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Investigating the Change in the Out-of-Pocket Cost of Insulin Over Time

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INVESTIGATING THE CHANGE IN THE OUT-OF-POCKET COST OF INSULIN OVER TIME

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By

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I dedicate this thesis to my wife, Olivia, for always being by my side and encouraging me. You are my everything, and I could not have done any of this without you. I also dedicate this work to my parents, Darin and Julie, and my brother Ryan for always supporting my pursuit of knowledge and pushing me to be my best.

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ABSTRACT

Insulin is often cited as a classic near perfectly inelastic good; for those living with Type-1 diabetes, antihyperglycemic medicines are the only thing standing between them and possible death, and they must be willing to pay for the medication regardless of the price. When researchers at the University of Toronto released the patent for insulin in 1922, they asked for only $1 so that the medication would be available to as many people as possible; however, as insulin analogs and new biosimilar substitutes have been invented, the price of medications has increased substantially. While the rising cost of insulin has been well researched, many of these studies focus on nominal prices and mean spending across a period of time. Building on previous research, this study utilizes fixed effects regression and instrumental variables to specifically analyze how the passage of time has affected out-of-pocket spending on insulin to discover if these estimates over- or underestimate the true nature of price changes to diabetic patients' out-of-pocket prescription expenditures.

Keywords: Econometrics, Fixed Effects Regression, Instrumental Variables, Antihyperglycemics, Insulin, Diabetes

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CONTENTS

LIST OF FIGURES AND EQUAITONS

LIST OF TABLES

I. INTRODUCTION

When learning about price elasticity, insulin is often one of the classic examples of a near perfectly inelastic good. For those living with Type-1 diabetes, antihyperglycemic medicines are the only thing standing between them and possible death, and they must be willing to pay for the medication regardless of the price. In 2015, 30.3 million Americans had diabetes, 1.25 million of which were Type-1 (ADA 2018b).

When researchers at the University of Toronto released the patent for insulin in 1922, they asked for only $1 so that the medication would be available to as many people as possible; as insulin analogs and new biosimilar substitutes have been invented, the price of medications has increased substantially. Estimates on these price increases range from doubling between 2000 and 2010 (Lipska 2014) to increasing by nearly 200% from 2002 to 2013 (Hua 2016). Excess lifetime medical spending for people with diabetes is estimated to reach $124,600 for those diagnosed at age 40, with even higher estimates for those diagnosed at a younger age (Zhuo 2014).

While the rising cost of insulin has been well researched, many of these studies focus on nominal prices and mean spending over across a period of time. Building on previous research, this study seeks to specifically analyze how the passage of time has affected out-of-pocket spending on insulin to discover if these estimates over- or underestimate the true nature of price changes to patients' out-of-pocket prescription expenditures.

II. LITERATURE REVIEW

The rising costs of insulin and other costs associated with diabetes are well documented. Zhuo et al. (2015) analyze how excess medical spending attributable to diabetes has changed from 1987 to 2010-2011. They find that of the $2790 increase in excess spending per person, 55% is due to prescription medication. Lipska et al. (2014) likewise find an increase in the median out-of-pocket spending for all types of insulin from $19 in 2000 to $36 in 2010. However, the study only analyzes privately insured patients and relies on unpublished working documents for data, bringing into question representativeness and validity of the data.

The American Diabetes Association (ADA) estimates that inflation-adjusted economic costs of diabetes increased by 26% from 2012 to 2017, as well as diabetic patients having around 2.3 times higher expenditures compared to a similar non-diabetic patient (2018a). Hua et al. (2016) break down inflation-adjusted expenditures for insulin alongside other antihyperglycemic medications, while also considering the change in use of these products. They find that the mean price of insulin increased from $4.34 per milliliter in 2002 to $12.92 in 2013. The above all estimate large increases in the cost of insulin, but Luo, Avorn, and Kesselheim (2015) note that Medicare reimbursements for insulin have also risen exponentially to account for rising prescription costs and usage.

These studies all contribute to the literature in unique ways, but each fail to consider one of several key aspects: insurance coverage status, the change in out-of-pocket expenditures compared to total expenditures, and change over each year rather than cumulatively over a period. This study attempts to address these issues by using instrumental variables to account for insurance coverage status, running separate regressions for total expenditures and out-of-pocket expenditures, and using an interaction between the use of insulin and a year count variable to estimate average yearly changes in costs.

III. DATA SOURCES

The data for this study consists of full year consolidated data files from the Medical Expenditure Panel Survey (MEPS) for the years 2007-2016. This database is one of the most used sources in the health economics literature for data on cost, usage, payment method, and more for health-related expenditures. After accounting for observations where key variables such as age and insulin use were not recorded and limiting the sample to observations where the respondent (R) is over the age of 18, the observation set includes 249,297 observations as noted in the summary statistics in Table 1. However, after taking the natural log of the key dependent variables, namely out-of-pocket prescription expenditure measured by prescription expenditures paid by oneself or family and total prescription expenditure to normalize the data, some observations were not usable due to having recorded $0 of prescription expenditures in one or more of the key dependent variables, and thus being undefined after taking the natural log. To remedy this, expenditures for all observations were increased in value by $1 to ensure they are retained in the sample; values originally undefined are thus preserved as a value of 0 after taking the natural log. This increase is minimal as a change of less than .1% of the sample mean and does not noticeably affect the distribution of the dataset.

In the second model used with Equations (3) and (4), not all respondents provided data for the potential instruments, so the observation counts for the model using whether the respondent's employer offered insurance to any at the firm as an instrument and for whether the respondent's firm has multiple locations as an instrument drop to 143,779 and 142,302, respectively. The smaller samples are similar to the original, both in demographic characteristics and in expenditure distribution. Sample statistics for the smaller samples can be found in Appendices A and B, respectively. Because the instruments proved to be unreliable, only the original model's results are of significance.

Table 1: Summary Statistics

VARIABLES	(1) N	(2) mean	(3) sd	(4) min	(5) max
Total Income	249,297	29,582	33,277	-204,643	731,653
Total RX Expenditures	249,297	1,037	5,986	0	2.227e+06
Total RX Expenditures Paid by Self/Family	249,297	181.2	659.3	0	42,770
Age	249,297	45.27	17.67	18	85
Female	249,297	0.535	0.499	0	1
Diabetic	249,297	0.0826	0.275	0	1
Uses Insulin	249,297	0.0244	0.154	0	1
Insurance Coverage	249,297	0.803	0.398	0	1
Black	249,297	0.207	0.405	0	1
White	249,297	0.712	0.453	0	1
Hispanic	249,297	0.270	0.444	0	1
Census Region	249,297	2.762	1.020	1	4
Year	249,297	5.606	2.824	1	10
Uses Insulin*Year	249,297	0.142	0.998	0	10
Ln(RX Expenditures)	249,297	3.479	3.233	0	14.62
Ln(RX Expenditures Paid by Self/Family)	249,297	2.539	2.572	0	10.66
Post ACA	249,297	0.715	0.451	0	1
Insulin*ACA	249,297	0.0185	0.135	0	1

IV. EMPIRICAL METHODS

For this study, two OLS regressions are run in each of the three models; the regressions are identical with only the dependent variables differing to compare nominal costs and out-of-pocket costs. First, total prescription expenditure is regressed to assess validity of the model compared to previous estimations, then prescription expenditure paid by self/family is analyzed to estimate the year-to-year change in the impact of insulin costs on patients. These variables are in logarithmic form, both to normalize the data and to put results in terms of percentages. The two regressions use the same set of controls including fixed effects for the year and region by including dummy variables for each year and region, leaving out one category respectively to avoid collinearity issues; standard errors were also clustered at the year level to accurately assess statistical significance. The independent variable of interest is an interaction term between the insulin use indicator and year to analyze whether excess medical expenditures due to insulin use, both out-of-pocket and total, are growing over time or shrinking.

Three models were estimated to assess the change in out-of-pocket costs of insulin. The first is shown in Equations (1) and (2). This is the most parsimonious model, where insurance coverage was left out to avoid endogeneity problems or bias from instruments. In Equations (1) and (2), γ represents a set of control variables, φ_i represents regional fixed effects, ω_t captures year fixed effects, and ε_{it} is the error term. γ includes the following variables: R's Age, R's Total Income, Female Indicator, Diabetic Indicator, R reports as Black, R reports as White, and R reports as Hispanic. Expenses for other antihyperglycemic medications other than insulin injections or by modified diet as well as hospitalization fees and visits to medical professionals are assumed as captured within the Diabetic Indicator variable so that β_2 accurately represents only the effect of insulin on prescription expenditures. The Census Region variable is read as follows: 1 corresponds to the Northeast region, 2 to the Midwest, 3 to the South, and 4 to the West. The Year variable is encoded to 2007 set as 1 through 2016 set as 10.

Equation 1:

$$\ln(RX\ Expenditures) = \beta_0 + \beta_1 Uses\ Insulin + \beta_2 Uses\ Insulin * Year + \gamma + \varphi_i + \omega_t + \varepsilon_{it}$$

Equation 2:

$$\ln(RX\ Paid\ by\ Self\ or\ Family) = \beta_0 + \beta_1 Uses\ Insulin + \beta_2 Uses\ Insulin * Year + \gamma + \varphi_i + \omega_t + \varepsilon_{it}$$

The second model uses Equations (3) and (4) with two separate instruments for the insurance coverage variable to show the estimation differences between the two instruments. To further refine the value of β_2, a variable indicating the respondent's insurance status was added.

To avoid estimation error due to endogeneity from adverse selection, two instrumental variable models were estimated. Instrumentation is important to consider when there is potential for reverse causality or other confounding issues in the model. In this case, those who are likely have higher prescription expenditures may be more likely to seek out insurance to cover those expenses. Instrumentation relies on two assumptions: the instrument must be correlated with the independent variable, but not correlated with the dependent variable except through its association with the independent variable. This process is illustrated in Figure 1. The instrument is then used to predict values of the independent variable, which are then used in the original model.

Figure 1: The Instrumentation Process

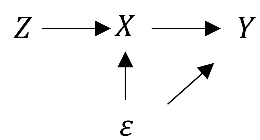
$$Y = \alpha + \beta X + \varepsilon$$

$$\downarrow$$

$$\hat{X} = \gamma + \varphi Z + u$$

$$\downarrow$$

$$Y = \alpha + \beta \hat{X} + \varepsilon$$



The first instrument considered is whether or not the respondent's firm offered insurance to anyone at the firm. The reasoning behind the first instrument is that if the respondent's firm offers insurance to others at the firm, it is likely that there is some standardized coverage plan to which the respondent can then choose to subscribe to or not. This should directly affect the respondent's insurance coverage status, but not the respondent's prescription expenditures. The second potential instrument is whether the respondent's firm has multiple locations. The reasoning behind the second instrument is that if the firm has multiple locations, it is likely to be a larger firm. The firm size should be directly correlated with the respondent's access to insurance plans, but not with prescription expenditures.

Equation 3:

$$\ln(RX\ Expenditures) = \beta_0 + \beta_1 Uses\ Insulin + \beta_2 Uses\ Insulin * Year + \beta_3 \widehat{Insurance\ Coverage} + \gamma + \varphi_i + \omega_t + \varepsilon_{it}$$

Equation 4:

$$\ln(RX\ Paid\ by\ Self\ or\ Family) = \beta_0 + \beta_1 Uses\ Insulin + \beta_2 Uses\ Insulin * Year + \beta_3 \widehat{Insurance\ Coverage} + \gamma + \varphi_i + \omega_t + \varepsilon_{it}$$

The third model uses the implementation of the Affordable Care Act (ACA) as a source of variation to further examine the change in the cost of insulin. This model uses Equations (5) and (6). In this model, the dependent variable of interest is the interaction between the insulin use indicator and the post-ACA indicator to specifically assess the change in costs associated with insulin use after the implementation of the ACA. The fixed effects are left out of this model so that the only time related variable is the ACA dummy.

Equation 5:

$$\ln(RX\ Expenditures) = \beta_0 + \beta_1 Uses\ Insulin + \beta_2 ACA + \beta_3 Uses\ Insulin * ACA + \gamma + \varepsilon_{it}$$

Equation 6:

$$\ln(RX\ Paid\ by\ Self\ or\ Family) = \beta_0 + \beta_1 Uses\ Insulin + \beta_2 ACA + \beta_3 Uses\ Insulin * ACA + \gamma + \varepsilon_{it}$$

V. RESULTS

Table 2 displays abridged results for both regressions with Equation (1) in the Column 1 and Equation (2) in Column 2 to show only the main variables of interest; outputs for the full regression can be found in Appendix C.

Table 2: Original Model

VARIABLES	(1) Ln(RX Expenditures)	(2) Ln(RX Expenditures Paid by Self/Family)
Uses Insulin	1.040***	1.138***
	(0.0572)	(0.0876)
Uses Insulin*Year	0.0605***	-0.0547***
	(0.00781)	(0.00955)
Diabetic	2.346***	1.689***
	(0.0217)	(0.0427)
Constant	-0.432***	-0.504***
	(0.0279)	(0.0495)
Observations	249,297	249,297
R-squared	0.317	0.302

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Equation (1) produces a statistically significant estimate of total prescription expenditures rising on average an additional 6.05% each year in the observed period for users of insulin relative to an average non-user of insulin, *ceteris paribus*. This aligns with current studies in assessing that the cost of insulin is rising exponentially year after year. There is also an economically and statistically significant coefficient on the insulin use indicator of 1.04, estimating that users of insulin are expected to pay 104% more in total prescription expenditures than non-insulin users as well as a coefficient of 2.346 on the diabetic indicator, supporting the fact that individuals with diabetes have over 200% higher prescription expenditures than non-diabetic individuals. Compared to the sample mean for prescription expenditures of $1,037, an individual with diabetes who also takes insulin would have expenditures of $3,511. Equation (2), however, provides a story contrary to that told by most studies in the literature. While out-of-pocket prescription expenditures are still substantially higher for users of insulin, as seen 114% greater expenditures implied by the coefficient on the insulin use indicator variable, the interaction term has a coefficient of -0.0547 which is statistically significant at the 1% level, indicating that patients who use insulin injections may spend over 5% less out-of-pocket for their prescriptions each year. This is also corroborated by the coefficients on the individual year dummy variables as they are all negative in sign and significant at the 1% level.

To assess the validity of the two potential instruments, two regressions were run for each. The first regression is shown in Equation (7) and regresses the instrument on the insurance coverage variable to assess the first assumption of instrumentation: correlation between the instrument and the independent variable. The second regression, shown in Equation (8), tests the second assumption: lack of correlation between the instrument and the dependent variable. The results are shown in Table 3. While both instruments fail to fulfill the second assumption, the model is still estimated with the instruments as an exercise in instrumentation. Further research is required to find an appropriate instrument for insurance coverage.

Equation 7:

$$Insurance\ Coverage = \alpha + \beta_1 Instrument + \gamma + \epsilon$$

Equation 8:

$$Ln(RX\ Expenditures) = \alpha + \beta_1 Instrument + \gamma + \epsilon$$

Table 3: Instrument Validity Tests

VARIABLES	(1) Insurance Coverage	(2) Ln(RX Expenditures)	(3) Insurance Coverage	(4) Ln(RX Expenditures)
Employer Offers Insurance	0.322***	0.442***		
	(0.0178)	(0.0351)		
Firm Has Multiple Locations			0.106***	0.257***
			(0.00331)	(0.0176)
Constant	0.508***	-0.616***	0.632***	-0.455***
	(0.0195)	(0.0581)	(0.0135)	(0.0580)
Observations	143,779	143,779	142,302	142,302
R-squared	0.269	0.238	0.153	0.234
Instrument	Employer Offers Insurance	Employer Offers Insurance	Firm Has Multiple Locations	Firm Has Multiple Locations
Conclusion	Assumption 1 Satisfied	Assumption 2 Violated	Assumption 1 Satisfied	Assumption 2 Violated

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4 shows results for Equations (3) and (4) using the two instruments for insurance coverage. The full regression results can be found in Appendix D. Columns 1 and 3 show the results of Equations (3) for both instruments, and Columns 2 and 4 show Equation (4).

Table 4: Instrumental Variables Model

VARIABLES	(1) Ln(RX Expenditures)	(2) Ln(RX Expenditures Paid by Self/Family)	(3) Ln(RX Expenditures)	(4) Ln(RX Expenditures Paid by Self/Family)
$\widehat{\text{Insurance}}$ Coverage	1.374***	1.223***	2.431***	1.732***
	(0.0590)	(0.0504)	(0.111)	(0.0954)
Uses Insulin	1.307***	1.423***	1.196***	1.423***
	(0.0557)	(0.131)	(0.0639)	(0.110)
Uses Insulin*Year	0.0472***	-0.0682***	0.0626***	-0.0730***
	(0.0111)	(0.0164)	(0.0114)	(0.0180)
Diabetic	2.672***	2.093***	2.589***	2.040***
	(0.0470)	(0.0523)	(0.0511)	(0.0488)
Constant	-1.314***	-1.322***	-1.991***	-1.630***
	(0.0522)	(0.0417)	(0.0891)	(0.0773)
Observations	143,779	143,779	142,302	142,302
R-squared	0.254	0.239	0.232	0.220
Instrument	Employer Offers Insurance	Employer Offers Insurance	Firm Has Multiple Locations	Firm Has Multiple Locations

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

As before, the expected nominal prices paid for insulin are increasing, although at a slower predicted rate of 4.72% as seen in the coefficient on the interaction term. Column 2 corroborates the evidence from the earlier model, but with a larger coefficient on the interaction term, implying that out-of-pocket insulin costs are declining at a rate of 6.82% per year. This estimate is again significant at the 1% level. The second instrument is consistent with the original model and with the first instrument. Nominal expenditures are increasing at a rate of 6.26% per year, while out-of-pocket costs are decreasing 7.3% per year. These estimates are also significant at the 1% level. However, these estimates are biased due to the flaws in the instrumentation. A result of this bias is also evident in the coefficients on the predicted insurance coverage variables. While an increase in expenditures from insurance coverage could be explained by the concept of moral hazard, where protection from risk or costs encourages additional risky or costly behavior. However, this would not likely explain such large estimates as having insurance predicting 100-200% increases in prescription expenditures.

Table 5 shows the results from the Affordable Care Act model which uses Equations (5) and (6). The full results can be found in Appendix E.

Table 5: ACA Model

VARIABLES	(1) Ln(RX Expenditures)	(2) Ln(RX Expenditures Paid by Self/Family)
Uses Insulin	1.202***	0.951***
	(0.0450)	(0.0503)
Post ACA	-0.220***	-0.348***
	(0.0121)	(0.00993)
Insulin*ACA	0.249***	-0.176***
	(0.0509)	(0.0565)
Diabetic	2.350***	1.697***
	(0.0196)	(0.0182)
Constant	-0.682***	-0.647***
	(0.0244)	(0.0194)
Observations	249,297	249,297
R-squared	0.315	0.298

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

An interesting result of this model is that the coefficient on the interaction term in Column 1 is positive while the coefficient on the Post-ACA indicator is negative. Considering that the ACA was designed to lower the cost of health care for all covered individuals, a result implying that insulin users are paying more for prescriptions post-ACA while others pay less seems counterintuitive. However, this increase in expenditures can also be interpreted as an increase in the demand for insulin which may be a result of lower costs or greater access to insulin after the implementation of the Affordable Care Act. Regardless, this paper does not attempt to evaluate the effectiveness of the ACA or directly measure its effect on medical expenditures. Rather, using the implementation of the policy as a source of variation and as a measure of time, the coefficient on the interaction term in Column 2 implies that insulin users are paying 1.76% less out-of-pocket on prescriptions after the ACA was implemented. This estimate is yet again significant at the 1% level.

VI. DISCUSSION

When using total prescription expenditures as the dependent variable, estimates match up with the current literature on the idea that insulin prices are increasing at an alarming rate. The additional costs associated with using insulin and with diabetes in general are also very large, both in nominal terms and in out-of-pocket costs. However, this problem seems to be mitigated by some outside entity as out-of-pocket costs for insulin are decreasing over time at an average rate of over 5% each year. Comparing the coefficients on the interaction term between the two equations in each model corroborates a point made by Luo, Avorn, and Kesselheim (2015). If the cost of insulin is rising so rapidly, yet patients' out-of-pocket costs are declining, not only are these increasing costs are being borne by insurance providers, both public and private, but they are becoming even larger due to the declining cost to end users.

For public sources of insurance such as Medicare and Medicaid, this may mean further increases in the federal debt if the federal government is unable to find sustainable funding for these programs. For private insurance companies, this may mean either higher premiums for patients who require insulin, which could further exacerbate the risk that poses low-income diabetic patients, or lower profits for the insurance firms. There is also the possibility of an adverse selection problem where healthier policy holders switching companies or plans to those with less prescription coverage. This could also lead to higher premiums and co-pays for diabetic patients, as well as, in the most extreme scenario, what is known as a death spiral, in which the pool of insurance policy holders progressively becomes less and less healthy as those who need insurance less leave the policy due to increasing rates. This, in turn, requires an increase in the cost of the insurance to those remaining which then continues the cycle until only those who need insurance the very most will be willing to stay and are then struck with astronomical insurance costs. While out-of-pocket costs for insulin seemingly falling over time may be a benefit to insulin users in the short term, this could lead to serious issues in how insurance policies will cover prescription medications in the future.

APPENDIX

Appendix A

VARIABLES	(1) N	(2) mean	(3) sd	(4) min	(5) max
Total Income	143,779	38,777	35,412	-186,193	731,653
Total RX Expenditures	143,779	607.1	6,576	0	2.227e+06
Total RX Expenditures Paid by Self/Family	143,779	130.4	545.8	0	38,560
Age	143,779	40.77	13.73	18	85
Female	143,779	0.490	0.500	0	1
Diabetic	143,779	0.0516	0.221	0	1
Uses Insulin	143,779	0.0130	0.113	0	1
Insurance Coverage	143,779	0.811	0.391	0	1
Employer Offers Insurance	143,779	0.688	0.463	0	1
Black	143,779	0.195	0.396	0	1
White	143,779	0.721	0.449	0	1
Hispanic	143,779	0.279	0.448	0	1
Census Region	143,779	2.772	1.015	1	4
Year	143,779	5.610	2.851	1	10
Uses Insulin*Year	143,779	0.0755	0.730	0	10
Ln(RX Expenditures)	143,779	2.904	2.993	0	14.62
Ln(RX Expenditures Paid by Self/Family)	143,779	2.221	2.442	0	10.56
Post ACA	143,779	0.711	0.453	0	1
Insulin*ACA	143,779	0.00986	0.0988	0	1

Appendix B

VARIABLES	(1) N	(2) mean	(3) sd	(4) min	(5) max
Total Income	142,302	37,961	34,542	-186,193	731,653
Total RX Expenditures	142,302	586.8	2,738	0	238,050
Total RX Expenditures Paid by Self/Family	142,302	127.8	538.2	0	38,560
Age	142,302	40.28	13.70	18	85
Female	142,302	0.506	0.500	0	1
Diabetic	142,302	0.0508	0.220	0	1
Uses Insulin	142,302	0.0127	0.112	0	1

Insurance Coverage	142,302	0.812	0.390	0	1
Firm has Multiple Locations	142,302	0.655	0.475	0	1
Black	142,302	0.203	0.402	0	1
White	142,302	0.715	0.452	0	1
Hispanic	142,302	0.272	0.445	0	1
Census Region	142,302	2.761	1.012	1	4
Year	142,302	5.606	2.839	1	10
Uses Insulin*Year	142,302	0.0738	0.721	0	10
Ln(RX Expenditures)	142,302	2.920	2.988	0	12.38
Ln(RX Expenditures Paid by Self/Family)	142,302	2.222	2.433	0	10.56
Post ACA	142,302	0.712	0.453	0	1
Insulin*ACA	142,302	0.00961	0.0976	0	1

Appendix C

VARIABLES	(1) Ln(RX Expenditures)	(2) Ln(RX Expenditures Paid by Self/Family)
Uses Insulin	1.040***	1.138***
	(0.0572)	(0.0876)
Uses Insulin*Year	0.0605***	-0.0547***
	(0.00781)	(0.00955)
Total Income	1.44e-07	3.38e-06***
	(3.52e-07)	(2.76e-07)
Age	0.0687***	0.0532***
	(0.000525)	(0.000546)
Female	0.812***	0.598***
	(0.0167)	(0.0344)
Diabetic	2.346***	1.689***
	(0.0217)	(0.0427)
Black	0.361***	0.166***
	(0.0303)	(0.0226)
White	1.014***	0.871***
	(0.0178)	(0.0176)
Hispanic	-1.147***	-0.942***
	(0.0187)	(0.0257)
Census Region = 2	0.00895	0.162***
	(0.0186)	(0.0204)
Census Region = 3	-0.118***	0.123***
	(0.0364)	(0.0190)

Census Region = 4	-0.299***	-0.148***
	(0.0226)	(0.0234)
Year = 2	-0.0574***	-0.112***
	(0.00103)	(0.00120)
Year = 3	-0.134***	-0.261***
	(0.00156)	(0.00138)
Year = 4	-0.281***	-0.335***
	(0.00133)	(0.00107)
Year = 5	-0.341***	-0.345***
	(0.00157)	(0.00138)
Year = 6	-0.442***	-0.440***
	(0.00209)	(0.00216)
Year = 7	-0.278***	-0.461***
	(0.00266)	(0.00256)
Year = 8	-0.247***	-0.531***
	(0.00244)	(0.00217)
Year = 9	-0.196***	-0.572***
	(0.00211)	(0.00238)
Year = 10	-0.232***	-0.662***
	(0.00224)	(0.00278)
Constant	-0.432***	-0.504***
	(0.0279)	(0.0495)
Observations	249,297	249,297
R-squared	0.317	0.302

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix D

VARIABLES	(1) Ln(RX Expenditures)	(2) Ln(RX Expenditures Paid by Self/Family)	(3) Ln(RX Expenditures)	(4) Ln(RX Expenditures Paid by Self/Family)
Insurance Coverage	1.374***	1.223***	2.431***	1.732***
	(0.0590)	(0.0504)	(0.111)	(0.0954)
Uses Insulin	1.307***	1.423***	1.196***	1.423***
	(0.0557)	(0.131)	(0.0639)	(0.110)
Uses Insulin*Year	0.0472***	-0.0682***	0.0626***	-0.0730***
	(0.0111)	(0.0164)	(0.0114)	(0.0180)
Total Income	1.96e-06***	2.04e-06***	-3.77e-07	8.93e-07**

	(3.17e-07)	(3.31e-07)	(4.27e-07)	(4.51e-07)
Age	0.0530***	0.0456***	0.0516***	0.0449***
	(0.000622)	(0.000403)	(0.000688)	(0.000542)
Female	0.913***	0.658***	0.825***	0.610***
	(0.0170)	(0.0348)	(0.0174)	(0.0337)
Diabetic	2.672***	2.093***	2.589***	2.040***
	(0.0470)	(0.0523)	(0.0511)	(0.0488)
Black	0.279***	0.151***	0.257***	0.131***
	(0.0245)	(0.0230)	(0.0274)	(0.0229)
White	0.991***	0.807***	0.948***	0.774***
	(0.0198)	(0.0205)	(0.0193)	(0.0195)
Hispanic	-0.846***	-0.636***	-0.638***	-0.533***
	(0.0202)	(0.0277)	(0.0302)	(0.0295)
Census Region = 2	0.0891***	0.167***	0.105***	0.176***
	(0.0312)	(0.0253)	(0.0338)	(0.0267)
Census Region = 3	0.0449	0.212***	0.123***	0.249***
	(0.0288)	(0.0131)	(0.0416)	(0.0221)
Census Region = 4	-0.228***	-0.132***	-0.221***	-0.128***
	(0.0348)	(0.0324)	(0.0444)	(0.0360)
Year = 2	-0.0560***	-0.108***	-0.0484***	-0.104***
	(0.000939)	(0.000906)	(0.000858)	(0.000933)
Year = 3	-0.103***	-0.177***	-0.116***	-0.190***
	(0.00121)	(0.00118)	(0.00117)	(0.00115)
Year = 4	-0.244***	-0.273***	-0.244***	-0.274***
	(0.00142)	(0.00106)	(0.00181)	(0.00155)
Year = 5	-0.308***	-0.283***	-0.293***	-0.277***
	(0.00168)	(0.00142)	(0.00186)	(0.00178)
Year = 6	-0.414***	-0.378***	-0.396***	-0.368***
	(0.00231)	(0.00202)	(0.00325)	(0.00306)
Year = 7	-0.270***	-0.358***	-0.266***	-0.365***
	(0.00278)	(0.00232)	(0.00370)	(0.00332)
Year = 8	-0.338***	-0.526***	-0.369***	-0.543***
	(0.00279)	(0.00297)	(0.00344)	(0.00354)
Year = 9	-0.305***	-0.572***	-0.364***	-0.609***
	(0.00412)	(0.00433)	(0.00607)	(0.00580)
Year = 10	-0.367***	-0.673***	-0.439***	-0.715***
	(0.00498)	(0.00506)	(0.00663)	(0.00647)
Constant	-1.314***	-1.322***	-1.991***	-1.630***
	(0.0522)	(0.0417)	(0.0891)	(0.0773)
Observations	143,779	143,779	142,302	142,302
R-squared	0.254	0.239	0.232	0.220
Instrument	Employer	Employer Offers	Firm Has	Firm Has Multiple

	Offers Insurance	Insurance	Multiple Locations	Locations

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix E

VARIABLES	(1) Ln(RX Expenditures)	(2) Ln(RX Expenditures Paid by Self/Family)
Uses Insulin	1.202***	0.951***
	(0.0450)	(0.0503)
Post ACA	-0.220***	-0.348***
	(0.0121)	(0.00993)
insulin*ACA	0.249***	-0.176***
	(0.0509)	(0.0565)
Total Income	1.18e-07	3.05e-06***
	(1.76e-07)	(1.46e-07)
Age	0.0687***	0.0530***
	(0.000314)	(0.000257)
Female	0.813***	0.596***
	(0.0109)	(0.00877)
Diabetic	2.350***	1.697***
	(0.0196)	(0.0182)
Black	0.444***	0.271***
	(0.0209)	(0.0164)
White	1.087***	0.958***
	(0.0192)	(0.0151)
Hispanic	-1.208***	-1.017***
	(0.0132)	(0.0105)
Constant	-0.682***	-0.647***
	(0.0244)	(0.0194)
Observations	249,297	249,297
R-squared	0.315	0.298

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

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