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Will knowing diabetes affect labor income? Evidence from a natural experiment

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HIGHLIGHTS

- We analyze the impact of diabetes on income using data from a natural experiment in China.
- We employ difference-in-differences and quantile difference-in-differences approaches of CHNS data.
- Diabetes leads to an average of 16.3% decrease in income after people being diagnosed.
- The adverse impact is heterogeneous across genders, HbA_{1c} levels, and the income distribution.
- The estimated income losses are primarily due to the psychosocial consequences of diabetes.

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ABSTRACT

This paper analyzes the impact of diabetes awareness on labor income using data from a natural experiment in China. We find that diabetes in general leads to a 16.3% decrease in annual income after people being diagnosed, and the adverse impact is heterogeneous across different populations.
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1. Introduction

Medical evidence shows that diabetes has become a major risk factor for morbidity and mortality worldwide (Roglic and Unwin, 2010). Despite a substantial economic burden on health care imposed by diabetes directly, it can also generate costs through adverse labor market impacts indirectly. In 2012, the loss in productivity from diagnosed diabetes in the US ($69 billion) is just over one third of the total medical costs ($176 billion) (ADA, 2013). Understanding the economic impact of diabetes is not only an academic matter, it also has important policy implications for public health.

Current research has widely documented the negative correlation between diabetes and labor productivity (Bastida and Pagan, 2002; Brown et al., 2005; Kahn, 1998; Latif, 2009; Ng et al., 2001; Tunceli et al., 2005). A few studies go further to examine how diabetes affects labor income (Kraut et al., 2001). Diabetes may affect income both through physical limits and psychosocial consequences. For example, diabetes may physically prevent people going to work or lower their labor productivity (ADA, 2013). From a psychological perspective, diabetic workers may be economically myopic and have diabetes-related emotional distress or a higher discount rate of future (Zulman et al., 2012). Employers may discriminate in promoting workers with diabetes as well, particularly against individuals using insulin (Kraut et al., 2001).

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A practical issue raised in assessing the causal impact of diabetes is that researchers rarely, if ever, observe the exact date that people become diabetic. As a chronic disease, people may be unaware of their elevated blood glucose levels and gradually suffer physical limits for many years before diagnosis.[1] Once diagnosed, however, diabetic patients may be suddenly confronted with severe stressors that can result in psychological distress, a great deal of anxiety or uncertainty, and peer or employer discrimination in the workplace. Hence, changes in income soon after the diagnosis of diabetes can be principally attributed to these psychosocial consequences caused by diabetes.

This paper seeks to understand how diabetes would affect labor income at the individual level, and whether the effect is heterogeneous across the population. We compare changes in income between people with newly-diagnosed diabetes and non-diabetics in a natural experiment in China by using hemoglobin A_{1c} (HbA_{1c}) as an indicator of diabetes. An HbA_{1c} of 6.5% is recommended as the threshold for diagnosing diabetes by American Diabetes Association (ADA, 2010). We find that people with newly-diagnosed diabetes earn 16.3% less annual income than non-diabetic workers, and the effect is discontinuous at the diabetes threshold. Additionally, the adverse impact is more significant for males and people with an HbA_{1c} between 8.0% and 10.0%. Respondents with an annual income below 10,168 RMB (about 1,543 US dollars) are more vulnerable to diabetes in terms of annual income losses. We attribute the income reduction mainly to psychosocial consequences after the diagnosis of diabetes.

China provides a good case study to achieve the research objective for two reasons. First, the prevalence of diabetes in China has increased dramatically over the last three decades. As a country with the largest diabetic population in the world, the percentage of Chinese adults with diabetes has surpassed that of the US in 2010 and reaches to 11.6% of the total population (CDC, 2011; Xu et al., 2013). This number indicates that 114 million of Chinese adults are suffering with diabetes. As the percentage of diabetics increases by more than 10 times since 1980, the regional distribution of the chronic disease becomes more widespread (Xu et al., 2013). Second, the China Health and Nutrition Survey (CHNS) data provides a natural experiment that allows us to identify the impact of diabetes through a difference-in-differences (DID) approach. CHNS is a nationally representative longitudinal household-based survey with detailed individual level data on socio-demographics, anthropometrics, and health-related conditions from 1989 to 2011 (Popkin et al., 2010). We use data from the 2009 and 2011 surveys since CHNS started to collect fasting blood samples of survey respondents in 2009. The change in respondents' diabetes awareness after the 2009 blood tests provides a natural experiment to investigate how that change affects labor income.

This paper extends the literature in three ways. First, it is the first attempt to identify the causal impact of diabetes awareness on income through a natural experiment. It is difficult to infer the causality because diabetes is potentially endogenous and tends to interact with an individual's occupation or earning. A few studies have used an individual's family history of diabetes as instrumental variables to control for the endogeneity and find substantial negative effects of diabetes on employment (Brown et al., 2005; Latif, 2009). The natural experiment in the present study allows us to control for the potential endogenous diabetes through an alternative identification strategy. Second, we find heterogeneous impacts of diabetes on individuals with different genders, HbA_{1c} and income levels, and identify that the main decreases in income are due to psychosocial consequences brought by diabetes. The results highlight the considerable indirect costs imposed by diabetes in China, and provide a baseline to evaluate the influence of possible policies addressing the health and social effects of diabetes. Third, this paper is one of the pioneer studies in economics that rely on HbA_{1c} concentration levels as the indicator of diabetes, while most previous studies use self-reported diabetic status from survey responses. A potential problem of self-reported data is that respondents with undiagnosed diabetes might be treated as "normal" workers, leading to underestimated impacts of diabetes on labor market outcomes.

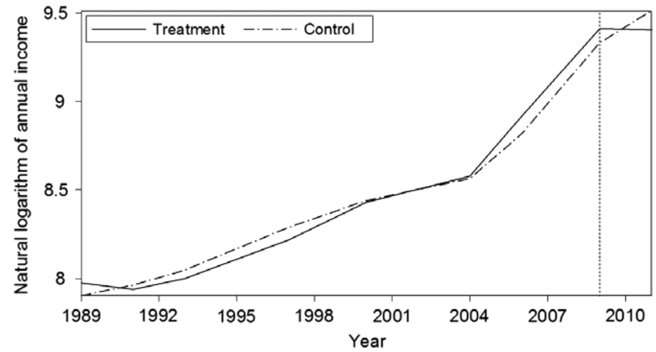

Fig. 1. Trends of average annual income in CHNS sample, 1989–2011. Note: All income values are inflated to 2011 values before taking the natural logarithm. The solid and dotted–dashed lines are income patterns of people with newly-diagnosed diabetes (treatment) and non-diabetics (control), respectively. The vertical dotted line represents the year 2009.

2. Data and empirical strategy

We use changes in diabetes awareness as a natural experiment. During three-day home visits in 2009, all respondents to the CHNS older than seven years were asked whether they would like to provide fasting blood samples and receive free health status examination/blood test feedback. If they agreed, respondents then visited a neighborhood clinic to have trained physicians collect fasting blood samples (CHNS, 2009). 394 individuals were newly diagnosed with diabetes based on their survey responses and HbA_{1c} concentration levels, which accounts for 61.0% of total diabetic respondents in sample. The newly-diagnosed diabetics may have diabetes for years without knowing it, thus the 2009 blood tests and feedback provide a natural experiment to investigate how changes in diabetes awareness affect respondents' labor market performance.

Our study focuses on respondents who were employed and had annual income reported in the 2009 and 2011 surveys. The resulting dataset includes 11,095 individual-level data from 207 communities and nine provinces.[2] We define the treatment and control groups by time and awareness of diabetes in the difference-in-differences approach. If an individual with diabetes does not know about his or her diabetes status until the CHNS blood test in late 2009, the individual is considered to be a newly-diagnosed diabetic and assigned to the treatment group. Individuals without diabetes are assigned to the control group. If awareness of diabetes affects income, we expect that individuals from two groups would have different income patterns before and after the treatment (2009 CHNS blood test and feedback).

The solid and dotted–dashed lines in Fig. 1 respectively plot the average annual income from 1989 to 2011 for treatment

1 For example, 27.1% of Americans have undiagnosed diabetes among a total of 25.8 million diabetic people in 2011 (CDC, 2011). The rate of diagnosis is much lower in China. Xu et al. (2013) estimate that the percentage of Chinese adults with undiagnosed diabetes is 69.9% in 2010 among those with diabetes.

2 From north to south, the nine provinces are Heilongjiang, Liaoning, Shandong, Henan, Jiangsu, Hubei, Hunan, Guizhou, and Guangxi. We exclude people who self-reported with diabetes before 2009 blood tests ($n = 252$) to make the causal inference of diabetes awareness changes on income in a DID setup.

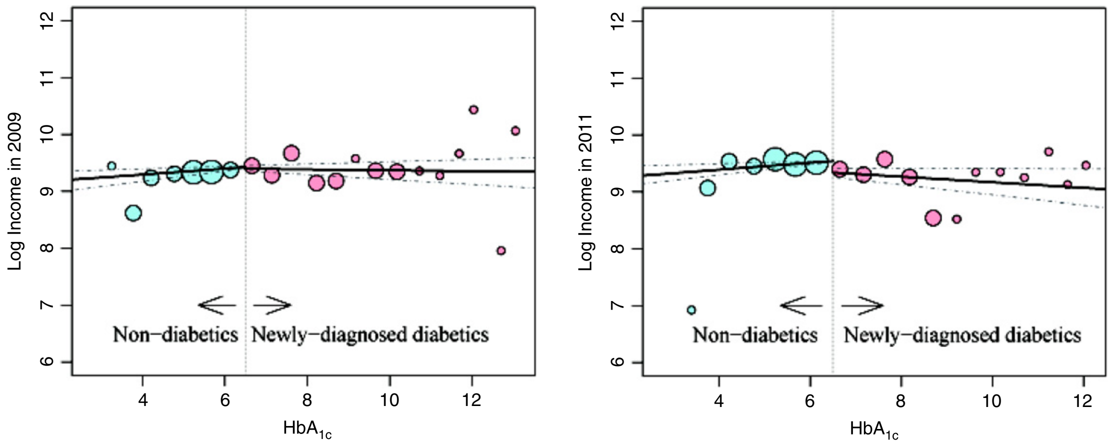

Fig. 2. Income and HbA_{1c} levels. Note: The 2009 and 2011 income values (in natural logarithm) of non-diabetics and respondents with newly-diagnosed diabetes are in the left and right panel, respectively. Each observation (circle) is generated by averaging log income values across the HbA_{1c} distribution within a 0.5 (%) range. The size of the circle is in proportion to the total number of observations within each range. The plotted solid lines report the linear fitted values, with 95% confidence intervals in dotted–dashed lines. The vertical dotted line represents HbA_{1c} level of 6.5%.

and control groups.[3] The trends of two groups are similar until 2009, when the average income of the treatment group becomes flat, while that of the control group continues to increase. These patterns suggest that in studying the impact of the diabetes awareness change after 2009 CHNS fasting blood tests through a DID approach, the non-diabetic group provides a suitable comparison for the group of people with newly-diagnosed diabetes.

Fig. 2 plots the average annual income against HbA_{1c} levels. The left and right panels give income values in 2009 and 2011, respectively. Respondents below the HbA_{1c} cut-off of 6.5% (vertical dotted lines) are non-diabetics in the control group, and those above the threshold are people with newly-diagnosed diabetes in the treatment group. The regression lines (solid black lines) are linear fitted on either side of the threshold, with 95% confidence intervals in dotted–dashed lines. The figure shows no visual evidence of a significant change in income at HbA_{1c} cut-off in 2009, but a small and noticeable discontinuity in income at the threshold in 2011. It implies that the psychosocial impact of being classified as "diabetic" is discontinuous at the HbA_{1c} threshold.

Suppose an individual i's annual income in year t is w_{it}. The standard difference-in-differences model is:

$$\ln w_{it} = \alpha_0 + \alpha_1 d_{post,it} + \alpha_2 d_{it,T} + \lambda \left(d_{post,it} \times d_{T,it}\right) + \beta X_{it} + \epsilon_{it}, \qquad (1)$$

where d_{post} and d_T are dummy variables. d_{post} is set to 1 for the post-treatment period. d_T is set to 1 for individuals in the treatment group. λ is the difference-in-differences estimator hereby the parameter of interest. X is a vector of control variables that can affect income, including human capital measures (e.g. age, gender, educational attainments), residential status (urban or rural), marital status, physical appearance measures (e.g. height), and province fixed effects. ϵ_{it} is the disturbance term with mean zero and constant variance.

To investigate potential varied treatment effects on different sections of the income distribution, we follow Koenker (2005) and estimate the model at each chosen quantile. The pth conditional quantile of $\ln w_{it}$ given d_{post}, d_T, and X is:

$$q_p(\ln w_{it}|d_{post}, d_T, X) = \alpha_0(p) + \alpha_1(p)\, d_{post,it} + \alpha_2(p) d_{T,it} + \lambda(p) \left(d_{post,it} \times d_{T,it}\right) + \beta(p) X_{it} + \epsilon_{it}(p). \qquad (2)$$

The quantile DID approach captures a more comprehensive picture of how changes in diabetes awareness affect individuals with different income levels. This approach is robust in handling "outliers" and reduces the importance of functional-form assumptions (Meyer et al., 1995). Without additional distributional assumptions about ϵ_{it}, quantile DID estimates can be obtained by minimizing the sum of the absolute residuals in Eq. (2).

3. Estimation results

Table 1 presents standard DID estimation results in Eq. (1). We first estimate the full sample (column 1) and then split the sample by gender (column 2–3) and by HbA_{1c} level (column 4–6).[4] The estimates of DID coefficients show that the awareness of diabetes leads to an average of 16.3% decrease in income for newly diagnosed diabetics in 2011.[5] The impact is more significant for males and people with HbA_{1c} levels between 8.0% and 10.0%, leading to a 22.0% and 28.0% decrease in annual income, respectively.

To ensure that our estimated DID coefficients are due to the diabetes awareness change rather than unobserved individual characteristics, we include individual fixed effects into benchmark DID regressions to remove observed and unobserved individual-level differences between the treatment and control groups. Robustness results suggest similar strong evidence.[6]

The quantile DID coefficients estimated at different quantiles of the natural log income distribution in Eq. (2) are graphed in Fig. 3. The solid line shows the treatment effects for different quantiles along the income distribution. Dotted lines are 95% confidence intervals constructed by 300 bootstrap replications. The mean DID effect is plotted as a horizontal dashed line for comparison. From the figure, the quantile treatment effect is negative and significant under the 34th percentile of the income distribution, which translates to an individual's annual income of 10,168 RMB (about 1,543 US dollars) and below in 2011. In our sample, 33.8%

3 Following the literature, we transform all annual income by taking its natural logarithm.

4 In specific, we divide the treatment group into three subsamples to quantify any variation in treatment effects across the distribution of HbA_{1c} levels: respondents with HbA_{1c} between 6.5% and 8.0%, between 8.0% and 10.0%, and greater than or equal to 10.0%.

5 The dependent variable is the natural log of annual income, so DID estimators can be interpreted as percentage changes in income after applying the exponential transformation.

6 The results for robustness check are available upon request.

Table 1
Effects of diabetes on income.

Variables	(1) Pooled ln (income)	(2) Males ln (income)	(3) Females ln (income)	(4) HbA_{1c} 6.5%–8.0% ln (income)	(5) HbA_{1c} 8.0%–10.0% ln (income)	(6) $HbA_{1c} \geq$ 10.0% ln (income)
d_{post}	0.177***	0.179***	0.172***	0.176***	0.176***	0.176***
	(0.022)	(0.026)	(0.026)	(0.018)	(0.019)	(0.020)
d_T	0.090*	0.164**	−0.007	0.086	0.016	0.201
	(0.049)	(0.071)	(0.069)	(0.060)	(0.144)	(0.156)
$d_{post} \times d_T$	−0.178**	−0.249**	−0.090	−0.128*	−0.328**	−0.175
	(0.077)	(0.123)	(0.117)	(0.068)	(0.158)	(0.229)
Constant	7.068***	6.481***	7.737***	6.571***	6.626***	6.634***
	(0.305)	(0.470)	(0.374)	(0.202)	(0.206)	(0.221)
Observations	11,095	5472	5623	10,978	10,795	10,733

Note: Standard errors in parentheses are calculated using 300 bootstrap replications. Controls include height, gender, marital status, residential status, age, and years of schooling, as well as province fixed effects. Estimates for control variables are available upon request.
* Statistical significance at the 10% level.
** Statistical significance at the 5% level.
*** Statistical significance at the 1% level.

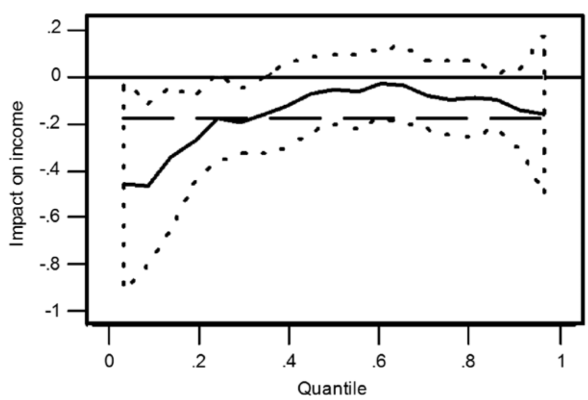

Fig. 3. Distributional effects of diabetes awareness change on annual income. Note: The solid line is the quantile DID effect on the natural logarithm of annual income; dotted lines give 95% confidence intervals based on 300 bootstrap replications; the dashed line is the mean DID effect. Estimation results are available upon request.

of respondents fall into this category and tend to be affected more after knowing about their diabetes status. This finding suggests that there is a need for social support to compensate individuals with lower income, for their loss in income due to diabetes.

4. Conclusion

This paper is the first attempt to investigate the impact of diabetes on income using data from a natural experiment. We find that the awareness of diabetes leads to a 16.3% decrease in annual income in general, and that the reduction is different across genders, HbA_{1c} levels, and the income distribution. Especially noteworthy, we find that individuals with lower income are more likely to be negatively influenced by diabetes in the labor market, suggesting that low socioeconomic status could lead to worse labor market performance after a diagnosis of diabetes and that social support may be needed. We attribute the income reduction found in this study principally to the psychosocial consequences of diabetes, such as reduced productivity, lower discount rate of future, and discrimination in the workplace. The discrete income decline of respondents with newly-diagnosed diabetics in 2011 supports this deduction.

A main limitation of the current study is that we use blood test results from the 2009 survey only. That is, we assume adults without diabetes in 2009 would not be diabetic in 2011. If this is not true, the estimated impact is likely to be biased upwards, i.e. the adverse impacts of diabetes on labor income are likely to be understated. Another limitation is that although we have demonstrated the causal relationship between "knowing diabetics" and income loss, we cannot completely separate the impacts of psychosocial consequences from the deterioration in health due to the setup of the current natural experiment. Future research could be done by monitoring participants' HbA_{1c} levels, important physical and mental health indicators, and socio-demographic status on a regular basis (biweekly or monthly), preferably in a long-term randomized controlled trial. It would also be interesting to quantify these psychosocial impacts, which arise from different sources, such as patients themselves and exogenous environments.

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References

ADA, 2010. Diagnosis and classification of diabetes mellitus. Diabetes Care 33 (suppl 1), S62–S69.
ADA, 2013. Economic costs of diabetes in the US in 2012. Diabetes Care 36 (4), 1033–1046.
Bastida, E., Pagan, J.A., 2002. The impact of diabetes on adult employment and earnings of Mexican Americans: findings from a community based study. Health Econ. 11 (5), 403–413.
Brown, H.S., Pagan, J.A., Bastida, E., 2005. The impact of diabetes on employment: genetic IVs in a bivariate probit. Health Econ. 14 (5), 537–544.
CDC 2011. National diabetes fact sheet: national estimates and general information on diabetes and prediabetes in the United States, 2011. http://www.cdc.gov/diabetes/pubs/pdf/ndfs_2011.pdf [Online; accessed 06-Mar-2014].
CHNS 2009. China Health and Nutrition Survey (CHNS) Manual for Specimen Collection and Processing. http://www.cpc.unc.edu/projects/china/data/datasets/Blood%20Collection%20Protocol_English.pdf/ [Online; accessed 06-Mar-2014].
Kahn, M.E., 1998. Health and labor market performance: the case of diabetes. J. Labor Econom. 16 (4), 878–899.
Koenker, R., 2005. Quantile Regression. Cambridge University Press.

Kraut, A., Walld, R., Tate, R., Mustard, C., 2001. Impact of diabetes on employment and income in Manitoba, Canada. Diabetes Care 24 (1), 64–68.
Latif, E., 2009. The impact of diabetes on employment in Canada. Health Econ. 18 (5), 577–589.
Meyer, B.D., Viscusi, W.K., Durbin, D.L., 1995. Workers' compensation and injury duration: evidence from a natural experiment. Amer. Econ. Rev. 85 (3), 322–340.
Ng, Y.C., Jacobs, P., Johnson, J.A., 2001. Productivity losses associated with diabetes in the US. Diabetes Care 24 (2), 257–261.
Popkin, B.M., Du, S., Zhai, F., Zhang, B., 2010. The China Health and Nutrition Survey—monitoring and understanding socio-economic and health change in China, 1989–2011. Int. J. Epidemiol. 39 (6), 1435–1440.
Roglic, G., Unwin, N., 2010. Mortality attributable to diabetes: estimates for the year 2010. Diabetes Res. Clin. Pract. 87 (1), 15–19.
Tunceli, K., Bradley, C.J., Nerenz, D., Williams, L.K., Pladevall, M., Lafata, J.E., 2005. The impact of diabetes on employment and work productivity. Diabetes Care 28 (11), 2662–2667.
Xu, Y., Wang, L., He, J., Bi, Y., Li, M., Wang, T., Wang, L., Jiang, Y., Dai, M., Lu, J., 2013. Prevalence and control of diabetes in Chinese adults. J. Am. Med. Assoc. 310 (9), 948–959.
Zulman, D.M., Rosland, A., Choi, H., Langa, K.M., Heisler, M., 2012. The influence of diabetes psychosocial attributes and self-management practices on change in diabetes status. Patient Ed. Couns. 87 (1), 74–80.