean Sq Footage(in 1000s) S S S Mean # Bedrooms

Percent H H H Excellent/very good health ADJ
U U U Excellent/very good health UN-AD
P P P Complete exclusive plumbing
E E E Working plugs
A A A Adequate Housing Quality

Figure R–12: Percent Excellent/Very Good Health and Housing Variables, Part 2 of 5
(Adults 20–74 age–adjusted and unadjusted)

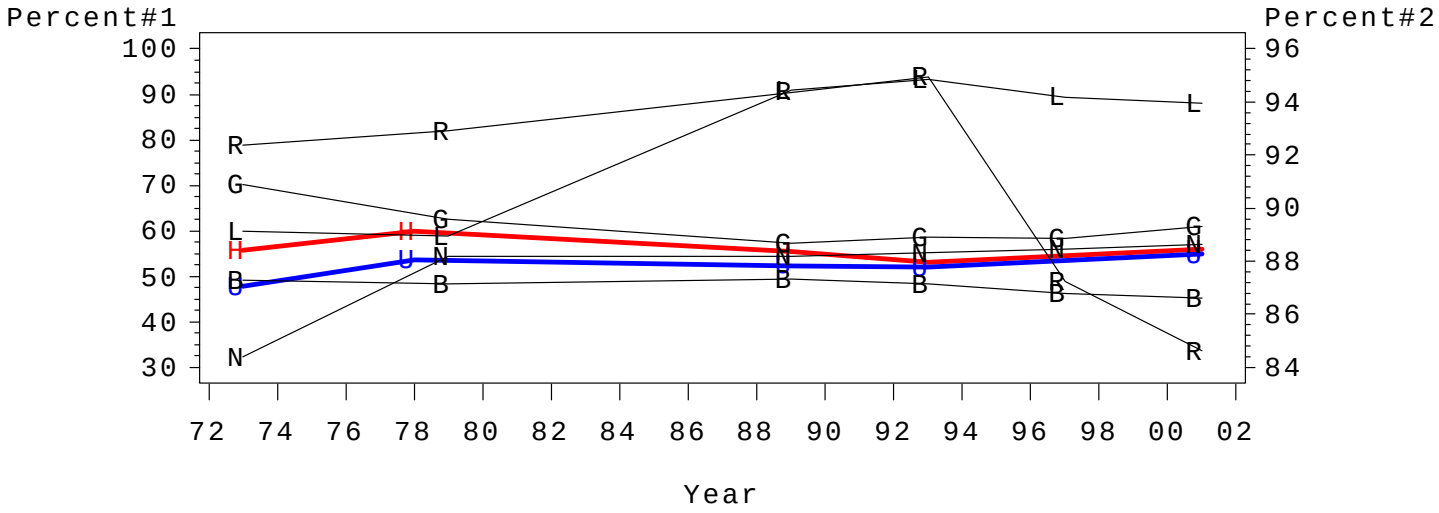
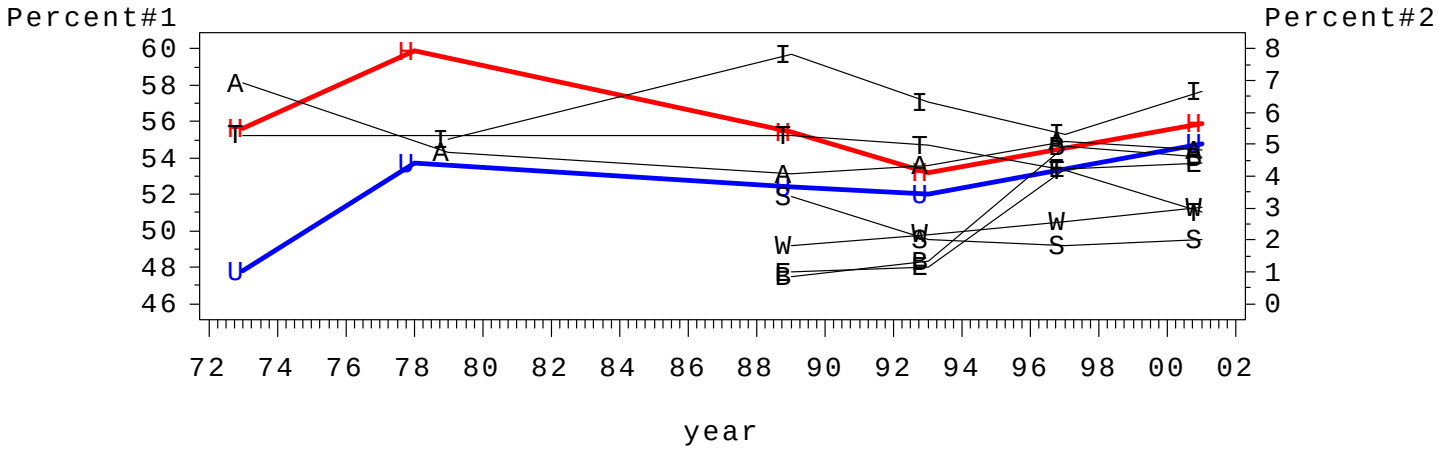


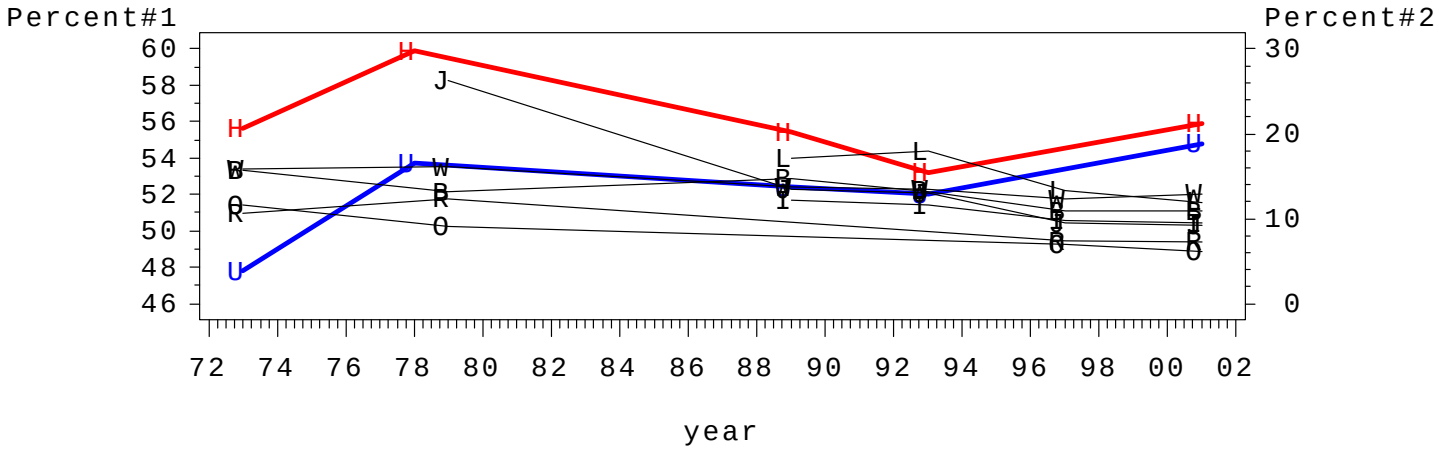
Figure R–13: Percent Excellent/Very Good Health and Housing Variables, Part 3 of 5
(Adults 20–74 age–adjusted and unadjusted)



Percent#2
S S S Severely Inadequate Housing
W W W Missing bricks or siding
E E E Broken windows in home
B B B Bars on Windows in home
T T T Toilets not working
A A A Abandoned/boarded up/vandalized
I I I Added/replaced insulation

Percent#1
H H H Excellent/very good health ADJ
U U U Excellent/very good health UN-AD

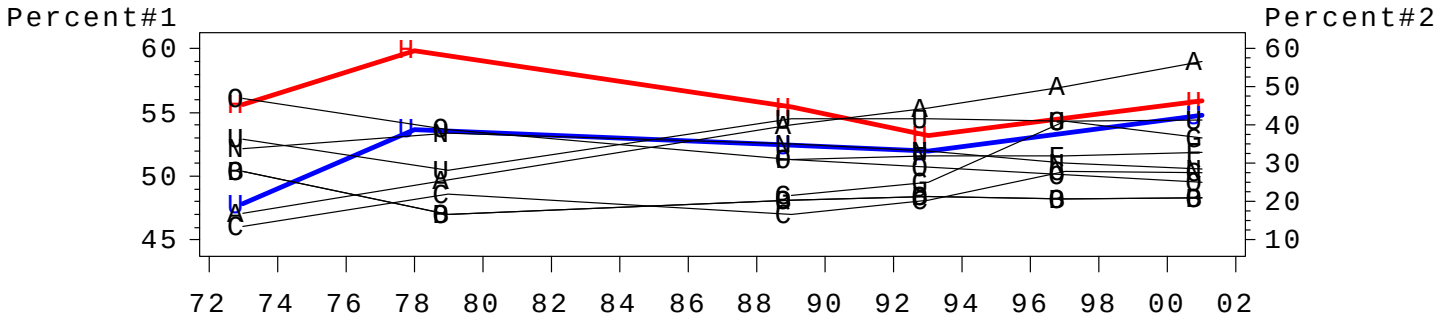
Figure R–14: Percent Excellent/Very Good Health and Housing Variables, Part 4 of 5
(Adults 20–74 age–adjusted and unadjusted)



Percent#1 L L L Outside Water Leak
J J J Trash/junk in streets/properties
W W W Well Water
B B B Fuses blown or circuit breakers
I I I Inside Water Leak
R R R Mice or rats
O O O Neighborhood has bad smells

Percent#1 H H H Excellent/very good health ADJ
U U U Excellent/very good health UN-AD

Figure R–15: Percent Excellent/Very Good Health and Housing Variables, Part 5 of 5
(Adults 20–74 age–adjusted and unadjusted)



Percent#2
- A A A Central air conditioning
- U U U Urban
- N N N Street noise
- O O O Built Before 1950
- F F F Unit has useable fireplace
- G G G Open Spaces
- C C C Commercial or industrial
- O O O Owner Occupied
- B B B Median Cost Burden

Percent#1
- H H H Excellent/very good health ADJ
- U U U Excellent/very good health UN-AD

Figure R–16: GM Toxoplasma IGG and Housing Variables
(Adults 20–74 age–adjusted)

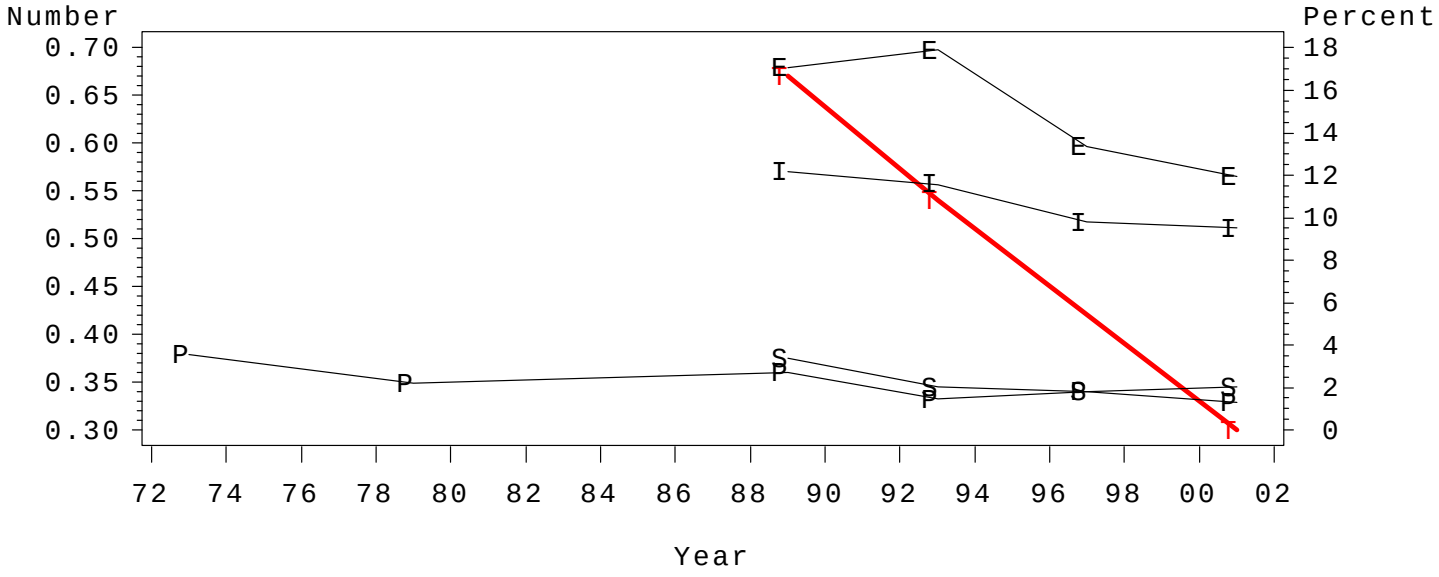


Table 2: Summary Statistics for Selected Health Outcomes

NHANES	Year on Plot	Percent							Geometric Mean			Mean
		Diagnosed with Diabetes	Excellent or Very Good Health	Excellent or Very Good Health (Unadjusted)	Currently have Asthma	High Blood Pressure Among People Diagnosed with Hypertension	High Blood Pressure Among People Not Diagnosed with Hypertension	Diagnosed with Hypertension	Toxoplasma (IU/mL)	Cotinine (ng/mL)	Blood Lead µg/dL	BMI (kg/m^2)
1971-1975 (NHANES I)	1973	2.1	55.6	47.8	3.4	77.4	32.6	13.8	.	.	.	24.9
1976-1980 (NHANES II)	1978	2.3	59.9	53.7	2.8	68	31	19.9	.	.	13.2	24.5
1988-June 30, 1991 (NHANES III, phase 1)	1989	3.7	55.4	52.4	4.8	43.2	8.6	18.5	0.67	3.07	2.8	25.8
July 1, 1991-1994 (NHANES III, phase 2)	1993	3.6	53.2	52	5.1	43.6	8.5	17.5	0.54	1.79	2.2	26.4
2001-2002	2001	4.5	55.9	54.8	7.8	37.1	9.9	17.4	0.3	0.74	1.4	27.7

Table 3: Summary Statistics for Selected Housing Factors

	Mean		Median	Percent						
AHS Year	Number of Bedrooms	Square Footage	Cost Burden	Owner Occupied	Built Pre-1950	Well-water source	Adequate housing quality	Severely inadequate housing quality	Urban area	Warm (forced) air furnace
1973	2.48	.	27.79	27.8	47.1	15.8	.	.	36.5	49.2
1979	2.53	.	16.52	16.5	39.5	16.2	.	.	28.3	54.3
1989	2.57	1633	20.32	20.3	30.7	13.7	91.9	3.4	41.8	61.0
1993	2.61	1664	21.26	21.3	29.0	13.5	93.5	2.0	41.6	63.0
1997	2.66	1870	20.67	20.7	26.9	12.3	93.0	1.8	41.2	70.1
2001	2.7	1774	20.97	21.0	25.0	12.9	93.7	2.0	41.4	71.9

Table 4: Percent of Homes with Selected Housing Factors (Part 1 of 2)

AHS Year	Basement (if single family dwelling)	Garage	Central air conditioning	Unit has useable fireplace	Owner added/replaced insulation	Peeling paint or plaster inside	Holes in floor	Mice or rats	Water leakage from inside in last 12 months	Water leakage from outside in last 12 months
1973	49.1	70.1	17.0	.	.	4.7	2.0	10.6	.	.
1979	48.3	62.5	25.8	.	5.2	.	1.8	12.4	.	.
1989	49.5	57.4	40.1	31.0	7.8	4.3	1.2	.	12.2	17.1
1993	48.3	58.6	44.5	31.9	6.3	3.8	1.2	.	11.6	17.9
1997	46.2	58.3	50.2	32.0	5.3	3.0	1.2	7.3	9.8	13.3
2001	45.2	60.9	56.6	33.0	6.7	2.6	1.1	7.3	9.5	12.0

Table 4: Percent of Homes with Selected Housing Factors (Part 2 of 2)

AHS Year	Complete exclusive plumbing facilities	Flush toilets not working anytime in last 3 months	Every room has working electrical plug	Fuses blown or circuit breakers tripped	Firmly attached stair railings in common areas*	Common hallway lights working*	Bars on windows in home*	Broken windows in home*	Missing bricks or siding*
1973	96.4	5.3	94.7	15.7	92.4	59.9	.	.	.
1979	97.8	.	96.6	13.1	92.9	58.7	.	.	.
1989	97.3	5.3	98.1	14.7	94.4	90.9	0.9	1.0	1.8
1993	98.5	5.0	98.2	13.2	95.0	93.3	1.3	1.2	2.2
1997	98.2	4.2	97.9	10.9	87.2	89.4	4.9	4.2	2.6
2001	98.7	2.9	98.8	11.0	84.6	87.9	4.6	4.4	3.0

* Question changed from observer to survey respondent response in 1997

Table 5: Percent of Homes with Selected Neighborhood Factors

AHS Year	Open spaces within 1/2 block*	Abandoned/ boarded up /vandalized buildings within 1/2 block*	Commercial/ institutional/ industrial buildings within ½ block*	Trash/junk in streets/properties within ½ block*	Neighborhood has crime**	Neighborhood has heavy street noise/traffic**	Neighborhood has bad smells**	Neighborhood public transportation satisfactory**
1973	.	6.9	13.5	.	13.2	33.9	11.6	32.4
1979	.	4.8	22.1	26.3	18.5	37.9	9.1	54.4
1989	21.5	4.1	16.5	13.4	23.0	35.1	.	54.4
1993	25.0	4.3	20.4	13.0	23.8	33.3	.	55.1
1997	41.1	5.1	28.0	9.5	17.2	30.0	6.9	55.9
2001	36.7	4.8	27.5	9.2	15.3	28.5	6.2	56.9

* Question changed from observer to survey respondent response in 1997

** Question wording and order changed in 1997