

COSTS OF PEOPLE WITH DIABETES IN RELATION TO AVERAGE GLUCOSE CONTROL: AN EMPIRICAL APPROACH CONTROLLING FOR YEAR OF ONSET COHORTS

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OVERVIEW

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2. **Objective**
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 - I. Data
 - II. Variables description
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 - a) By cost component
4. **Regression results**
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5. **Discussion and Conclusions**

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INTRODUCTION

- Number of adults with diabetes has raised worldwide: 4.3% and 5% of men and women in 1980 up to 9% and 7.9% in 2014
 - Netherlands: diabetes prevalence= 5.45%; T2DM prevalence = 5.13%
- Higher prevalence → higher costs (three time higher) (Clarke et al., 2010)
 - 2010: **12% of worldwide healthcare costs** (1,330\$ per person with diabetes)
 - Netherlands: 4,000\$ per patient
 - 35 – 40% of total costs due to (cardiovascular) **complications** management and **hospitalization** (Bruno et al., 2008)
 - Cardiovascular diseases associated with **glycaemic control**
- Glycaemic control programs have been found to be **cost-effective**, reducing the cost per patient by £258 in the United Kingdom (Clarke et al., 2001)
- Few studies focusing on the short term impact of poor glycaemic control:
 - Italy: **€219.28** mean two-year cost in people with diabetes (Degli Esposti et al., 2013)
 - Canada: **\$1,623** mean five-year cost in people with diabetes (McBrien et al., 2012)

INTRODUCTION

- Diabetes duration and higher care costs
 - **U-shape**: decrease until the fifth year and then increase (Nichols and Brown, 2002)
 - Greater risk of **developing complications** (or worse management)
 - Glycaemic control more difficult to be implemented → need for **multiple and/or more complex treatments**
- No study has been found analysing care costs in people with diabetes and glucose level taking into account **year of diagnosis cohorts effects**
 1. Expenditure pattern according to date of diagnosis?
 - i. Different treatments or technologies
 2. Impact of cohort effects on other covariates

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OBJECTIVE

- To estimate the impact of glucose level on total care costs, but not only diabetes-related costs, of people with type 2 diabetes:
 1. Controlling for **treatment**, since glycaemic control drugs represent 18% of the total costs in people with diabetes (Liebl et al., 2015) and treatment modality modifies glucose level (Booz&Co, 2011)
 2. Adding **diabetes duration** and **diagnosis cohort effects**
 3. Exploiting the **panel data**
 4. We also include a list of **chronic conditions** and registered by the General Practitioner (GP)

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DAT

The logo for 'vektis' features the word in a bold, lowercase, sans-serif font. The letters 'v', 'e', 'k', and 't' are white, while the 'i' is orange with a white dot, and the 's' is white. The text is set against a solid black rectangular background.The logo for 'ZODIAC' consists of the word in a bold, uppercase, sans-serif font. The letters are white with a bright green outline, giving it a glowing or neon-like appearance.

- National insurance dataset on **healthcare use and costs** in the Netherlands
- **Annual care costs + cost type**
 - Hospitalization and specialist; drugs; devices; GP; and others (obstetrics, costs abroad, etc.)
- Other information: date of birth, gender, socioeconomic level, GP code and year of death
- 211,484 observations were merged from 2008 to 2011
- After selection criteria: **22,612 observations**, grouped in **5,653 individuals** observed every year
- **Observational prospective** study (from 1998) consisting of an **integrated care program** for people with T2DM
- **Standard of care** in 2002 in the Northern region of the Netherlands
- Information: ethnicity, lifestyle, chronic conditions according to ICPC codes

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VARIABLES DESCRIPTION: DEPENDENT VARIABLES

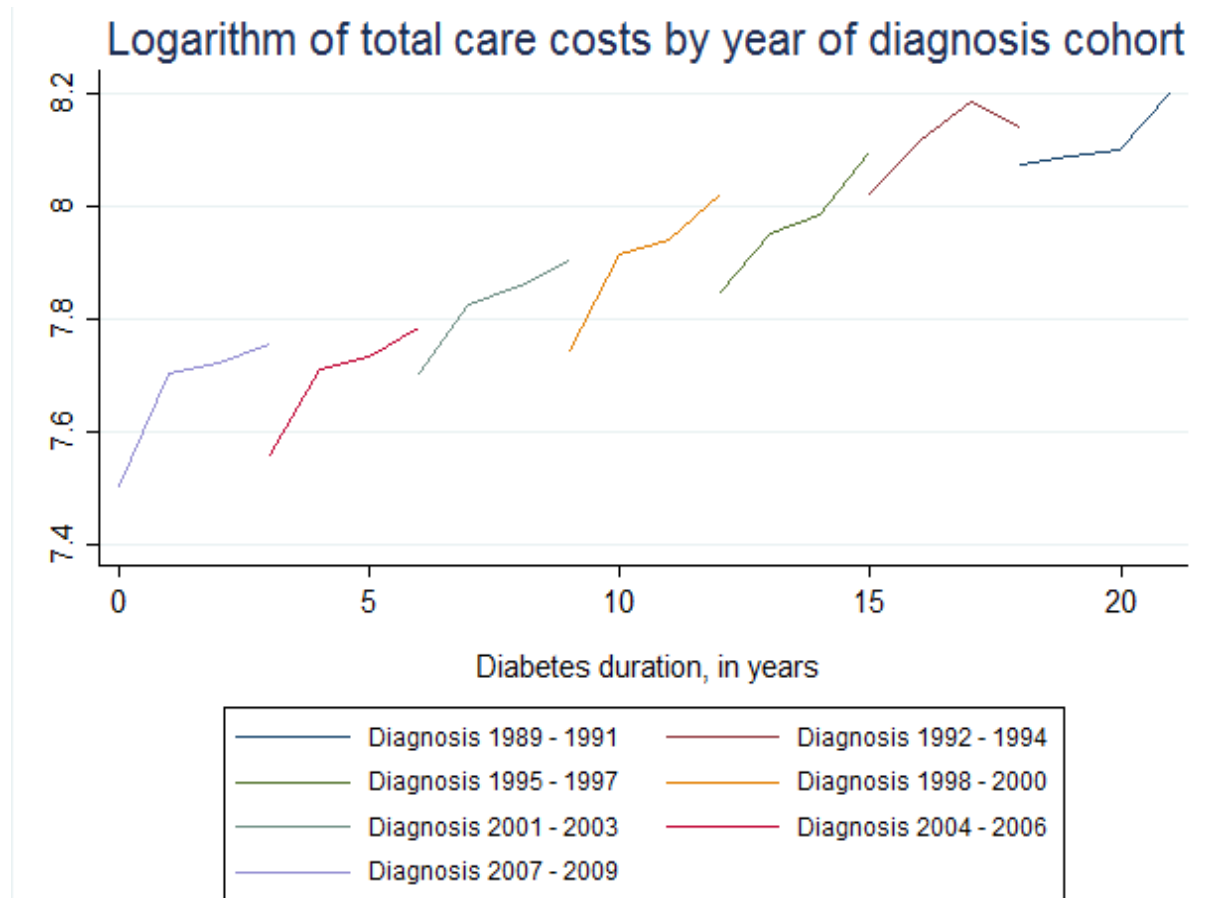
	Mean (SD)	Number of zeros	P25	P50	P75	P90	P95
Total care costs	4,361.32 (7,173.35)	0	1,248.36	2,214.55	4,396.38	9,536.25	15,308.57
Logarithm of total care costs	7.83 (0.96)	0	7.13	7.70	8.39	9.16	9.64
GP costs	219.61 (130.01)	0	135.44	186.12	262.9	373.19	465.97
Logarithm of GP costs	5.26 (0.49)	0	4.91	5.23	5.57	5.92	6.14
Drugs costs	1,008.33 (2,280.29)	33	345.23	686.24	1,214.63	1,964.17	2,577.1
Logarithm of drugs costs	6.45 (0.95)	0	5.85	6.53	7.10	7.58	7.85
Hospitalization and specialist costs	2,259.23 (5,758.75)	198	139.54	485.87	1,647.02	5,747.85	10,990.69
Logarithm of hospitalization and specialist costs	6.23 (1.78)	0	4.97	6.21	7.42	8.66	9.31
Devices costs	264.67 (698.54)	11,894	0	0	234.92	752.31	1,271
Other costs	532.01 (1,974.05)	1,086	192.5	353.83	385	789.56	1,485

VARIABLES DESCRIPTION: INDEPENDENT VARIABLES

- **Average glucose control level: HbA1c**, in %
 - **5.7%** denoting the maximum level of good average glucose control in a **non-diabetic person**
 - **6.5%** as the maximum value in a **person with diabetes**
- **Treatment**: oral medication or diet and insulin
- **Interaction treatment # HbA1c**
 - HbA1c is the representation of effort the individual and the healthcare professionals make to reach a good glucose level
- **Diabetes duration + diabetes duration²**
- **Cohorts** (groups) according to diagnosis year: three-year series
- **GP codes**
 - Some patients might be treated more efficiently by their GP



VARIABLES DESCRIPTION: INDEPENDENT VARIABLES



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SAMPLE CHARACTERISTICS

Variables	HbA1c ≤ 6.5%	6.5% < HbA1c ≤ 7.5%	HbA1c > 7.5%	Comparison of means
	(N = 9,845)	(N = 9,779)	(N = 2,988)	p-value
Total care costs	4,393.47 ± 7,737.18	4,160.31 ± 6,517.51	4,913.28 ± 7,262.05	0.001***
Logarithm of total care costs	7.79 ± 0.98	7.81 ± 0.93	7.98 ± 0.95	0.000***
Types of costs				
GP costs	216.20 ± 126.24	219.32 ± 126.90	231.78 ± 150.05	0.000***
Drugs costs	1,010.09 ± 3,147.87	954.61 ± 1,202.50	1,178.31 ± 1,390.12	0.043**
Specialists and hospitalization costs	2,303.38 ± 5,878.40	2,129.51 ± 5,450.95	2,538.32 ± 6,304.91	0.057*
Devices costs	218.44 ± 710.30	279.29 ± 691.02	369.16 ± 670.23	0.000***
Other costs	565.75 ± 2,172.21	503.86 ± 1,928.19	513.00 ± 1,330.72	0.104

SAMPLE CHARACTERISTICS

Variables	HbA1c ≤ 6.5%	6.5% < HbA1c ≤ 7.5%	HbA1c > 7.5%	Comparison of
	(N = 9,845)	(N = 9,779)	(N = 2,988)	means
	Mean ± SD	Mean ± SD	Mean ± SD	p-value
Gender: females	0.51	0.53	0.53	0.053*
Age	68.18 ± 10.11	68.49 ± 10.25	68.71 ± 10.85	0.081*
Non-caucasian ethnicity	0.001	0.003	0.003	0.177
<i>Socioeconomic status</i>				0.088*
Low	0.36	0.32	0.33	
Medium	0.35	0.36	0.38	
High	0.29	0.31	0.29	
Current smoker	0.16	0.14	0.14	0.014**
HbA1c	6.12 ± 0.33	6.99 ± 0.28	8.19 ± 0.68	-
Diabetes duration	6.79 ± 4.65	8.02 ± 5.38	9.60 ± 6.39	0.000***
<i>Treatment</i>				
No treatment	0.14	0.10	0.06	0.003***
Oral medication or diet	0.84	0.85	0.86	0.015**
Insulin	0.07	0.19	0.39	0.000***

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STATISTICAL ANALYSIS

- Stepwise random-effects linear regression model
- Baseline model (Model 1)

$$\log(\text{totalcarecost}_{it}) = \beta_1' SE_{it} + \beta_2 HbA1c_{it} + \beta_3 smoker_{it} + c_i + u_{it} \quad (1)$$

- Model 2: Model 1 + treatment + interaction treatment # HbA1c
- Model 3: Model 2 + diabetes duration + duration²
- Model 4: Model 3 + diabetes diagnosis cohorts
- Model 5: Model 4 + dichotomous variables for GP codes

$$\begin{aligned} \log(\text{totalcarecost}_{it}) &= \beta_1' SE_{it} + \beta_2 HbA1c_{it} + \beta_3 smoker_{it} \\ &+ \beta_4' treatment_{it} + \beta_2 \beta_4' (HbA1c_{it} * treatment_{it}) + \beta_5 diabetesdur_{it} \\ &+ \beta_6 diabetesdur_{it}^2 + \beta_7' yearofdiagnosis_{it} + \beta_8' GP_{it} + c_i + u_{it} \quad (2) \end{aligned}$$

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ANALYSIS BY COST COMPONENT

- **Model 5** (full model) for i) **GP** costs; ii) **drugs** costs; iii) **hospitalization** and **specialist** costs

$$\begin{aligned} \log(\text{totalcarecost}_{it}) &= \beta_1' SE_{it} + \beta_2 HbA1c_{it} + \beta_3 \text{smoker}_{it} \\ &+ \beta_4' \text{treatment}_{it} + \beta_2 \beta_4' (HbA1c_{it} * \text{treatment}_{it}) + \beta_5 \text{diabetesdur}_{it} \\ &+ \beta_6 \text{diabetesdur}_{it}^2 + \beta_7' \text{yearofdiagnosis}_{it} + \beta_8' GP_{it} + c_i + u_{it} \quad (2) \end{aligned}$$

- Due to the great number of zeros in **devices costs** (more than 50%) →

Two-part regression model

1. Part 1: **Probit**: dependent variable = 1 if devices costs > 0; dependent variable = 0 if claimed devices costs = 0
2. Part 2: **GLM with the logarithm** of devices costs

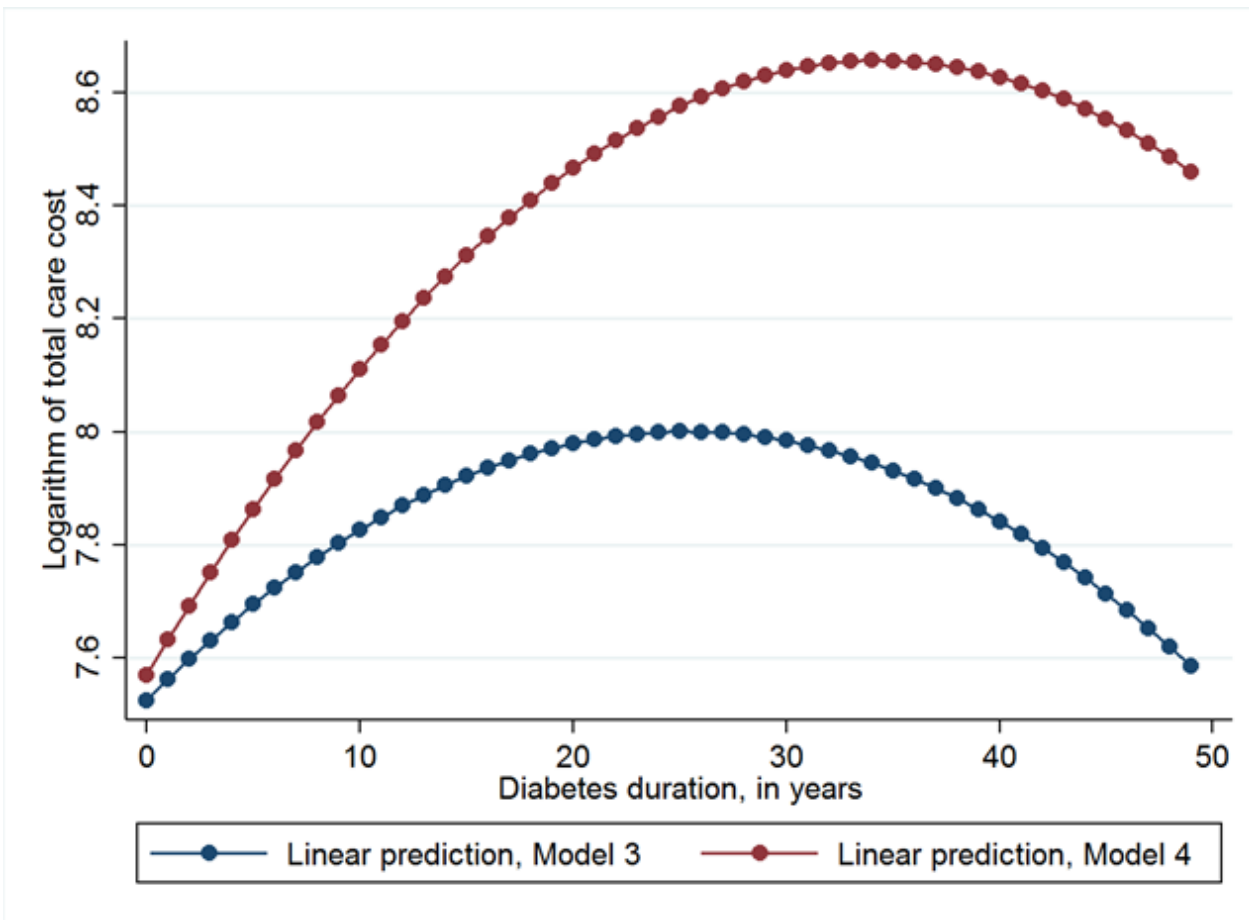
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REGRESSION RESULTS

	Coef. Model 1	Coef. Model 2	Coef. Model 3	Coef. Model 4	Coef. Model 5
HbA1c	0.0222*** (0.00835)	0.0342* (0.0191)	0.0169 (0.0190)	0.0154 (0.0190)	0.0145 (0.0193)
Treatment modality					
Oral medication or diet		0.104 (0.132)	0.0631 (0.131)	0.0781 (0.131)	0.0441 (0.133)
Insulin		0.658*** (0.145)	0.536*** (0.144)	0.565*** (0.144)	0.589*** (0.144)
Interaction HbA1c # treatment					
HbA1c # Oral medication		-0.0217 (0.0194)	-0.0145 (0.0193)	-0.0141 (0.0193)	-0.00961 (0.0196)
HbA1c # Insulin		-0.0498** (0.0197)	-0.0402** (0.0196)	-0.0406** (0.0195)	-0.0436** (0.0196)
Diabetes duration			0.0368*** (0.00367)	0.0628*** (0.00569)	0.0605*** (0.00597)
Diabetes duration²			-0.000732** (0.000113)	-0.000911*** (0.000158)	-0.000923*** (0.000162)
Significance of year of diagnosis cohort effects (χ^2)				57.22***	48.35***
Significance of GP effects (χ^2)					5.1 ^{e6} ***

REGRESSION RESULTS



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REGRESSION RESULTS BY COST COMPONENT

	Coef. Model 5 logarithm GP costs	Coef. Model 5 logarithm drugs costs	Coef. Model 5 logarithm specialist and hospitalization costs	Coef. Model 5 devices costs (probit)	Coef. Model 5 devices costs (GLM with log)
HbA1c	0.0348*** (0.0103)	0.0540*** (0.0143)	0.0219 (0.0399)	0.252*** (0.0397)	0.0173 (0.0374)
<i>Type of treatment</i>					
Oral medication or diet	0.127* (0.0712)	0.200** (0.0936)	0.0765 (0.277)	0.896*** (0.274)	0.274 (0.263)
Insulin	0.229*** (0.0769)	0.300*** (0.104)	0.904*** (0.292)	2.805*** (0.362)	0.675*** (0.248)
<i>Interaction HbA1c # treatment</i>					
HbA1c # Oral medication	-0.0257** (0.0106)	-0.0296** (0.0137)	-0.0128 (0.0407)	-0.153*** (0.0408)	-0.0608* (0.0366)
HbA1c # Insulin	-0.0228** (0.0105)	-0.0224 (0.0137)	-0.0914** (0.0402)	-0.142*** (0.0496)	-0.0495 (0.0342)
Diabetes duration	-0.120*** (0.00310)	0.0266*** (0.00509)	-0.0118 (0.0119)	0.0622*** (0.0111)	0.00361 (0.0149)
Diabetes duration²	0.00168*** (0.000105)	-0.000723*** (0.000166)	0.000330 (0.000349)	-0.000682** (0.000335)	2.30e-05 (0.000289)

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DISCUSSION & CONCLUSIONS

- **Mean care costs across four years** in people with T2DM increases by **€520** between people with HbA1c > 7.5% and those with HbA1c < 6.5%
- Higher **HbA1c** by 1% is associated with **higher total costs 2.2%**
 - (Degli Esposti et al., 2013; McBrien et al., 2012)
 - **Limited comparison** of the effect: absolute vs relative (%) terms
- HbA1c impact is **mediated** by **treatment modality**
 - **Insulin: significant and positively related** to total care costs (49.57% - 60.81% for every 1% higher HbA1c)
- **Each additional year** lived with diabetes is associated with **higher total costs by 3.68%**
→ **6.28%** if cohort effects are included
 - Point at which costs start decreasing also varies (after 25 year vs 35 if cohort effects included)
- Cost component:
 - Higher impact of **HbA1c** on **drugs** and **GP** costs
 - Higher impact of **insulin** on **specialist and hospitalization** costs, and **devices** costs



DISCUSSION & CONCLUSIONS

- **Limitations**

1. Northern area of the Netherlands
 - i. **Generalization of results is limited**, but same relative differences to be maintained
2. Time **limited to four years only** with low number of observations with full information (10% of the original sample)
 - i. Might not be enough to disentangle the diagnosis cohort effect from the diabetes duration effect
 - ii. Longer time period with more complete cases

- **Conclusions**

1. Glucose level + treatment + diabetes duration + cohort effects → **new** in the existing literature
 - i. **Overestimation of the effect of other variables**
2. Diabetes management focused on **modifiable factors** (HbA1c and treatment) rather than irreversible ones (chronic conditions)

THANK YOU

GRACIAS
ARIGATO
SHUKURIA
JUSPAXAR
DANKSCHEEN
TASHAKKUR ATU
YAQHANYELAY
SUKSAMA
EKHMET
MEHRBANI
PALDIES
GOZAIMASHITA
EPCHARISTO
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