Gatton College of Business and Economics

The Economic Impact of Diabetes in Kentucky

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Department for Public Health
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Executive Summary

The Kentucky Department of Public Health is responsible for improving the health and safety of Kentucky's residents by preventing disease and injuries and encouraging healthy lifestyles. The department administers nearly 150 programs that address critical health issues affecting Kentuckians. These programs screen newborns for health problems, prevent the spread of infectious diseases, promote oral health, and provide numerous other services.

Diabetes represents a growing health concern for the nation and Kentucky. It is a chronic condition that causes blood sugar levels to rise and contributes to other serious health conditions such as heart and kidney disease. The U.S. Centers for Disease Control and Prevention lists diabetes as the 7th leading cause of death in the nation.

The disease imposes significant costs on the country's economy. The American Diabetes Association estimates that the U.S. spends $237 billion annually on diabetes-related health care. In addition, diabetes also adversely affects the nation's workforce. As the disease progresses, individuals may find it more difficult to work. This can reduce employment, productivity, wages, and tax revenue.

To better understand how diabetes affects Kentucky residents, the Kentucky Department of Public Health contracted with the University of Kentucky's Center for Business and Economic Research to study the economic impacts of the disease. This study has three main goals:

1. estimate the effect diabetes has on Kentucky's workforce;
2. estimate the short-run and long-run effects diabetes has on state tax revenues; and
3. examine how prevention and education programs could affect the health of those with diabetes and how they could potentially affect the state's workforce and tax revenues.

Nationally, 10.9 percent of adults have been diagnosed with diabetes, but the incidence rate for the disease in Kentucky is higher. The percentage of Kentucky adults diagnosed with diabetes has increased from 9.9 percent in 2007 to 12.8 percent in 2017. Currently, approximately 441,000 Kentucky adults have diabetes. The disease is more common among older adults, African Americans, and individuals with less education.

Past research shows that diabetes is associated with lower employment and earnings. In Kentucky, diabetes reduces employment by approximately 15,700 workers. This represents a loss of $551.3 million in earnings and $33.1 million in state tax revenue annually.

Diabetes contributed to 473 deaths of Kentucky residents between the ages of 35 and 64 in 2016. In the absence of the disease, many of these individuals would have worked and earned wages. These deaths represent lost earnings of $12 million and lost state tax revenue of $710,000 during the first year after death.

Note that this estimate only represents the losses for deaths that occurred in a single year, 2016. The total earnings and tax revenues lost to diabetes in any given calendar year would actually be

larger than the result of a single-year’s deaths, once the cumulative effects of losses associated with those who have died over the preceding years are also factored in.

The present value of lifetime lost earnings and revenues for the 473 Kentucky residents who died due to diabetes in 2016 total $100.4 million and $6.02 million, respectively.

The American Diabetes Association estimates that those with diabetes incur $5,000 to $12,300 in additional health care costs relative to those without diabetes per year. These estimates suggest that diabetes contributes to an additional $3.9 billion in health care costs in Kentucky annually.

Lifestyle intervention programs help individuals who have a high risk of developing diabetes lose weight through healthier lifestyles. Evaluations of these programs show that they can reduce the long-term incidence of diabetes. Although these programs do not appear to reduce total health care costs relative to typical treatment for diabetes, research shows that lifestyle interventions can be cost-effective ways to improve the quality of life for participants.

Lifestyle intervention programs may also improve employment and earnings. Because lifestyle interventions reduce the incidence of developing diabetes, they might also increase the percentage of people who are able to work and earn a living. However, it is unlikely that lifestyle interventions would increase tax revenues by enough to cover the costs of the program. For example, an average 45-year-old male who participates in the program could expect to earn approximately $12,600 in additional income and generate $756 in additional state tax revenue over his lifetime, when compared to a male of the same age with diabetes who does not participate in an intervention program. While this amount would not cover the cost of the program, it would help offset a portion of these costs.

Diabetes education programs are designed to help those with diabetes manage their disease. Past research has shown that these programs can provide meaningful improvements in weight, blood sugar levels, and blood pressure. Researchers have generally found that they appear to be cost-effective, but estimates vary. There appears to be little meaningful research on whether education programs improve labor market outcomes.

Section 1: Introduction

Diabetes is a chronic health condition that limits the body's ability to turn food into energy. This occurs either because the pancreas does not produce insulin, or the body is unable to use the insulin produced. As a result, blood sugar levels rise and contribute to other serious health conditions such as heart and kidney disease.

The U.S. Centers for Disease Control (CDC) estimates that the number of people in the U.S. who suffer from diabetes has grown by 300 percent in the past 20 years and now stands at over 30 million. Twenty-five percent of these individuals do not yet realize they have the disease. An additional 84 million adults in the U.S. have prediabetes.

The cost associated with diabetes creates a significant burden on the national economy. Health care costs of diabetes alone has been estimated at $237 billion annually (American Diabetes Association 2018). In 2016, diabetes contributed to over 80,000 deaths in the U.S., making it the nation's 7th leading cause of death (CDC, Leading Causes of Death).

Diabetes also creates an economic burden by reducing employment and earnings. As their health declines, individuals suffering from diabetes may be less likely to work, earn lower wages, and incur higher rates of absenteeism. The American Diabetes Association estimates that lost earnings associated with diabetes in the U.S. totaled $90 billion in 2017.

These adverse economic effects have implications for state and local policy makers as they consider whether to adopt policies to address diabetes. Not only does diabetes increase the costs for state and local assistance programs such as Medicaid, but it also affects labor market outcomes. These effects can in turn reduce state and local tax revenues. By increasing expenditures and decreasing revenues, diabetes can have significant fiscal implications for state and local governments.

In July 2018, the Kentucky Department of Public Health contracted with the University of Kentucky's Center for Business and Economic Research (CBER) to examine how the prevalence of diabetes in Kentucky affects the Commonwealth's labor market. This study has three specific objectives:

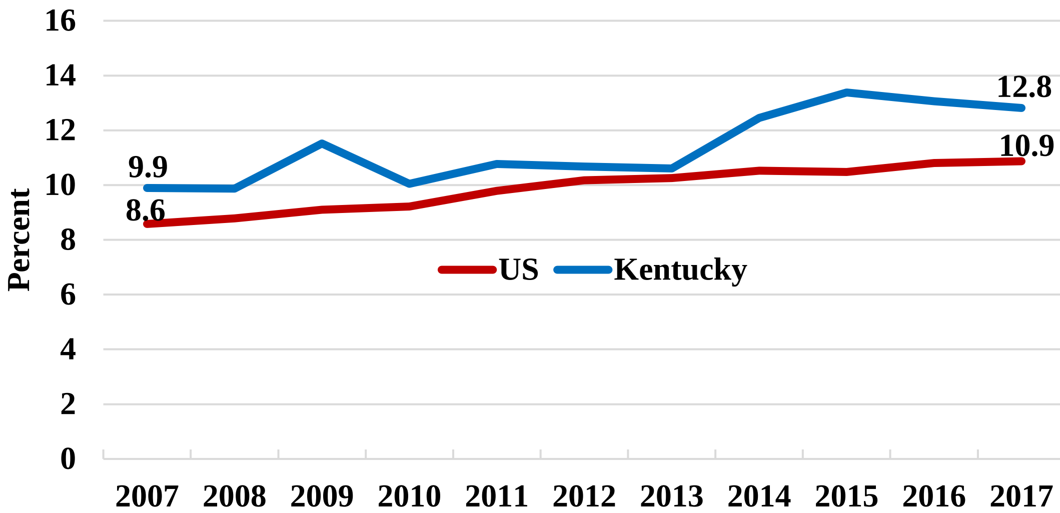
1. estimate the effect diabetes has on Kentucky's workforce;
2. estimate the short-run and long-run effects diabetes has on state tax revenues; and
3. examine how prevention and education programs could affect the health of those with diabetes and how they could potentially affect the state's workforce and tax revenues.

Section 2: Prevalence of Diabetes in Kentucky

Data from the CDC shows that diabetes is more common in Kentucky than the nation. Approximately 12.8 percent of Kentucky adults, or 441,000 individuals, have been diagnosed with diabetes. This compares to 10.9 percent in the U.S. While diabetes occurs among the entire population, it tends to be more prevalent among certain demographic groups. This section examines trends in the prevalence of diabetes in Kentucky over time and across these demographic groups. The figures below focus on the adult population and exclude cases of diabetes that are related to pregnancies or are undiagnosed. The data for this analysis comes from the U.S. CDC's Behavioral Risk Factor Surveillance System (BRFSS).

Figure A shows that the share of the population with diabetes has been growing for both Kentucky and the U.S. In 2007, only 9.9 percent of Kentucky adults were diagnosed with diabetes. This rate grew to 12.8 percent by 2017. The CDC cites the aging of the population and increasing obesity rates as factors contributing to this growth.

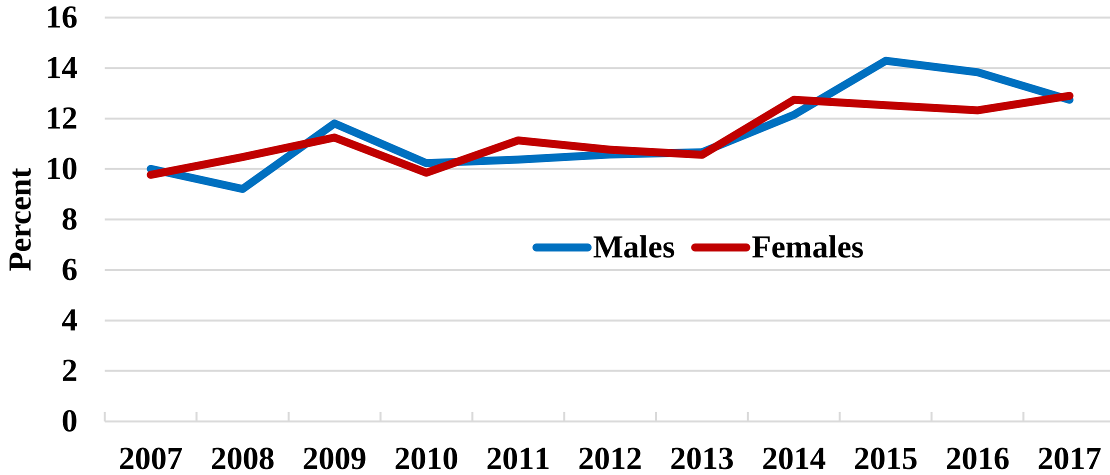
Figure A
Prevalence of Diabetes among Adult Population
US and Kentucky



Source: CBER analysis of data from the Kentucky Department of Public Health and the United States Centers for Disease Control and Prevention. Behavioral Risk Factor Surveillance System 2007 to 2017.
Note: Excludes diabetes related to pregnancies.

Diabetes has generally been equally prevalent among males and females. Figure B shows that the rate of diabetes has grown for both groups.

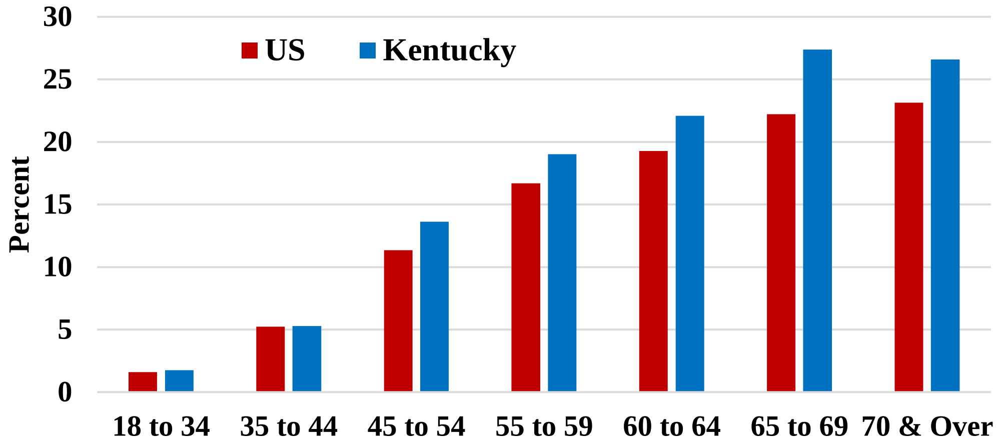
Figure B
Prevalence of Diabetes Among Adults by Gender
Kentucky



Source: CBER analysis of data from the Kentucky Department of Public Health and the United States Centers for Disease Control and Prevention. Behavioral Risk Factor Surveillance System 2007 to 2017.
Note: Excludes diabetes related to pregnancies.

Diabetes becomes more prevalent later in life (Figure C). In Kentucky, approximately 14 percent of those aged 45 to 54 had diabetes, while roughly 22 percent of those aged 60 to 64 reported having diabetes. There was little difference between the U.S. and Kentucky in prevalence among those under the age of 45. Type 1 diabetes is usually diagnosed at an early age, while type 2 diabetes develops later in life and is often associated with lifestyle choices such as diet and physical activity. Approximately 90 percent of diabetes cases are type 2 (U.S. Centers for Disease Control and Prevention).

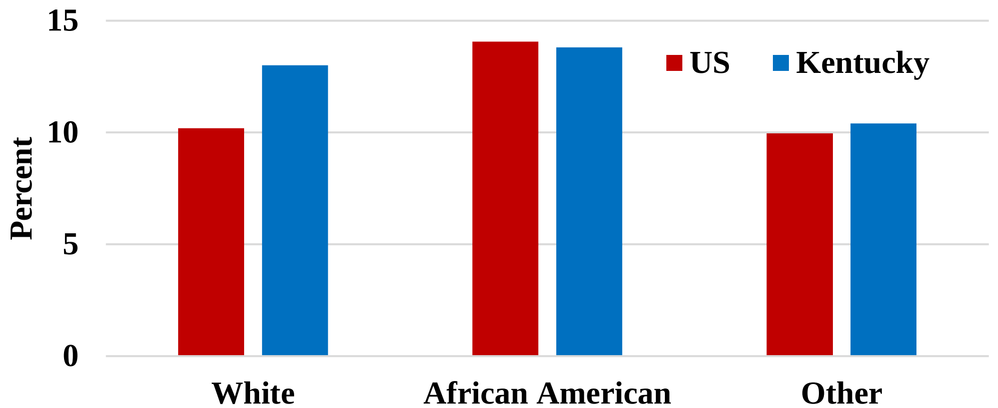
Figure C
Prevalence of Diabetes by Age
US and Kentucky



Source: CBER analysis of data from the Kentucky Department of Public Health and the United States Centers for Disease Control and Prevention. Behavioral Risk Factor Surveillance System 2017.
Note: Excludes diabetes related to pregnancy.

Nationally, diabetes is more common among African Americans than Whites and other racial groups (Figure D). However, there is little difference in the prevalence of diabetes among African Americans and Whites in Kentucky.

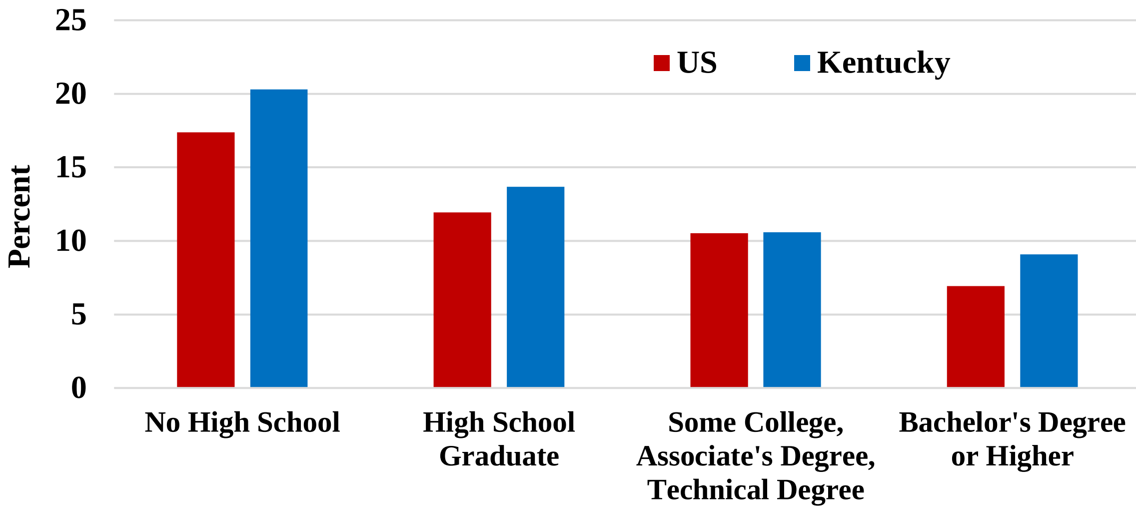
Figure D
Prevalence of Diabetes by Race
US and Kentucky



Source: CBER analysis of data from the Kentucky Department of Public Health and the United States Centers for Disease Control and Prevention. Behavioral Risk Factor Surveillance System 2017.
Note: Excludes diabetes related to pregnancy.

Diabetes is more common among individuals with less education (Figure E). In Kentucky, adults not completing high school are more than twice as likely to suffer from diabetes compared to those with a college education.

Figure E
Prevalence of Diabetes by Education
US and Kentucky



Source: CBER analysis of data from the Kentucky Department of Public Health and the United States Centers for Disease Control and Prevention. Behavioral Risk Factor Surveillance System 2017.
Note: Excludes diabetes related to pregnancy.

Section 3: Employment and Earnings

Diabetes has been associated with reduced employment, earnings, and productivity. This section reviews past research examining these relationships and estimates the impact that diabetes has on Kentucky’s labor market and state tax revenues.

Past Research

The negative labor market effects associated with diabetes may begin at an early age. Fletcher and Richards (2012) followed a group of adolescents from 1995 through 2008 to examine how diabetes affected their educational attainment. After controlling for other health conditions and family illnesses, they found that those with diabetes were six percentage points more likely to drop out of school; completed 0.254 fewer years of education; and were nearly eight percentage points less likely to attend college. These lower educational outcomes contributed to reductions in employment and earnings later in life.

Numerous studies have examined the relationship between diabetes and employment. While the studies generally found that diabetes was associated with lower employment, the magnitudes of the association varied considerably. Most estimates suggested that those with diabetes are three to 10 percentage points less likely to be employed (Seuring et al. 2015). However, some studies found no statistically significant effects for certain groups of the population, and one found a 45-

percentage-point decrease in the likelihood of employment (Bastida 2002; Brown et al. 2005; Minor 2011). Some of the differences in these results occur because these studies focused on different population groups and used different statistical methods to estimate the effects (Seuring et al. 2015).

The negative impacts appear to be stronger for older individuals. Tunceli et al. (2009) provides a good example of this difference. Between the ages of 20 and 44, those with diabetes were 1.2 percentage points more likely to be disabled; 3.1 percentage points more likely to report having health related work limitations; and 3.4 percentage points more likely to not work. The effects were considerably larger for those with diabetes between the ages of 45 to 64, who were 3.4 percentage points more likely to be disabled; 5.7 percentage points more likely to report having health related work limitations; and 8.1 percentage points more likely to not work. The larger effects for older workers is likely due to the progressive nature of the disease (Minor 2013).

Diabetes also appears to reduce days and hours worked. The research is less clear on this issue, and the effects appear to differ by gender and the type of diabetes. Vijan et al. (2004) and Valdmanis and Page (2001) estimated that those with diabetes worked 2.4 and 3.9 fewer days per year, respectively. Tuncelli et al. (2005) found that diabetes was associated with a reduction in days worked for men but not women. Minor (2011) found that those with type 1 diabetes worked on average 3.3 fewer days in the past year than those without diabetes, but they found no evidence that those with type 2 diabetes worked fewer days. Ng et al. (2001) found days worked decreased when complications related to diabetes arose. However, Collins et al. (2005) found no difference in the number of days worked. Minor and MacEwan (2016) presented evidence to suggest that the main adverse effect may come from reductions in hours worked. They found that men with type 2 diabetes worked seven fewer hours per week and women with type 2 diabetes worked eight fewer hours.

If diabetes causes workers to be less productive—by reducing the time they spend working, limiting their investments in education, or through some other mechanism—then diabetes may also reduce their wages and earnings. Valdmanis et al. (2001), Bastida (2002), Brown et al. (2011), and Minor (2011) all present evidence that diabetes was associated with lower wages or earnings among certain groups. However, their results were somewhat inconsistent. For example, Brown et al. (2011) found an earnings penalty for men but not women. Bastida (2002) found an earnings penalty for women but not men. Minor (2011) concluded that females with type 2 diabetes suffered a wage penalty of nearly 50 percent, by far the largest estimate of how diabetes affects wages. As Seuring et al. (2015) notes, differences in the populations studied, such as age groups, likely contribute to some of these different results. Given that diabetes is a progressive disease, it may affect workers differently as the disease advances. Minor (2013) looked at this in more detail by examining whether the effect on wages varied base on the number of years since diagnosis. They found that wages among men decreased 6 to 10 years after being diagnosed.

As diabetes progresses, it appears to contribute to workers exiting the labor force early—and ultimately can lead to premature deaths. The CDC ranks diabetes among the top 10 causes of death in the U.S. Vijan et al. (2004) found that individuals who suffered from diabetes lost 0.54 years of life relative to those without diabetes. When considering the economic losses associated with diabetes, it is important to recognize that the losses are not limited to people living with diabetes who might work in the absence of the disease. It also includes losses associated with those who died prematurely due to diabetes. In the absence of the disease, these individuals might not have died so early and might have continued to work.

Overall, diabetes appears to have a significant negative effect on the labor market, primarily by reducing employment and increasing premature deaths. The evidence that diabetes reduces employment appears strong, but the actual size of the effect is not entirely clear. While there is also evidence to suggest diabetes reduces workers' earnings, this research is somewhat inconsistent. The remainder of this section discusses the lost economic activity associated with diabetes in Kentucky, focusing primarily on the lost reductions in employment and premature deaths.

Reduced Employment and Earnings Due to Diabetes

As discussed above, individuals with diabetes are less likely to work than the general population. Data from the Kentucky Behavioral Risk Factors Surveillance System (BRFSS) show that, while approximately 54 percent of Kentucky's adult population was employed, only 26 percent of those with diabetes worked. These differences suggest that a considerably larger share of those who suffer from diabetes might work and earn an income in the absence of the disease.

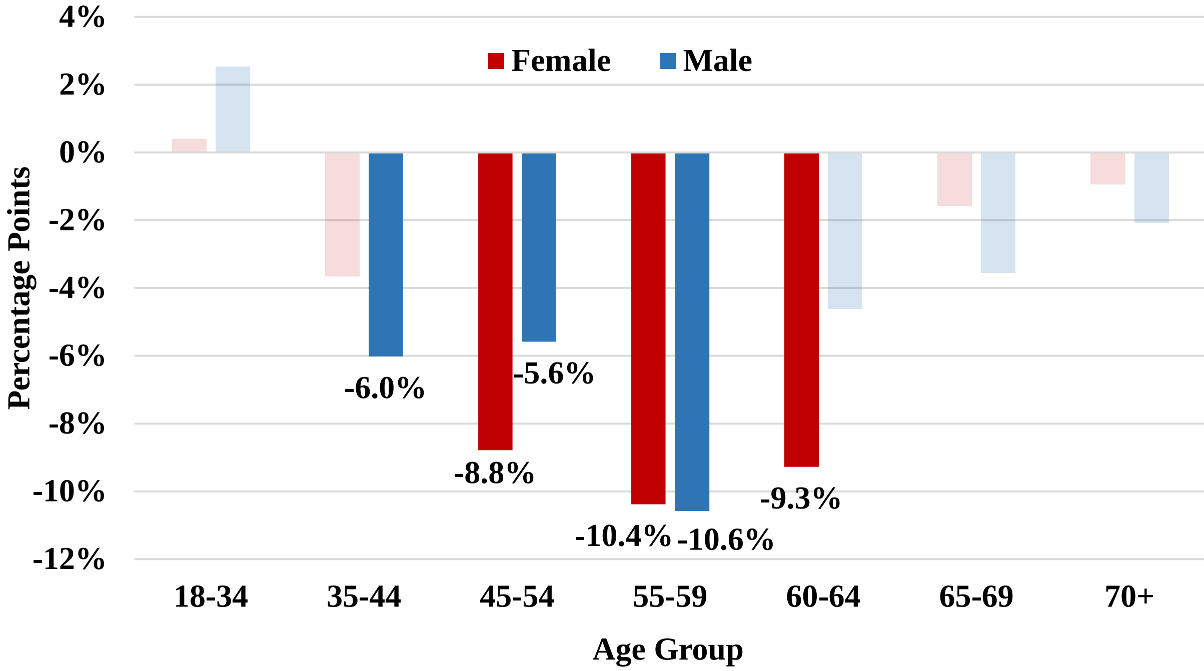
Because diabetes is more prevalent among particular groups who may be less likely to work and earn less income even without diabetes, simply comparing the employment rates for those with and without diabetes is insufficient. Therefore, logistic regression analysis was used to estimate the effect of diabetes on employment while accounting for factors such as gender, race, education, state of residence, and other health conditions that could also affect employment.[1] This type of analysis better isolates the effect of diabetes from these other factors. Figure F summarizes the estimated effects of diabetes on employment.

The estimates show that diabetes affected employment differently across age and gender. There were no statistically significant effects on employment for females aged 18 to 44 and males aged 18 to 34. Likewise, diabetes appeared to have little effect on the employment status of older workers. The negative effects occurred for women between the ages of 45 and 64 and men between the ages of 35 and 59. For example, diabetes reduced the probability of employment by 10.6 percentage points for men aged 55 to 59. Diabetes had a similar effect on the employment of women in this age group.

The overall effect of diabetes was somewhat larger for women than men. Diabetes reduced employment by 4.2 percentage points for adult women and 3.1 percentage points for adult men. This result differed from the research literature, which typically found a larger adverse effect for men than women.

[1] The regression includes controls for race, gender, age, education, state, and other health conditions. Estimates shown in Figure F are the marginal effects of diabetes for each group.

Figure F
Percentage Point Difference in the Probability of Employment between Those with and without Diabetes



Source: CBER analysis of data from the Kentucky Department of Public Health and the United States Centers for Disease Control and Prevention. Behavioral Risk Factor Surveillance System 2017.

Note: Light red and blue bars show estimates of the marginal effect of diabetes, but were not statistically significant.

Applying these estimates to the number of adult Kentucky residents with diabetes provides an indication of the total employment losses for the state (Table 1). Diabetes appears to have reduced employment in Kentucky by 15,700 workers—58 percent, or 9,100, of whom were women.

In the absence of diabetes, these individuals could potentially earn similar amounts to workers with comparable characteristics, such as gender, race, and education. The BRFSS records earned income as ranges, which was insufficient for accurately predicting lost earnings. Therefore, the Census Bureau's American Community Survey (ACS) was used to predict lost earnings for Kentucky residents with diabetes. The first step to estimate these lost wages was to develop a regression model of annual earnings based on age, gender, race, and education from the ACS. This model was then used to predict the earnings for Kentucky residents in the BRFSS who had diabetes. Multiplying these average predicted earnings for each age and gender group by the number of workers who would be employed in the absence of diabetes provides an estimate of the lost earnings. Table 1 displays the results of these calculations. The lower levels of employment that are associated with diabetes reduced earnings in Kentucky by approximately $551.3 million annually. Assuming a total effective state sales and income tax rate of six percent suggests that the loss of annual tax revenue totals $33.1 million.

Table 1
Annual Effect of Diabetes on Employment, Earnings, and Tax Revenues
Kentucky

Age Group	Number of Kentucky Adult Residents with Diabetes	Effect on Employment		Average Annual Earnings per Person	Total Earnings ($millions)
		Percentage	Number		
Females					
18-34	11,000	0	-	20,800	-
35-44	20,200	0	-	25,500	-
45-54	36,100	-8.8	(3,200)	28,300	(90.6)
55-59	27,100	-10.4	(2,800)	28,900	(80.9)
60-64	33,100	-9.3	(3,100)	24,200	(75.0)
65-69	30,200	0	-	14,200	-
70+	59,900	0	-	11,400	-
Subtotal	**217,600**	**-4.2**	**(9,100)**		**(246.5)**
Males					
18-34	8,600	0	-	30,400	-
35-44	22,300	-6	(1,300)	40,000	(52.0)
45-54	38,100	-5.6	(2,100)	47,400	(99.5)
55-59	30,300	-10.6	(3,200)	47,900	(153.3)
60-64	28,100	0	-	40,100	-
65-69	32,100	0	-	26,200	-
70+	56,700	0	-	20,500	-
Subtotal	**216,200**	**-3.1**	**(6,600)**		**(304.8)**
Total			**(15,700)**		**(551.32)**
Potential State Sales & Income Tax Revenue*					**(33.08)**

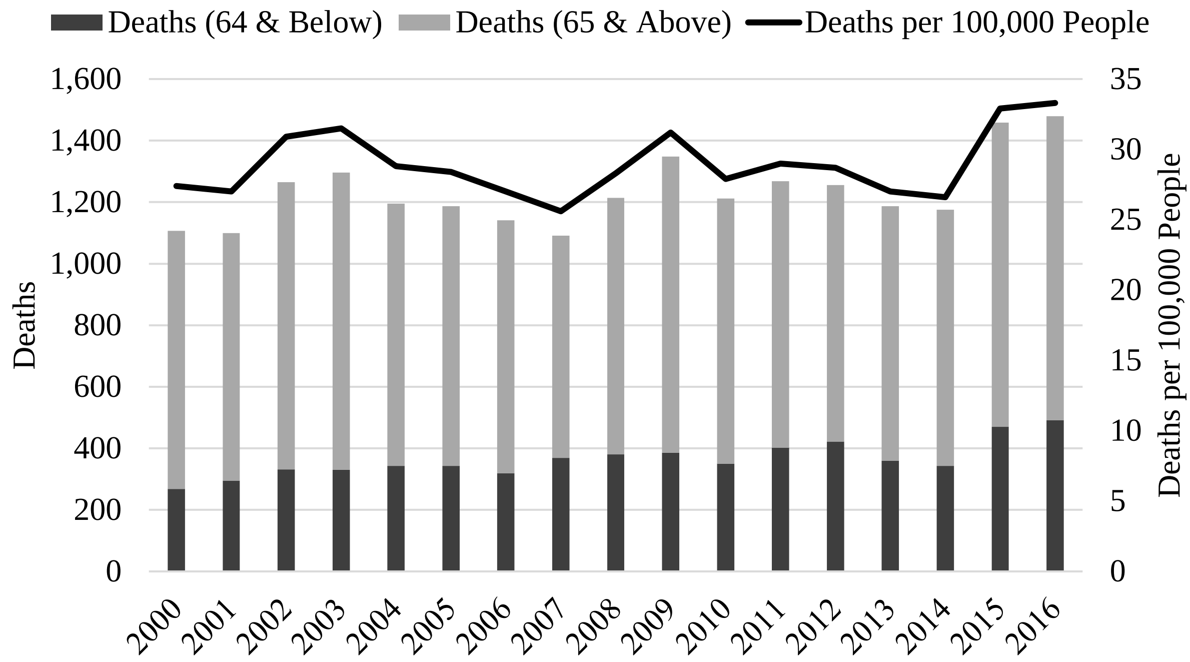
* Assumes an effective state sales and income tax rate of 6 percent.

Sources: CBER analysis of data from the Kentucky Department of Public Health and the U.S. Centers for Disease Control and Prevention Behavioral Risk Factor Surveillance System 2017 and the U.S. Census Bureau, American Community Survey.

Diabetes-Related Deaths

In 2016, diabetes was listed as a contributing factor to 1,497 deaths in Kentucky (Figure G). Thirty-three percent of these deaths occurred before the age of 65. In addition to the loss of life, these deaths during prime working ages represent lost economic activity. Estimates of the lost earnings can be obtained by examining the amounts these individuals could have earned over a typical lifetime in the absence of diabetes.

Figure G
Diabetes-Related Deaths
2000 to 2016
Kentucky



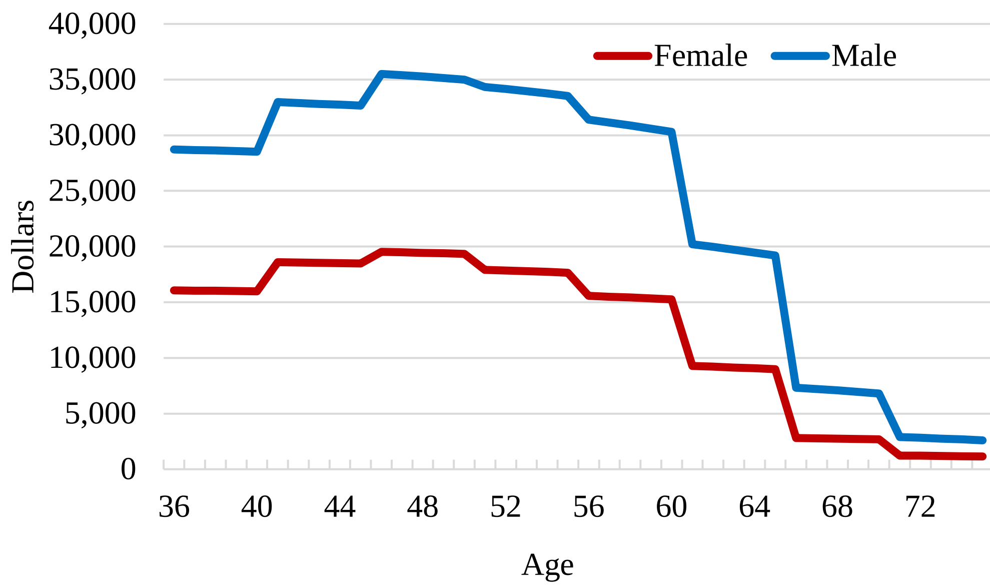
Source: U.S. Centers for Disease Control and Prevention, WONDER.

The economic losses associated with diabetes-related deaths were estimated based on the amounts that each person who died might have earned had they been able to live out a natural life. Others such as Vijan et al. (2004) and the American Diabetes Association (2018) have used similar methods to estimate lost earnings from premature deaths. This method is based on three estimates for each decedent given their age and gender: the probability they would be alive; the probability they would work; and the average income they would earn in each of the following years had they not died. The probability each person would be alive was calculated from standard actuarial life tables (United States Social Security Administration, 2005). Unfortunately, no single data source has the complete information needed to show the amounts those with diabetes might earn in the absence of the disease. Therefore, multiple data sources were combined for these estimates.

Disclosure concerns cause the CDC to limit the detail available on the characteristics of Kentucky residents whose deaths were related to diabetes. For this analysis, age ranges and gender for each decedent were obtained from the CDC WONDER data system. An approach similar to the one described earlier was used to estimate the probability of employment and the average earnings given the age range and gender of each decedent. The ACS, which provides detailed data on the employment and earnings of respondents living in Kentucky – but does not indicate whether they had diabetes – was used to develop models of the probability that individuals work and their earnings if employed. The model accounts for gender, race, age, and education. The resulting models were applied to data for Kentucky respondents in the BRFSS, which does indicate whether respondents have diabetes. This provides estimates of the probability of employment and earnings for each Kentucky respondent with diabetes in the BRFSS data. These estimates reflect the age, gender, racial characteristics, and educational attainment of Kentuckians with diabetes. The predicted earnings for each year were multiplied by the probability of employment and the probability of surviving each year.

Figure H shows examples of the earnings profiles for a 35-year old male and female. The profiles essentially show the average lifetime earnings lost among individuals with diabetes who die at the age of 35. The average earnings are low because they include those who do not work and therefore have no earned income. Average earnings are generally highest during the late 40s and early 50s. During these ages, individuals are more likely to work and tend to earn their highest wages. Average earnings tend to fall significantly after the age of 60 when people are much less likely to work. The average male diabetic who dies at age 35 could have expected to earn an additional $906,000 of income by the age of 64 in the absence of the disease. Given a discount rate of four percent, the present value of these lost earnings is $555,000.

Figure H
Profile of Average Annual Earnings
After Age 35



CBER analysis of data from the Kentucky Department of Public Health and the U.S. Centers for Disease Control and Prevention Behavioral Risk Factor Surveillance System 2017 and the U.S. Census Bureau, American Community Survey.

Applying the lost future earnings to the number of deaths by age and gender yields estimates of the lost earning associated with diabetes-related deaths. The estimates exclude deaths over the age of 64. While they account for a large percentage of deaths, they account for only a small portion of earnings given the small percentage of people who work past the age of 64.

Table 2 summarizes the lost earnings. In 2016, there were 473 diabetes-related deaths between the ages of 35 and 64 in Kentucky. In the absence of diabetes, these individuals could have expected to earn a total of almost $12 million during the year following their death. Assuming an effective state income and sales tax rate of six percent suggests that the lost state tax revenue for this year would be $710,000, or $1,505 per person. The present value of lifetime lost earning was $100.4 million and the present value of lost state tax revenues would have been over $6 million.

Table 2
Lost Annual Earnings from Diabetes-Related Deaths
Kentucky

Age	Deaths	1st-year Lost Earnings (millions)	Present Value Lost Earnings (millions)
35 to 39	12	$0.34	$6.66
40 to 44	35	0.96	14.44
45 to 49	55	1.68	19.77
50 to 54	92	2.72	24.98
55 to 59	119	3.25	20.78
60 to 64	160	2.91	13.72
Total	473	$11.86	$100.35
State Tax Revenue		$0.71	$6.02

Note: Excludes diabetes-related deaths over the age of 64. Estimates of state tax revenues are based on a total effective state sales and income tax rate of six percent.

Three important caveats should be considered when interpreting these estimates. First, the figures represent losses for deaths that occur in one year. However, the total lost earnings and tax revenues for any year reflect deaths that have occurred over the past several years. So, the losses associated with diabetes in any one year would be substantially higher.

Second, the analysis only counted deaths in which diabetes was listed as a contributing factor. Diabetes contributes to other health issues such as renal failure and cardiovascular disease, but might not be listed as a cause of death. The American Diabetes Association includes a portion of deaths from these other diseases when estimating the economic losses from premature deaths. Because the estimates in Table 2 do not include a portion of these diseases, they may understate the total losses attributable to diabetes.

Finally, while this study focuses on lost earnings, economists often use the value of a statistical life (VSL) to measure the losses associated with death. The VSL represents the amount society would be willing to pay to reduce the number of deaths by one. VSL is often estimated by examining the additional compensation workers require to take on additional risk. Current estimates suggest that the VSL is approximately $11 million in the U.S. Value of a life-year (VLY) is a similar concept that might be more relevant for diabetes-related deaths that often occur later in life. It refers to the amount society is willing to pay for one additional year of life. Currently, estimates suggest the VLY is $515,000 (Boardman et al. 2018). Both measures are considerably larger than the lost earnings.

Absenteeism

As discussed above, the research provides a wide range of estimates on how diabetes affects the number of days worked—from no effect to nearly four days lost per year. Given this wide range, the American Diabetes Association (2018) assumed that diabetes was associated with a reduction of 1.7 working days for its estimate of the economic losses. Of the nearly 441,000 adults with diabetes in Kentucky, approximately 123,000 are employed. Although it is not entirely clear how much they earn, it is assumed that their average wages are $17 per hour. Missing work for 1.7 eight-hour days suggests lost productivity of $231 per year. Lost productivity for all 123,000 workers with diabetes totals over $28 million annually. The extent to which this results in lost earnings is unclear. Workers and employers may share these costs. Workers who do not receive paid time off would earn less. Workers who receive paid time off might not see an immediate decline in their earnings. Employers would initially bear the cost of lower productivity but pass these costs on to workers in the form of slower wage growth. Assuming the full value of the lost productivity results in lost earnings suggests that the lost state tax revenues would be $1.7 million annually.

Limitations

While diabetes can reduce employment, the relationships between diabetes and labor market outcomes are more complicated than diabetes simply reducing employment and earnings. Being unemployed may contribute to an individual developing diabetes as those without work may find living a healthy lifestyle to be unaffordable. Additionally, other underlying issues such as a lower level of motivation or an inability to care for one's self may contribute to an individual being both less likely to work and more likely to develop diabetes. This makes it more difficult for researchers to isolate the degree to which diabetes reduces employment.

One potential limitation of this analysis, and many of the previous studies on this issue, is that it simply measures the correlation between diabetes and employment rather than the causal impact. By examining the correlation, even after controlling for factors such as education and other health conditions, the analysis may over- or under-state the true effects that diabetes has on employment and earnings. Some researchers have attempted to address this issue by accounting for genetic markers that signal higher risk of diabetes or a family history of diabetes. The results are mixed, with some studies finding higher effects, while others find lower effects after attempts to address these issues. Seuring et al. (2015) suggests that it is not clear how this issue affects the estimates.

This is an important caveat for policy makers to consider as they evaluate the potential benefits of programs to address diabetes. Because the analysis addresses the correlation between diabetes and labor market outcomes rather than isolating the causation, the benefits associated with policies to reduce the incidence of diabetes are more uncertain.

Section 4: Health Care Costs

Individuals with diabetes generally have significantly higher health care expenditures than the rest of the population. Data from the Medical Expenditure Panel Survey (MEPS) suggests that annual national health care spending averaged $13,642 for those with diabetes compared to $4,991 for those without. However, the higher prevalence of diabetes among older populations, along with the other health conditions often associated with diabetes, contributes to this spending difference.

Every five years, the American Diabetes Association releases a detailed analysis of the economic cost of diabetes. The association's analysis includes estimates of the additional health care costs those with diabetes incur relative to similar individuals without the disease. These estimates, therefore, account for differences in the prevalence of diabetes across factors such as age, gender, and race. These figures are often referred to as "excess" health care costs because they represent costs over the amount an individual without diabetes would typically incur.

Table 4 shows the association's estimates from 2017 adjusted for medical inflation and regional differences in health care costs. For example, a 35- to 44-year old with diabetes incurs an additional $5,074 in health care costs per year relative to a similar person without diabetes. Applying the ADA's per capita costs for each age group to the number of Kentucky adults with diabetes in each age group indicates that diabetes results in approximately $3.9 billion in additional health care costs to Kentucky annually.

Table 3
Excess Health Care Costs Associated with Diabetes
Kentucky

Age	Cost per Person	Population with Diabetes	Health Care Costs (millions)
18 to 34	$6,241	17,500	$109.2
35 to 44	5,074	28,300	143.6
45 to 54	5,963	77,300	460.9
55 to 59	6,852	59,200	405.6
60 to 64	6,407	60,800	389.6
65 to 69	12,065	66,200	798.7
70 & Over	$12,352	128,700	1,589.6
Total		438,000	$3,897.2

Sources: American Diabetes Association. Economic Costs of Diabetes in the U.S. in 2017; Kentucky Department of Public Health and the U.S. Centers for Disease Control and Prevention Behavioral Risk Factor Surveillance System 2017.
Notes: Dollars figures are stated in 2018 dollars and adjusted to reflect regional price differences.

Nationally, the health care expenditures for those with diabetes is largely paid through Medicare. Table 4 shows the distribution of national health care expenditures for those with and without diabetes by the source of payment. Medicare pays for 45.4 percent of health care expenditures for those with diabetes but only 27.4 percent of the expenditures for those without diabetes. Medicaid pays for approximately 10 percent of the expenditures for those with diabetes.

The Cabinet for Health and Family Services estimated that approximately 168,200 Kentucky Medicaid recipients had diabetes in 2017. Medicaid expenditures, excluding prescription drugs, totaled nearly $117 million.

Table 4
Distribution of Health Care Expenditures
by Source of Payment
United States

Source of Payment	Individuals with Diabetes	Individuals without Diabetes
Medicaid	10.3%	9.4%
Medicare	45.4	27.4
Private Insurance	26.6	42.5
Self-pay	9.0	13.5
Other	8.6	7.2
Total	100.0%	100.0%

Source: CBER analysis of Medical Expenditure Panel Survey 2016.

Section 5: Diabetes Prevention and Education Programs

This section examines how two broad programs designed to address diabetes—prevention and education programs—can affect the lives of their participants. Prevention programs focus on individuals who are at high-risk of developing diabetes in the future or have been diagnosed with prediabetes. They are designed to improve participants' diets and increase their physical activity to prevent diabetes from developing. Education programs focus on helping those who have already developed diabetes manage the disease. They also attempt to improve participants' diets and physical activity, but they may include components to help participants monitor their glucose levels or address diabetes-related complications.

The remainder of this section reviews research on the effects of these programs. Because there is a large volume of research on these programs, the following reviews rely heavily on previous summaries of the research and meta-analyses. Because prevention and education programs are diverse, care should be taken in generalizing the results to Kentucky.

Diabetes Prevention Programs

Lifestyle intervention programs appear to be one of the more promising efforts to prevent diabetes. These programs typically focus on groups who are at high-risk of developing diabetes or who already exhibit prediabetes. They are designed to reduce the incidence of disease by helping participants reduce their weight through diet and exercise. The details of lifestyle interventions and the resources they provide to participants vary considerably across programs. However, they typically provide educational material and training and may provide continuing support through case managers and individual or group sessions.

There is a considerable body of research evaluating the effectiveness of lifestyle interventions. Generally, this research finds that lifestyle interventions can reduce the incidence of diabetes and improve quality of life among participants. Roberts et al. (2017) provided a meta-analysis of lifestyle intervention studies across several countries. They found that lifestyle intervention programs that last for three or more years reduce the incidence of diabetes by 45 percent. Programs lasting less than three years reduced diabetes by 26 percent. The impact varied across programs, ranging from no reduction to a 58 percent reduction in the incidence of diabetes. The study noted that differences in the intensity and duration of the programs likely contributed to much of this variation.

The U.S. Diabetes Prevention Program conducted a clinical trial of a lifestyle intervention program in the U.S. during the late 1990s. Researchers randomly assigned participants to one of three groups. The first group was able to participate in the lifestyle intervention program. The second group received metformin, a drug used to control blood sugar in patients with type 2 diabetes. The third group received a placebo. The lifestyle intervention consisted of a 16-session curriculum that included weekly meetings initially then monthly meetings for approximately three years. After three years, all participants, regardless of which group they were initially assigned to, were offered an opportunity to participate in continued follow-up assistance to encourage weight loss and physical activity.

During the first three years, the lifestyle intervention cost approximately $1,110 to $2,300 per participant annually.[2] The follow-up assistance cost approximately $140 to $216 per participant annually. In 2016, the Centers for Medicare & Medicaid Services estimate that similar prevention program targeted at Medicare recipients would cost approximately $470 per person during their first year of participation and $188 per person annual to provide maintenance session (United States. Department of Health and Human Services).[3] The AMA estimates the costs of diabetes prevention programs range from $400 to $500 per person (American).

During the three-year evaluation period, the incidence of diabetes among the lifestyle intervention group was 58 percent lower than the placebo group (Knowler et al. 2002). Follow-up studies showed the lifestyle intervention reduced the incidence of diabetes by 34 percent at 10 years and 27 percent at 15 years (Diabetes Prevention Program Research Group 2015).[4]

The Diabetes Prevention Program Research Group (2009) reported that the lifestyle program did not reduce health care costs sufficiently to cover the intervention costs. However, they concluded the program was a cost-effective way to improve the lives of those with diabetes. Among health care programs, cost-effectiveness is often measured by calculating the ratio of additional cost of the program to the incremental improvement in Quality Adjusted Life Years (QALY). QALYs represent the number of years that a program or treatment is expected to increase one’s life with the additional years weighted by the quality of life during those years. For example, a program that increases life expectancy by two years with a high quality of life during the first year and a low quality of life during the second year might represent 1.5 QALYs. The lifestyle intervention yielded an increase of 0.14 QALYs over the placebo. Considering only health care costs, the cost-effectiveness ratio of the lifestyle program was $16,076 per QALY. However, participants would likely also incur higher costs such as the value of time spent traveling to and participating

[2] Cost stated in 2018 U.S. dollars.
[3] Cost stated in 2018 U.S. dollars.
[4] The reduction in incidence may be understated because those in the placebo group were given the option to participate in lifestyle session after the three-year assessment.

in the program. The cost-effectiveness considering all costs was estimated to be $24,732 per QALY.

While cost-effectiveness ratios do not provide a clear indication that a program should be implemented, they provide a method to compare alternative programs. Generally, programs with lower cost-effectiveness ratios are preferred. Some studies considered a program with a cost-effectiveness ratio below $50,000 per QALY as cost-effective. Although this appears to be a common benchmark, there are some concerns that it might be too low and not reflect the value people place on improvements in quality of their lives (Neumann et al. 2014).

Li et al. (2010) reviewed the cost-effectiveness of interventions recommended by the American Diabetes Association to prevent and control diabetes. They concluded that intensive lifestyle interventions were very cost-effective relative to many of the other interventions recommended by the association. Only considering costs related to the health care system, they found the median cost-effectiveness of lifestyle intervention to be $2,074 per QALY. [5] This is lower than estimates from the U.S. Diabetes Prevention Programs and might reflect differences in the costs included in the analysis or other differences in the programs. Li et al. (2010) also identified six other interventions, such as ACEI therapy for intensive hypertension control, which appear to reduce costs and improve health (see Li et al. (2010) for a complete list).

While this review discusses the potential benefits of lifestyle intervention programs in general, it will be important for policy makers to consider how these programs would operate in Kentucky. Much of the research on these programs comes from controlled pilot programs. Often these programs operate differently when developed for the broader population. Policy makers would need to consider whether Kentucky might face specific challenges, such as limited access to exercise and health care facilities in rural areas that could reduce effectiveness.

Potential Effects of Lifestyle Intervention Programs on Earnings

Because lifestyle intervention programs prevent or delay the onset of diabetes, it is reasonable to expect that they could also improve employment and earnings. While there appears to be no research examining this relationship, it is possible to illustrate the potential labor market effect by applying the reductions in incidence to the lifetime earnings of individuals with diabetes in Kentucky. Figures I, J, and K show how a lifestyle intervention could affect the lifetime earnings of a 45-year old male with a high risk of developing diabetes.

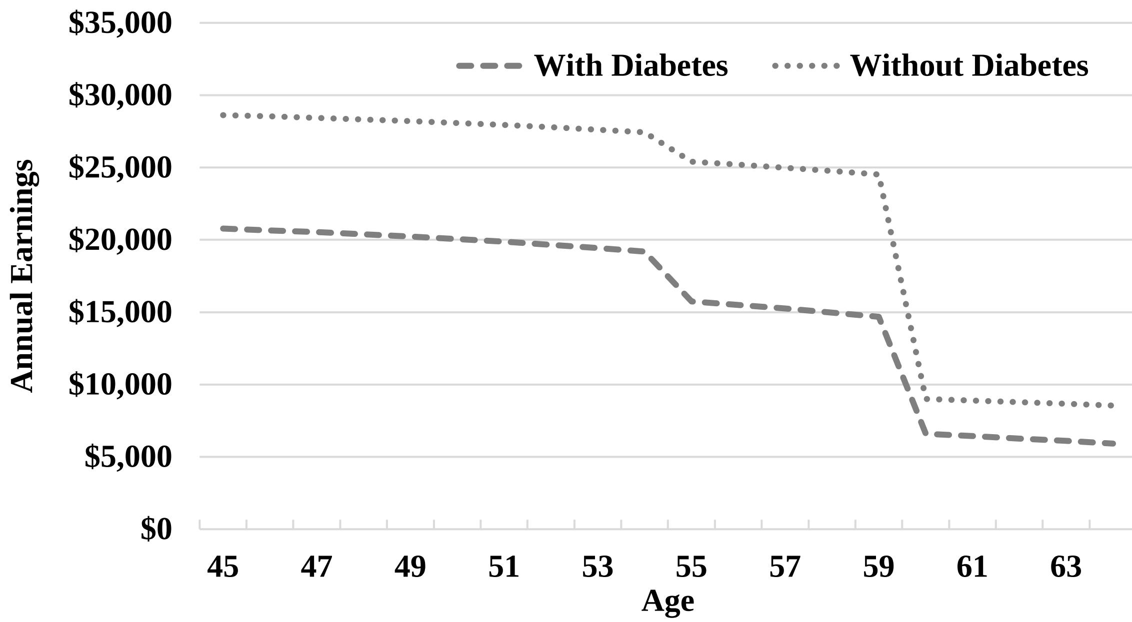
Figure I shows the expected annual earnings from age 45 through 64 based on data from the previous analysis of the BRFSS and ACS data. These earnings reflect the probability of being employed, the average annual earnings for those who are employed, and the probability of being alive each year.

For example, approximately 60.4 percent of males between the ages of 45 and 54 work, and those who do earn approximately $47,400 per year. The remaining 39.6 percent of males who do not work have no earnings. Therefore, the average earnings for a 45-year old male would be $28,600. The expected earnings at age 46, and each subsequent year, would be somewhat lower

[5] Figures were adjusted using the CPI-U.

to reflect the increased probability of death. Because those with diabetes are less likely to work, may earn less, and have a greater risk of premature death, their expected earnings each year would be lower than someone without the disease. Although the effect of diabetes on earnings was unclear, diabetes was assumed to reduce earnings by 20 percent for this analysis. Those with diabetes are 1.85 times more likely to die than those without diabetes (Nwaneri et al. 2013). The probability of surviving each year was adjusted to reflect the higher risk of death for those with diabetes.

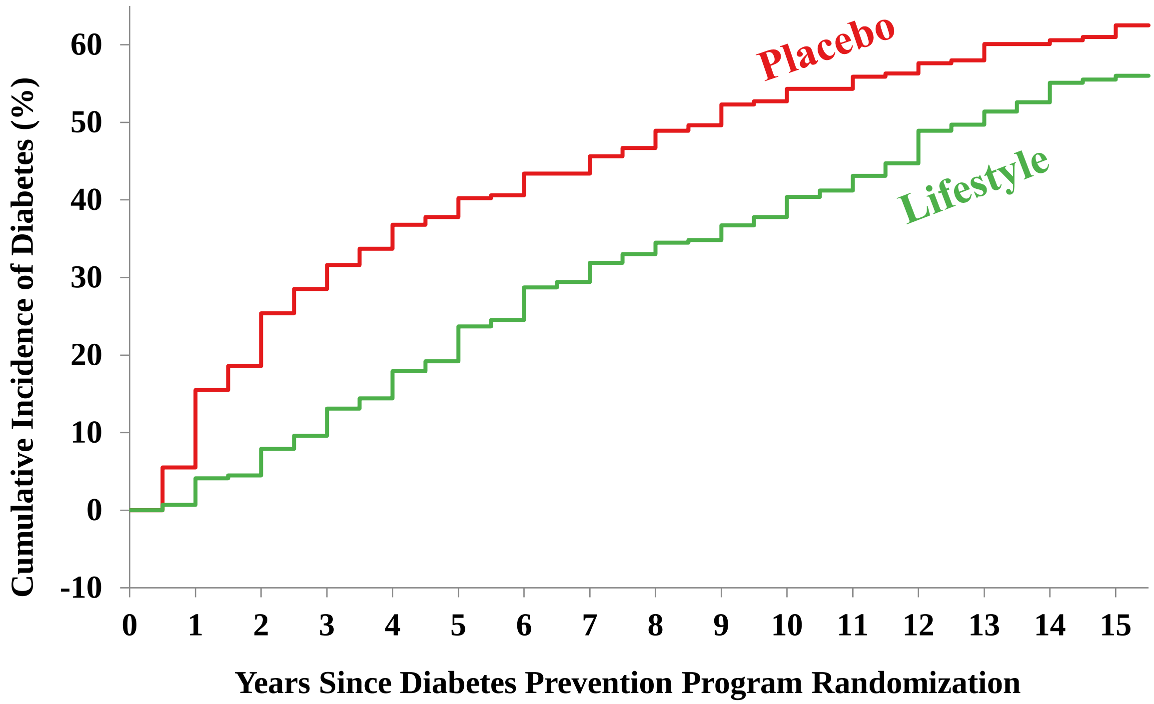
Figure I
Expected Earnings Profile of 45-year Old Male
With and Without Diabetes



Source: CBER analysis of data from the Kentucky Department of Public Health and the U.S. Centers for Disease Control and Prevention Behavioral Risk Factor Surveillance System 2017 and the U.S. Census Bureau, American Community Survey.

Figure J shows the incidence rates of diabetes among males who participated in the lifestyle intervention and those who were in the placebo group from the U.S. Diabetes Prevention Program (Diabetes Prevention Program Research Group 2015). These rates show that those who participated in the lifestyle group were considerably less likely to develop diabetes later in life.

Figure J
Cumulative Incidence of Diabetes among Participants in the Diabetes Prevention Program



Source: Diabetes Prevention Program Research Group (2015) Supplemental Material.

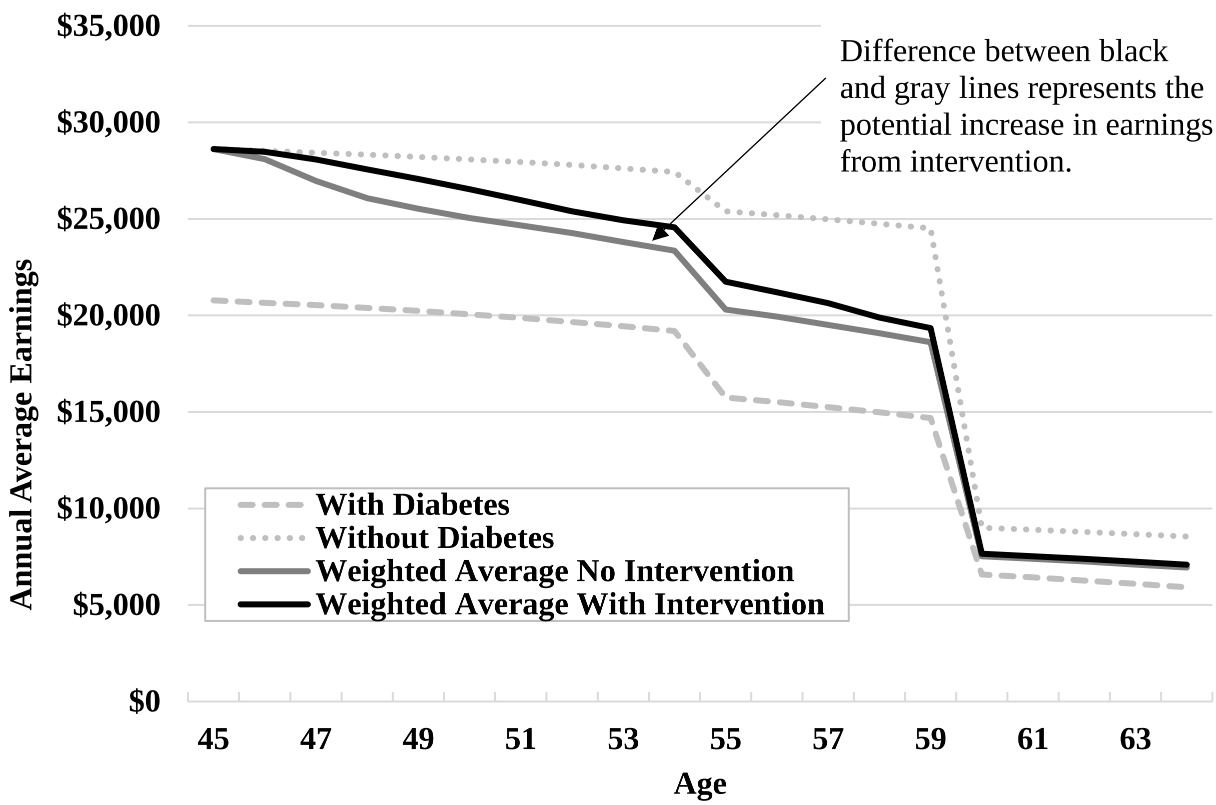
Because lifestyle interventions reduce the risk of developing diabetes, they could increase the likelihood that individuals work and earn a higher wage. Figure K illustrates the potential effect this could have on the average earnings of participants. The earnings profiles that were shown in Figure I reflect expected earnings profiles for a 45-year old male with and without diabetes. However, at age 45, he does not know whether he will develop diabetes, and if so, when. Figure K addresses this uncertainty by showing the weighted average of these two profiles where the weights represent the incidence rates of developing diabetes. The incidence rates come from the DPP study.

The solid grey line in Figure K uses the incidence rates for those assigned to the placebo group in the DPP study for weights. This line represents the average earnings that a 45-year-old, high-risk male could expect to earn in the absence of a lifestyle intervention program. The solid black line is also a weighted average, but the weights reflect the lower incidence of diabetes among those who participate in the lifestyle intervention. This line represents the average earnings a 45-year-old, high-risk male could expect to earn if he participated in a lifestyle intervention program. The lower incidence of diabetes among those participating in lifestyle intervention suggests that these individuals will have a higher probability of working and earning higher wages.

The difference between these earnings shows the potential increase in average earnings that could result from participating in a lifestyle intervention. A 45-year-old male could expect to earn nearly $17,000 more over his career by participating in a lifestyle program. The present value of these additional earnings is $12,600 using a four percent discount rate. The present value of the additional state tax revenues is approximately $756. The state would collect these additional revenues over several years.

While this amount might not cover the cost of participating in a program, it would help offset a portion of these costs. By reducing the incidence of diabetes, these programs would likely reduce the losses associated with absenteeism and premature deaths as well.

Figure K
Potential Effect of Lifestyle Intervention Programs on Earnings of a 45-Year-Old Male with High Risk of Developing Diabetes



Source: CBER analysis of data from the Kentucky Department of Public Health and the U.S. Centers for Disease Control and Prevention Behavioral Risk Factor Surveillance System 2017; U.S. Census Bureau's American Community Survey; and Diabetes Prevention Program Research Group (2015).

Diabetes Education Programs

Education programs are designed to teach those diagnosed with diabetes how to manage their disease. Evaluation studies have generally found that participants see meaningful improvements in clinical outcomes such as blood glucose levels, weight, and blood pressure (Chrvala 2016). However, the few studies that provide estimates of their cost-effectiveness vary substantially, ranging from $373 per QALY to nearly $87,000 per QALY. The wide range of estimates makes it difficult to draw firm conclusions (Lian et al. 2017).[6] Several factors contribute to this range of estimates.

First, researchers often include different types of costs depending on whether they examine cost-effectiveness from the health care system's perspective or society's perspective. The health care system perspective is narrower and often focuses only on the direct health care costs and the costs to operate the education program. The societal perspective is broader and includes more costs. Studies that take a societal perspective often include added costs incurred by those participating in the program, such as the time they spend traveling to and attending sessions, the added expense of purchasing healthier food, and increased spending on gym memberships or exercise equipment.

Second, there are significant differences in the scope of services and operations provided by education programs, which can affect the outcomes. For example, programs with 10 or fewer hours of contact with participants provided few benefits, but those with more than 10 hours significantly lowered blood sugar levels (Pillay et al. 2015). Programs also differed in terms of the type of health care professionals who provided training, how training was delivered (i.e. individual sessions, group session, or remotely), and the amount of follow-up provided.

Cost-effectiveness measures may also differ based on the timeframe studied. Both Ricci-Cabello et al. (2014) and Chatterjee et al. (2018) note that there is little information on the long-term effects of education programs. Two studies simulated the potential long-term effects based on clinical improvements observed during trial studies. Gillet et al. (2010) estimated that an education and self-management program implemented in the United Kingdom incurred $9,993 in additional cost per QALY gained over participants' lifetimes.[7] Prezio et al. (2014) estimated that cost per QALY for participants between the ages of 35 and 54 was $143,499 at five years, but improved to $53,293 at 10 years and $6,187 at 20 years. Their simulations suggest that there may be long-term savings and improvements in health over the life of participants. Studies that only include the short-term benefits of the programs may underestimate the cost-effectiveness of education programs.

The improvements in clinical outcomes associated with education programs might help those with diabetes remain in the workforce longer and improve their productivity. However, there appears to be little research on this issue. Cranor et al. (2003) was the only study found that examined labor market outcomes. The study examined diabetes care programs implemented by two employer groups. The authors found that the number of sick days used by employees decreased in one employer group. Unfortunately, the available information was not sufficient to provide meaningful insight into how education programs might affect employment and earnings outcomes.

Diabetes education programs appear to have significant potential to help participants manage their disease. Evaluations show the programs improve clinical outcomes such as blood glucose

[6] Costs stated in 2018 U.S. dollars.
[7] Costs stated in 2018 U.S. dollars.

levels, weight, and blood pressure. Currently, there are relatively few studies examining the cost-effectiveness of education programs. Those studies that do suggest education programs can be cost-effective unfortunately provide a wide range of results. A few studies suggest that education programs might yield cost savings if costs to participants and long-term benefits are included. Because these studies include participants' costs such as travel time, their results should not be interpreted to suggest that government programs would experience fiscal savings. While the improvements in clinical outcomes might help workers remain in their jobs longer, take fewer sick days, and earn more, there is currently little information examining these issues.

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