The Effect of Informal Caregiving on the Caregivers' Health

Research Report Master Health Economics, Policy and Law

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The Effect of Informal Caregiving on the Caregivers' Health

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Summary

As a consequence of an ageing population, it is inevitable that the demand for care will increase. This increase could result in more pressure on the collective finances for formal care. In order to prevent this, many countries are willing to reform the current collectively financed systems by shifting from formal care to informal care. However, before reforming the financial long-term care (LTC) system, policy makers need to consider the possible consequences of providing informal care on the health of the informal care giver. According to current empirical studies, providing informal care has various effects on the informal care givers' mental health. No robust effects were found on the physical health due to endogenous and heterogeneity problems in the empirical studies. The aim of this research is to analyse the causal impact of providing informal care on both mental and physical health in people aged between 45 and 64 years old who are living in the Netherlands.

The current study uses panel data and is drawn from a four wave (from 2010 to 2013) self-reported prospective cohort study named: "Study on Transition in Employment, Ability and Motivation" (STREAM). 15118 people were included in the first wave. This study provides comprehensive information on socio-economic and demographic factors of a 45+ aged population in the Netherlands. The STREAM used the following dependent variables to indicate the health state: 'self-reported health'; 'vitality'; 'longstanding diseases'; 'depression'; 'musculoskeletal complaints' and 'sick leave from work' with the use of different questionnaires. In the current study, the association between providing informal care and these dependent variables is analysed with the use of a pooled ordinary least squared analysis (OLS) regression. Second, a fixed-effect model is provided to account for the unobserved time-invariant individual heterogeneity (e.g. personality). Furthermore, an instrumental variable (whether the participant experienced a health shock among their spouse, friends and family) in a Two-Stage Least Squares (2SLS) analysis is used in order to deal with endogeneity. Lastly, the association between the intensity of providing care and the dependent variables is analysed with the pooled OLS and the fixed-effect model.

The pooled OLS regression shows a significant negative health effect on all the dependent variables, except for self-reported health. The fixed-effect analysis shows that providing informal care increases the depression score by 0.02 points (on a scale of one to four) and caregiving decreases the vitality score by 0.49 (on a scale of zero to 100). The 2SLS shows statistical significant effects on all the depended variables. Furthermore, the analysis of intensity of informal care shows that care providers who provided high intensity care (>4 hours) have a worse health compared to individuals who do not provide care.

The study shows an interesting significant robust relation between providing informal care and both mental and physical health of the informal care provider.

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1. Introduction

The European population is ageing (1). The "European Commission" recently stated that the old-age dependency ratio (the number of people aged above 65 years divided by those aged between 15 and 65 years) will increase from 26% now to 50% by 2050 (2) A contributing factor to this ageing population is the shift from life-threatening or fatal diseases to chronic diseases (3). This shift will inevitably increase the need for long-term care (LTC) and increase collective finances required for long-term care (LTC) in Europe (4). Therefore, many European countries are reforming the collectively financed LTC system in order to keep the healthcare system financially sustainable and are increasing the responsibility of citizens in regard to helping others (informal care) (5).

However, providing informal care could have disadvantages. A recent Dutch study stated that over 10% of informal caregivers experience an extra burden (6). This burden could result in physical and mental complaints, which could lead to increased societal costs. Societal costs consist of direct and indirect costs for the society (7). Direct societal costs are directly related to costs of medical treatments, while indirect societal costs are costs due to loss of labour force participation, out-of-the-pocket costs of the caregiver, the time of the caregiving, travel time and opportunity costs (7).

Providing informal care can last for years so it is necessary to consider the potential consequences of providing informal care on the caregiver. Based on current studies providing informal care has various effects on the informal care givers' mental health (8, 9). However, most studies did not find a robust effects on the physical health due to endogeneity problems (e.g. a healthy individual may be more inclined to provide informal care than an unhealthy individual) (10, 11). Furthermore, current literature on the consequences of providing informal care on the caregiver relies on small and selective samples (e.g. providing care for somebody with Alzheimer or dementia) (12-18). The aim of the current study is to analyse the impact of providing informal care on both mental and physical health in people aged between 45 and 60 years old living in the Netherlands.

In the current study different contributions will be made to existing literature. As mentioned before, previous research showed various effects of providing informal care on the caregivers' mental health but no robust effects on the physical health of the informal care provider (10, 11). I will focus on different elements of health by estimating the impact of providing informal care on both mental and physical health of the informal care provider. Also, previous literature is based on small and selective samples, while I will use a large (N=15118) dynamic population dataset drawn from a four wave study named "Study on Transition in Employment, Ability and Motivation" (STREAM). The STREAM provides comprehensive information on socio-economic and demographic

factors of a 45+ aged population in the Netherlands (19). Lastly, because longitudinal data were used with four different waves over four years, both a fixed-effect model and a Two-Stages-Least-Squares (2SLS) analysis can be performed. This analysis will contribute to this research, because I can control for time constant factors and for endogeneity by including an instrumental variable in the model.

2. Theoretical framework

This chapter will discuss the previous approaches used in empirical research (8-18, 20-24) and the theoretical model related to the impact of providing informal care on the caregivers' health. It is important to note that the economic value of informal caregiving also needs to be taken into account when reforming the collectively financed LTC system from formal care to more informal care. From a fiscal perspective, informal care provision has direct impact on public finances, because it reduces the amount of formal care provision. But, informal care could lead to indirect costs due to loss of labour force participation, out-of-the-pocket costs of the caregiver, the time of the caregiving, travel time and opportunity costs (7). Furthermore, providing informal care could increase costs because providing care can influence the mental and physical health state of the caregiver (8, 9). Schmitz and Westphal (2015) assume that these mental and physical health issues due to providing informal care could make providing informal care not economically beneficial and can lead to higher expenditures for healthcare services and drugs (24).

2.1 Empirical background

Based on current literature studies (8-18, 20-24), providing informal care has various effects on the informal care givers' mental health. However, no robust effect was found on the physical health of the informal care provider due to endogeneity problems in the design of these studies. An example of endogeneity is that someone with a good health state or low opportunity cost losses could have a higher chance to make the decision to become an informal caregiver compared to someone with a lower health state or higher opportunity cost losses. Individual heterogeneity plays a role in this decision (time-variant: e.g. health state or time-invariant: e.g. gender). The decision could also be based on an exogenous (at random) change such as, a healthy spouse, friend or family becoming unhealthy.

Furthermore, when studying a group of people providing informal care, heterogeneity of the tasks of the informal care givers could be a problem. For example, helping someone with groceries is very different from taking care of someone with severe dementia and the time spend on these tasks can also differ among individuals. Measuring the tasks of informal care givers or the time spend on informal care provision is difficult because the type of tasks and hours spent on informal care are not formally registered (25).

Di Novi et al. (2013) used data from the "Survey of Health, Ageing and Retirement in Europe" (SHARE) (22), which contains data of a 50+ years old population from thirteen different European countries and their socio-economic state and demographic characteristics to analyse the impact of

providing informal care on the quality of life (QoL) of the informal caregiver, particularly the female informal caregiver (20, 21). Di Novi et al. (2013) compared an exposed group (informal caregivers) with a unexposed group (no informal caregivers) and tried to deal time-variant individual heterogeneity by using the Propensity Score (23) to match the individuals. The authors showed that the impact of caregiving on the caregivers' QoL and health depends on their geographical location, the degree of formal care in the country and specific cultural and social factors of the area (20).

Schmitz and Westphal (2015) also used the Propensity Score to match the individuals and compared an exposed group with an unexposed group. This study used data of the "German Socio-Economic Panel", which contains four waves over seven years, in order to assess the effect of informal caregiving on the caregivers' health. The study included only women who provided at least two hours of informal care every week (24). The authors found that providing informal care results in a temporary reduction of the informal caregivers' mental health. However, in the long term (>5 years) these results did not hold and they did not find any significant effect on the physical health state of the informal caregiver (24). Furthermore, the authors stated that the double-burden-effect has to be addressed in future research because providing informal care might have a bigger impact on people with a full-time job (24).

Heger et al. (2016) used SHARE data (22) from four different waves to estimate the informal caregivers' mental health after starting to provide care for a disabled parent (10). The study tried to estimate the association with the fixed-effect method and used an instrumental variable combined with a fixed-effect method to estimate the causal effect. The fixed-effect model assumes that the independent variable is correlated with the individual specific effect. Therefore, the fixed-effect model controls for the unobserved time-invariant individual heterogeneity. However, to estimate the causal effect Heger et al. (2016) also had to deal with endogeneity or account for time-variant individual heterogeneity problems (10). For example, a major life event such as death of a close relative could influence the change of the informal caregivers' mental health.

To deal with this endogeneity problem or time-variant individual heterogeneity problem Heger et al. (2016) used an instrumental variable (10). The study used one parent alive as an instrumental variable for the informal caregivers' behaviour, by using the change from having two parents alive to having one parent alive and having one parent to having no parents (10). The authors assume that the need for informal care of one parent alive is higher because of the absence of the informal care provision by the spouse (10). Heger et al. (2016) argue that the instrumental variable 'one parent alive' controlled for both the loss of a parent and the health of the parent (10). The study showed that providing informal care on average generates more depressive symptoms in women

than men. Though, the probability of more than four depressive symptoms is equal for the women and men who provide informal care.

Do et al. (2015) used data from South Korea, in which the participants had a strong incentive from social-cultural beliefs to provide care for their parents or parents-in-law (11). The study used a random-effect and fixed effect model for each of the health outcomes in order to run a falsification test (11). The authors showed that providing informal care has a negative effect on the caregiver and informal care increases the probability of decreasing physical health (11). Moreover, they found that the healthcare costs of the caregiver increased (11).

Lastly, Coe and Van Houtven (2005) used instrumental variables in order to avoid endogeneity problems and examined the causal effect of providing informal care on the informal caregivers' health by controlling for the death of family (selection out) and sibling characteristics (selection in) as the instrumental variables (7). They used the "Health and Retirement Survey" from the USA, which included seven waves and used the amount of medication that was used (self-reported data) as a health state indicator (7). The study used an ordinary least squares (OLS) estimation to estimate the quantity of drug consumed and the caregiving intensity (7). The authors found a significant increase of depressive complaints for both men and women. However, no effect was found between providing care and the physical health of the informal caregivers (7).

To summarize, Di Novi et al. stated that geographic location could influence the caregivers' health (20). Schmitz and Westphal (2015) found a reduction of the health state of the informal caregiver, however this effect did not hold after a longer period (5>years) (24). Heger et al. (2016) concluded that women develop more depressive symptoms than men when providing informal care (10). Coe and Van Houtven (2005) found a significant increase of depressive complaints for both men and women (7). Do et al. (2015) found that providing informal care has a negative effect on the caregiver and informal care increases the probability of decreasing physical health (11). However, most of these studies can only claim an association between providing informal care and the caregivers' health due to endogeneity or the use of small and selective samples. In the current study we use an empirical model based on the described literature to assess the impact of providing informal care on the caregivers' health.

Based on the review of the earlier empirical studies, we selected different determinants which we assume to have an impact on informal caregiving and on the caregivers' health. The assumption of the influencing determinants of the current study are illustrated in a conceptual model in Figure 1.
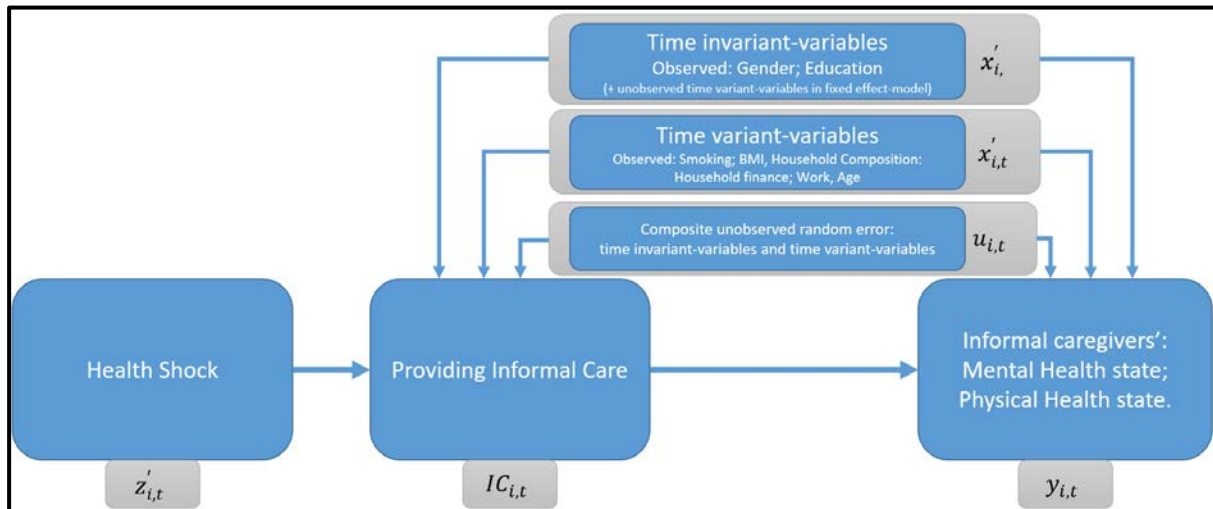
Figure 1

Figure 1. Conceptual model. Providing informal care is the independent variable (explanatory variables), mental health states; physical health states are the dependent variables (exposure variables), health shock is the instrumental variable.

The current study assumes that providing informal care has a different impact on the informal caregivers' mental health and physical health. Different questionnaires are used to obtain the specific effect on the mental or physical health.

In order to estimate unbiased association of informal care on the caregivers' health, the model controls for time variant (variable $x_{i,t}$) and time-invariant confounders (variable x_i). Because different determinants are associated with individuals selecting themselves in (reason of starting with care provision) or selecting themselves out (reason of stopping with care provision) of providing informal care, which could have an impact on the caregivers' health. The following confounders are considered: gender; education; smoking; BMI (in categories); household composition; household finance; work and age. Gender has on impact on providing care because Do et al. (2015) argue that women are more likely to provide informal care than men and gender has an impact on health (11).

The 'Economic theory', described in Do et al. (2015) assumes that the main informal caregiver is the family member with the lowest opportunity cost losses (11). People with low opportunity cost losses usually have a lower level of education on a less paid job than people with higher opportunity cost losses. This is equivalent to the determinants 'work' and 'household finance'

in the current study. People with a higher household income are more likely to outsource informal care provision to private formal caregivers (11). Besides, these determinants are expected to be associated with the caregivers' health as well (7).

Do et al. (2015) assume that people with a worse health state are less likely to provide informal care (26). A worse health state is generally associated with a worse lifestyle. Therefore, the current study includes lifestyle factors smoking and BMI in the confounding model. Another confounder is the 'social-cultural' aspect of the household composition, a spouse or a family member is more likely to provide informal care if someone in the same household needs the informal care (11). On the other hand, a single parent with children living at home is less likely to provide care for someone not in the same household. The same goes for people with a lower age: we assume that they are less likely to provide care, because people who are older mostly have older spouses, family members or friends. Also a higher age correlates with a higher risk of being unhealthy.

However, we cannot control for all determinants because of the unobserved random error which includes the unobserved time-invariant variables and unobserved time-variant variables, labelled as $u_{i,t}$ in Figure 1. Although we control for the unobserved time-invariant variables when estimating the effect within the same individual over multiple time periods. The assumption is all time-invariant variables stay the same over all time periods within the same individual. Therefore, when analysing the effect within the same individual the unobserved time-invariant variables are included in $x_{i,t}$(Figure 1). The remaining variables: the unobserved time-variant variables, are included in this model as $u_{i,t}$.

Lastly, the changes in $IC_{i,t}$ could not be random at all and possibly can be influenced by another variable. We assume that changes in $IC_{i,t}$ are associated with z (instrumental variable) and z do not have an indirect influence other than through $IC_{i,t}$ on $y_{i,t}$. We assume that changes in the health state of a spouse, friend and family member will influence whether the informal care provider starts with providing care (selecting in) or stop with providing care (selecting out). These changes are called 'health shock' and is the z variable (instrumental variable) of the conceptual model. This does not exclude that z has a direct correlation with y, but by using the instrumental variable this path is closed (Figure 1).

3. Data and empirical strategy

3.1 Data

The current study uses panel data from the "Study on Transition in Employment, Ability and Motivation" (STREAM), collected by the institution of "Toegepast-Natuurwetenschappelijk Onderzoek" (TNO) (19). The STREAM is a self-reported prospective cohort study among working individuals (n=12.055), self-employed individuals (n=1.029) and non-working individuals (n=2.034) with four waves of data over four years (from 2010 to 2013) (19). The respondents are aged between 45 to 64 years old at the start of the STREAM (19).

TNO recruited respondents in different ways: they asked participants who were already included in other national representative research carried out by TNO and they recruited people through newsletters and different banners. To create an incentive for participants to fill out an online questionnaire, the participants received around 3 euros for each completed STREAM questionnaire and the exact amount depended on the time the respondents spent filling out the questionnaires.

In 2010, in the first wave, 15118 (T1) people were participating in the STREAM study and in the following waves (2011, 2012, 2013) the same respondents who responded in the first wave were invited to participate again. In the second wave the participating rate decreased to 12430 (T2) people, in third wave to 12057 (T3) people and in the fourth wave to 11237 (T4) people due to non-response. However, not every respondent of wave four participated in all the waves. Of the 15118 included participants in the first wave, 64% (9639 people) of these respondents completed every questionnaire of all the waves, illustrated in Table 1. The STREAM did not include new participants and did not replace a participant if they did not respond.

Table 1. Participation Pattern

Participation Pattern*	Frequency (N)	Percentage (%)
1-1-1-1	9639	63.76
1-0-0-0	1337	8.84
1-1-1-0	1313	8.69
1-1-0-0	850	5.62
1-0-1-1	724	4.79
1-1-0-1	628	4.15
1-0-1-0	381	2.52
1-0-0-1	246	1.63
Total	15118	100.00

*The participation patterns is displayed with a 1 for participation and a 0 for no participation over all four waves.

3.1.1 Dependent variables

The current study examines the effect of providing informal care on the mental and physical health of the caregiver. The STREAM data contains the following health outcomes to obtain the physical and mental health of the respondent: 'self-reported health'; 'vitality'; 'longstanding diseases, conditions or handicaps'; 'depression state'; 'musculoskeletal complaints' and 'sick leave'. The perceived self-reported health is assessed with the following question: "In general, what would you say what your health is?" (19). The score of the question ranges from one to five. Where 'one' indicates the highest self-reported health and 'five' the lowest self-reported health.

Vitality reflects both mental health and physical health. The perceived vitality is assessed with the "Short Form Health Survey" (SF-12) (27). The SF-12 contains twelve questions and is the short version of the "Medical Outcome Study 36-item Short- Form Health Survey" (SF-36) (28). The SF-36 measures the following eight domains: "emotional well-being; role of limitations due to emotional problems; physical functioning; role of limitations due to physical health; energy and fatigue; social functioning; pain; general health" (28). The scores of these questions are computed together and range from zero to 100. Where 100 indicates the highest health state and zero indicates the lowest health state.

In order to measure the physical health of the respondents the participant could fill out which kind of longstanding diseases, conditions or handicaps they have. The questionnaire assessed with separate questions whether the respondents had any complaints of their hands or arms, legs or feet, back or neck (e.g. arthritis), had any cardiovascular diseases, asthma, bronchitis, emphysema, gastrointestinal disorders, diabetes, severe skin disease, hearing problems, epilepsy, life-threatening diseases (e.g. cancer, AIDS), vision problems or other diseases (19). The outcome score ranged from zero to thirteen, where 'zero' indicates no longstanding diseases, conditions or handicaps and each other point stand for having one longstanding disease, conditions or handicaps.

Also the musculoskeletal health problems were assessed with four different questions: whether the respondent had suffered (pain or discomfort) from their back, neck or shoulders, arms or hands and legs in the past 12 months. These four questions related to musculoskeletal health problems were derived from the Netherlands Working Condition Survey (NWCS) (29). The outcome score of 'zero' indicates no musculoskeletal health problems and one indicates that the respondent has or has had musculoskeletal problems in the past 12 months.

The "Centre for Epidemiologic Studies Short Depression Scale" (CES-D10) was included to assess the depression state (30, 31). Furthermore, the DISC-R version 3 was used to observe the recovery and relaxation state of the informal caregiver (32). The scores of these questions are

computed together and range from one to four. A higher score indicates more depressive symptoms in the respondent.

The dependent variable "Sick Leave and Presentism", is measured with different questions assessing the quantity of work, productivity losses and the days the person was absent because of illness. The respondent could fill in how many days, in total, he/she had been on sick leave in the past 12 months (19). The outcome score represent the days the respondent had been on sick leave during the past months. The STREAM questionnaires belonging to the above variables can be found in Appendix 1.

3.1.2 Independent variable

The main independent or exposure variable is providing informal care. The current study identifies the informal caregivers by how the respondents responds to the question: "Have you spent part of your time on providing informal care in the past twelve months?" (19). Table 2 illustrates the frequency of the respondents who provided informal care in the past twelve months of every wave.

Table 2. Descriptive of providing informal care

Year	Not providing informal care		Providing informal care		Total
	Frequency (N)	Percentage (%)	Frequency (N)	Percentage (%)	
2010	11955	79.08	3163	20.92	15118
2011	9753	78.46	2677	21.54	12430
2012	9245	76.68	2812	23.32	12057
2013	8331	74.14	2906	25.86	11237

The previous question is followed by more detailed questions in regards to providing informal care assessing the time spent on the informal care (19). This variable 'intensity of informal care'' is used for the secondary analysis. The intensity of providing of care is divided in the following three categories: 'not providing care', 'providing one to four hours of care' and 'providing more than four hours of care'. Table 3 shows information of the different categories.

Table 3. Descriptive of intensity of providing informal care

Year	Not providing care		1≤4 hours providing care		>4 hours providing care		Total
	Frequency (N)	Percentage (%)	Frequency (N)	Percentage (%)	Frequency (N)	Percentage (%)	
2010	11955	79.18	1589	10.52	1555	10.30	15099
2011	9753	78.65	1404	11.32	1243	10.02	12400
2012	9245	76.83	1484	12.33	1304	10.84	12033
2013	8331	74.30	1515	13.51	1366	12.18	11212

3.1.3 Controlling variables

In the current study, individual characteristics (e.g. demographic characteristics) and work characteristics (e.g. workload) of the participant are controlled for. Table 4 illustrates the following individual characteristics that were assessed in the STREAM data under the demographic characteristics: gender; date of birth (age); level of education and household compositions (19). The demographic characteristics gender and level of education do not change over time (time-invariant). Time-variant variables, such as household financial situation, smoking, age, household composition, body mass index (BMI), and work characteristics were assessed to complete the time-variant individual characteristics.

Table 4. Descriptive of controlling variables in wave 1 and wave 4

	Wave 1		Wave 4	
	Frequency (N)	Percentage (%)	Frequency (N)	Percentage (%)
Smoking:				
Yes	3434	22.78	2055	18.34
No, but done in the past	6795	45.08	5414	48.32
Never smoked	4845	32.14	3735	33.34
Total	15074	100.00	11204	100.00
BMI Categories:				
BMI <=18.5 – Low	74	0.50	59	0.54
BMI 18.5-25 - Normal	5151	34.52	3693	33.64
BMI 25-30 – Overweight	6565	44.00	4854	44.22
BMI >=30 – Obesity	3130	20.98	2372	21.61
Total	15118	100.00	10978	100.00
Household Composition:				
Living together without children at home	6235	41.24	5548	49.37
Living together with children at home	5200	34.40	2926	26.04
One parent Household	896	5,93	531	4.73
Single	2660	17.59	2166	19.28
Other	127	0.84	66	0.59
Total	15118	100.00	11237	100.00
Household Finance:				
Very short on money	757	5.02	597	5.33
Somewhat short on money	2424	16.09	1922	17.15
Just adequate	3902	25.90	2975	26.54
Some money left over	6431	42.68	4621	41.23
A lot of money left over	1553	10.31	1093	9.75
Total	15118	100.00	11208	100.00
Work:				
(ref) Employee	12055	79.74	7281	64.79
Self-Employed	1029	6.81	765	6.81
Not Working	2034	13.45	3191	28.40
Total	15118	100.00	11237	100.00
Gender:				
Male	8112	53.66	8112	53.66
Female	7006	46.34	7006	56.34
Total	15118	100.00	15118	100.00
Education:				
Low (primary education)	4462	29.51	4462	29.51
Middle (secondary education	5811	38.44	5811	38.44
High (higher education)	4845	32.05	4845	32.05
Total	15118	100.00	15118	100.00
Age				
	Respondents (N)	Mean	Respondents (N)	Mean
	15118	54.48	15118	57.48

The current study divided the variable smoking in the following three different categories: 'yes, 'no, but done in the past' and 'never smoked'. The BMI was divided in the following categories: 'low' (BMI ≤18.5); 'normal' (BMI 18.5-25); 'overweight' (BMI 25-30); 'obesity' (BMI ≥30). The current study divided household composition in five different values: 'living together without children living at home'; 'living together with children living at home'; 'part of a one parent household'; 'single' or 'other'. The category 'other' contains household combinations that do not fit into the other categories (e.g. living with friends). Furthermore, the household financial situation was categorized in: 'very short on money', 'somewhat short on money', 'just adequate', 'some money left over' and 'a lot of money left over'. The category work characteristics contained whether the respondent was an employee or was self-employed or was not working during the last 12 months. Lastly, education contained three categories: 'low educated' (primary school); 'middle educated' (secondary school) and 'high educated' (higher education). Table 4 also shows the average age of wave one (54 years-old) and wave four (57 years-old).

Furthermore, Table 4 shows that the body mass index (BMI) category 'Low', only has 74 representatives and does not represent even 1% of the BMI population group. Similarly to the category 'Others' of the household composition, which consist of only 127 representatives and does not even represent 1% of respondents either. There seem to be 4.44% less smokers and more people living together without children at home (8.13%). Furthermore, the category 'Employee' which represented 79.74% of the study group in the first wave, decreased over the years to 64.79% in the fourth wave. This change can be due to the non-response (selection drop) in the category 'Employee' due to the age of the respondents (close to retirement age). However, the time-variant variables BMI and household finance seem to be very stable over time and do not differ more than 1% within the categories over the four year time period despite the loss of about 4000 respondents.

Provision of informal care varied over time (not shown in the table). Women provided 65% of the total informal care (N=3163) which decreased to 59% of the total in wave four (N=2906). The provision of care among the level of education wasn't equally distributed either. The 'less' educated people provided 24% of the informal care, while 40% of the care was provided by the middle incomes and 36% provided by the high incomes. This was similar to wave four: 25% of the informal care was provided by people with low incomes, 38% by people with middle incomes and 37% where people with high incomes. The respondents who provided the highest percentage of care in wave one and four among the different household composition categories is the category 'married living together without children' which provided respectively 44% (N=3163) in wave one and 51% (N=2906) in wave four. The other categories 'married living together with children at home' provided 32% and

26%, 'one parent household' 6% and 5%, 'single' 16% and 17%, 'others' 2% and 1% of the informal care in the first and last wave respectively.

3.1.4 Instrumental variable

The current study uses health shock among family and friends as an instrumental variable, by using the change from having a healthy partner, family and/or close friends to having a partner, family and/or friends with a serious disease. The instrumental variable 'health state among spouses, friends or family' is named 'health shock' in the current study. This instrumental variable is assessed in the STREAM data by questions about previous life events of the participant and whether the participants had one or more of the following events: "the partner of the participant got a serious disease; a close family member or friend of the participant got a serious disease" (19). Table 5 shows the frequency of the participants who experienced a health shock.

Table 5. Descriptive of instrumental variable

Year	No health shock		Experienced a health shock		
	Frequency (N)	Percentage (%)	Frequency (N)	Percentage (%)	Total
2010	12174	80.62	2944	19.38	15188
2011	9974	80.24	2456	19.76	12430
2012	9862	81.79	2195	18.21	12057
2013	9206	81.93	2031	18.07	11237

3.2 Methods

3.2.1 Pooled Ordinary Least Squared

The aim of the current study is to estimate the effect of providing informal care on the caregiver's health based on the conceptual model of Figure 1. First, I analyse the association with a pooled ordinary least squared (OLS) regression. Considering the following regression model:

$$y_{i,t} = \alpha + x'_{i,t}\beta + \theta IC_{i,t} + u_{i,t} \qquad , [1]$$

where $y_{i,t}$ is the health outcome for an individual i in year t and $u_{i,t}$ is the error term. The current study includes as independent variable ($IC_{i,t}$) providing informal care and as controlling variables ($x'_{i,t}\beta$) smoking, BMI in categories, household composition, household finance, gender, age, work, education and year of the measurement. The pooled OLS takes from the time-invariant variables the same value of each year of a given individual and the value i, t of the observed time-invariant variables is equal to the value of the individual on time t. I control for the fact that same individuals are included multiple times by correcting the standard errors using Stata's cluster option.

3.2.2 Fixed effects model

I use longitudinal data, which makes it possible to account for the unobserved time-invariant heterogeneity with a fixed-effect model. The problem with the OLS model in Equation [1] is that $u_{i,t}$ can contain individual unobserved factors that might correlate with the outcome $y_{i,t}$ as well as with the decision to provide informal care and the decision to stop with providing care. For example, the personality of the respondent can be considered as an unobserved time-invariant variable because personality can influence life-style which has an effect on health. Also, people who have a caring personality might be more inclined to start providing informal care. The fixed-effect model assumes that these unobserved individual factors are constant over time. Considering the following fixed effect model:

$$y_{i,t} = \alpha + x'_{i,t}\beta + x'_i\beta + \theta IC_{i,t} + u_{i,t} \qquad , [2]$$

where a is the constant, $x'_{i,t}$ represents the observed time variant factors, x'_i is the individual specific effect (all unobserved and observed time-invariant variables) and $u_{i,t}$ represents the remaining unobserved time-variant variables as the error. The fixed-effect model uses the fact that the unobserved individual effect are constant by demeaning all variables. Therefore, the unobserved time invariant variables (x'_i) drop out in this following model:

$$y_{i,t} - \bar{y}_{i,t} = \alpha + (x_{i,t} - \bar{x}_{i,t})'\beta + (IC_{i,t} - \overline{IC}_{i,t}) + (u_{i,t} - \bar{u}_{i,t}) \qquad , [3].$$

3.2.3 Instrumental variable

Whereas a fixed-effect model accounts for time-constant differences between the informal caregiver and the non-caregiver, there might still be an endogeneity problem when the unobserved effects are not constant over time. For example, if the demand for informal care changes it will change the supply of informal care, based on the supply and demand model shown by Alfred Marshall (33). Therefore, an individual who experiences a health shock among their spouse, friends or family is more likely to provide informal care (higher demand) than an individual who does not experience a health shock among their spouse, friends or family (lower demand). This change in the health state of a spouse, friend or a family member could influence the likelihood that someone provides informal care, but might also have a direct effect on the caregivers' health. To deal with this time-varying endogeneity problem the current study uses the change in health state among spouses, friends or family as an instrumental variable in order to estimate an unbiased effect of providing informal care on the caregivers' health. In order to conduct an analysis with an instrumental variable the current study will use a 2SLS analysis. The 2SLS contains two stages and considers the following equations in the first stage:

$$\widehat{IC}'_{i,t} = \alpha + x'_{i,t}\beta + z'_{i,t}\gamma + u_{i,t} \qquad , [4].$$

In this first stage of the 2SLS the current study regressed the endogenous variables or informal care on the instrument health shock and the other independent variables. Because health shock is a partial determinant of whether people are providing informal care, there should be a significant outcome in this first stage.

In order to estimate the causal effect the second stage regress the health state $y_{i,t}$ on the predicted value $\widehat{IC}'_{i,t}$ (from the first stage) with the following regression model:

$$y_{i,t} = \alpha + x'_{i,t}\beta + \widehat{IC}'_{i,t}\delta + u_{i,t} \qquad , [5].$$

After performing this analysis, I used the Wu-Hausman test (34) to test the relevance of the instrumental variable to ensure that I included a valid instrument to the analysis. The Wu-Hausman test shows the significance of the correlation between providing informal care and the health shock by using the F-tests in a regression model. Furthermore, we examined partial R-squared statistic in order to study whether the instrument contributes to the model. The partial R-squared is the difference in the R-squared of the following two regression of the first stage: a regression model with the instrumental variable included and a regression model without the instrumental variable included.

4. Results

4.1 Pooled Ordinary Least Squares

The results of the relation between providing informal care and the health state of the informal care giver are shown in Table 6. The OLS regression shows that providing informal care has a significant negative impact on both the caregivers' physical and mental health. However, the OLS regression did not find any significant association in the self-reported health of the respondent with providing informal care.

Table 6. Pooled Ordinary Least Squared regression

Pooled Ordinary Least Squared regression	Self-reported Health	Vitality	Longstanding Diseases	Depression	Musculoskeletal Complaints	Sick Leave
	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient
Providing Informal Care						
	0.0206	-1.182***	0.135***	0.037***	0.373***	0.578***
Smoking						
	-0.099***	0.980***	-0.060***	-0.020***	-0.259***	-0.480***
BMI Categories						
(ref)[a] BMI <=18.5 – Low	-	-	-	-	-	-
BMI 18.5-25 - Normal	-0.424***	10.721***	-0.499***	-0.254***	-0.997**	-1.601
BMI 25-30 – Overweight	-0.274***	9.939***	-0.304**	-0.253***	-0.538	-1.060
BMI >=30 – Obesity	-0.116	6.155***	0.107	-0.193***	0.349	0.954
Household Composition:						
(ref)[a] Living together without children at home	-	-	-	-	-	-
Living together with children at home	-0.116***	2.225***	-0.135***	-0.046***	-0.472***	-1.417***
One parent Household	-0.058**	-0.637	-0.188***	0.083***	-0.573***	-0.171
Single	0.085***	-3.336***	0.023	0.133***	-0.050	0.220
Other	0.023	-0.082	0.121	0.015	-0.073	0.356
Household Finance						
	-0.122***	3.328***	-0.164***	-0.102***	-0.557***	-0.982***
Work						
(ref)[a] Employed	-	-	-	-	-	-
Self-Employed	-0.059**	3.119***	-0.028	-0.024**	-0.220*	-3.082***
Not Working	0.590***	-9.583***	0.755***	0.287***	2.977***	-
Gender						
	0.075***	-2.793***	0.245***	0.048***	1.87***	0.747***
Age						
	-0.0124***	0.610***	0.010***	-0.012***	-0.061***	0.004
Education						
	-0.050***	0.474***	-0.055***	-0.017***	-0.421***	-0.444***
Year						
(ref)[a] 2010	-	-	-	-	-	-
2011	-0.012*	0.531***	-0.051***	0.001	-0.103***	-0.456***
2012	-0.033***	0.354**	-0.086***	-0.001	-0.159***	-0.851***
2013	-0.046***	0.906***	-0.160***	-0.018***	-0.290***	-0.877***
constant	4.330	13.198	1.295	2.725	8.955***	10.647
R-squared	0.163	0.152	0.137	0.137	0.163	0.021

[a] reference category *Indicates significance of $p<0.1$. **Indicates significance of $p<0.05$. ***Indicates significance of $p<0.01$

Provision of care significant decreases the SF36 scale by 1.182 points on a 0-100 scale, where 'zero' indicates the lowest health state. Furthermore, providing informal care results in a significant negative effect on longstanding diseases and increases the number of longstanding diseases by 0.135, where each point stand for one longstanding disease. The OLS results in a significant negative

effect of providing informal care on the musculoskeletal complaints. Providing informal care increases the score with 0.373 points on a 0-15 scale. Where '15' indicates highest musculoskeletal complaints. The pooled OLS regression shows a significant negative effect on the mental health as well. Providing informal care significantly increases depressive symptoms with 0.037. Lastly, providing care has an association with sick leave on work. Respondents who provided informal care showed a significant increase in days of sick leave by 0.578 days.

Women overall seem to have a significant poorer health state in all the OLS regressions compared to men. However, age does have a different impact on the different dependent variables. A higher age seems to have a significant positive effect on self-reported health, SF36, depression and musculoskeletal complaints. In addition, age did not have any impact in sick leave, but a higher age did have a significant negative effect on longstanding diseases. Comparable with the dummy variable year which has a significant positive influence on the health state compared to the health state of the first wave. Furthermore, higher level of education does have a significant positive effect on all the dependent variables. Similar to the financial situation of the household, where having a better financial situation has a significant positive impact on all the dependent variables. The controlling variable smoking has a significant negative effect on all the dependent variables in the pooled regression. 'Never smoked' seems to have more positive effect on the health state than people who did smoke in the past or current smokers.

4.2 Fixed-effect model

The results of the Fixed-Effect model for providing informal care are illustrated in Table 7. The current study shows a significant negative effect of providing care only on the SF36 and the CES-D (Depression). Informal caregiving significantly increases the CES-D score by 0.015 points. Caregiving significantly decreases the SF36 score by 0.491.

Besides the informal care giving effect, the study finds that the financial situation of the respondents' household has an effect on the SF36 and the CES-D, where having a better financial situation has a significant positive impact on the SF36 and the CES-D. Furthermore, the analysis shows that not working has a significant positive effect on the SF36 and the CES-D compared to being an employee. Being self-employed shows to have a bigger positive effect on the SF36 than not working. In addition, a higher age has a significant positive effect on the SF36, but did show a significant effect on the CES-D. However the dummy variable year shows a significant mixed result compared to the reference category on the SF36, but on the CES-D the respondent' health declines significantly over time.

Table 7. Fixed-effect model

Fixed-effect model	Self-reported	Vitality	Longstanding Diseases	Depression	Musculoskeletal Complaints	Sick Leave
	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Providing Informal Care						
	-0.002	-0.491**	0.0081	0.015***	0.052	0.237
Smoking						
	0.039***	-0.301	0.023	0.015**	0.045	1.296
BMI Categories						
(ref) BMI <=18.5 – Low	-	-	-	-	-	-
BMI 18.5-25 - Normal	-0.094	2.468	0.038	-0.048	-0.010	-4.367**
BMI 25-30 – Overweight	-0.038	1.750	0.057	-0.038	0.104	-3.723**
BMI >=30 – Obesity	0.087	0.183	0.157	-0.012	0.590*	-3.061
Household Composition						
(ref) Living together without children at home	-	-	-	-	-	-
Living together with children at home	0.001	0.137	-0.030	0.004	-0.063	-0.589
One parent Household	-0.040	-0.434	-0.047	0.058***	-0.051	1.184
Single	0.003	-0.561	-0.028	0.082***	-0.077	1.266*
Other	-0.047	0.484	-0.031	0.028	0.121	1.511
Household Finance						
	-0.027***	1.144***	-0.018**	-0.040***	-0.078***	-0.452***
Work						
(ref) Employed	-	-	-	-	-	-
Self-Employed	-0.049*	3.689***	0.026	-0.054***	-0.148	-1.289*
Not Working	-0.009	2.069***	-0.002	-0.006	0.147**	
Age						
	0.009***	0.196***	0.004	0.002	0.009	0.065
Year						
(ref) 2010	-	-	-	-	-	-
2011	-0.003	0.291**	-0.003	0.007*	-0.034	-0.034
2012	-0.006	-0.246**	0.023**	0.009***	0.016	-0.138
2013	(omitted)	(omitted)	(omitted)	(omitted)	(omitted)	(omitted)
constant	2.390	49.000	0.942	1.557	4.345	3.706
Overall R-squared	0.028	0.040	0.044	0.080	0.053	0.005

[a] reference category *Indicates significance of $p<0.1$. **Indicates significance of $p<0.05$. ***Indicates significance of $p<0.01$

4.3 Two Stages Least Squares regression

Table 8 illustrates the results of the pooled OLS regression and the first stage of the 2SLS, and Table 9 illustrates the second stage of the 2SLS analysis.

4.3.1 Relevance of the instrument

Before starting the 2SLS analysis with the instrumental variable health shock, the current study provided a pooled OLS analysis in order to analyse the correlation between the endogenous variable and the instrumental variable. In the Table 8 the pooled OLS regression is illustrated. This analysis shows that health shock had a significant negative effect on all the depended variables. The results of the endogeneity test are illustrated in Table 8. All the first stage regressions show a strongly significant coefficient of health shock on providing of care. The Wu-Hausman analysis shows in the first stage: F= 56.551 for self-reported health; F= 93.005 for the SF36; F= 116.413 for the longstanding diseases; F= 96.189 for depression; F= 102.25 for musculoskeletal complaints and F= 8.885 for sick leave. This results were all statistically significant and were correct in treating providing

informal care as endogenous variable. Furthermore, including the instrumental variable in the model increased the R-squared values by about 0.035 (partial R-square in Table 8) for all the first stage regressions. Without the instrument the model had an R-squared of 0.038 and after including the instrument the model increased to 0.073.

Table 8. First stage of the two stages least squares analysis

	Self-reported Health	Vitality	Longstanding Diseases	Depression	Musculoskeletal complaints	Sick Leave
Pooled OLS regression						
Coefficient	.089***	-2.557***	.226***	.070***	.736***	.717***
R-squared	0.164	0.154	0.139	0.167	0.165	0.021
First stage 2SLS						
Coefficient	0.199***	0.199***	0.199***	0.199***	0.199***	0.202***
Partial R-squared	0.035	0.035	0.035	0.035	0.035	0.036
Robust F	$F_{(1,15065)}=$ 1023.73	$F_{(1,15066)}=$ 1025.01	$F_{(1,15067)}=$ 1024.56	$F_{(1,15065)}=$ 1024.49	$F_{(1,14995)}=$ 997.173	$F_{(1,13336)}=$ 848.217
Wu-Hausman test	$F_{(1,15065)}=$ 56.551***	$F_{(1,15066)}=$ 93.005***	$F_{(1,15067)}=$ 116.413***	$F_{(1,15065)}=$ 96.189***	$F_{(1,14995)}=$ 102.25***	$F_{(1,13336)}=$ 8.885***

*Indicates significance of $p<0.1$. **Indicates significance of $p<0.05$. ***Indicates significance of $p<0.01$

4.3.2 Second Stage 2SLS

In the second stage, the 2SLS shows statistical significant effects on all the depended variables. The coefficient of the independent variable seems to be higher than the coefficients in the pooled OLS regression or the fixed-effect model. The analysis shows a causal relationship between providing informal care and the self-reported health of the participant. Providing care showed a significant increase of 0.446 on a scale of one to five, where five indicates the worst health state. Provision of care decreased the SF36 scale by 12.843 points on a 0-100 scale, where zero indicates the lowest health state. Furthermore, providing informal care results in a significant negative effect on longstanding diseases and increases the number of longstanding diseases by 1.134, where the score 'one' stand for having one longstanding disease. The respondents who provided care show a significant increase of depressive symptoms by 0.35. On the musculoskeletal complaints the 2SLS finds a significant result and a negative effect of providing informal care on the musculoskeletal complaints. Providing informal care increases the score with 3.702 points on a 0-15 scale. Where 15 indicates highest musculoskeletal complaints. The 2SLS regression finds a significant negative effect of providing of care on sick leave and showed an increase in sick leave of work by 3.547 days.

Women seem to have a significant poorer health state in all the OLS regressions compared to men. This results were found in the SF36, longstanding diseases and musculoskeletal complaints. Furthermore, age seems to have a significant positive impact on all the dependent variables, but the coefficients are small compared to the independent variable 'providing informal care'. Comparable with the dummy variable year which has a significant positive influence on the health state compared

to the health state of the first wave. Furthermore, a higher level of education does have a significant positive effect on all the dependent variables. Similarly to the financial situation of the household, where having a better financial situation has a significant positive impact on all the dependent variables. The controlling variable smoking has a significant effect on all the dependent variables in the pooled regression. Never smoked seems to have more positive effect on the health state than people who did smoke in the past or compared to the current smokers.

Table 9. Second stage of the two stages least squares analysis

Second stage 2SLS	Self-reported Health	Vitality	Longstanding Diseases	Depression	Musculoskeletal complaints	Sick Leave
	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Providing Informal Care						
	0.446***	-12.843***	1.134***	0.349***	3.702***	3.547***
Smoking						
	-0.101***	1.012***	-0.063***	-0.021***	-0.266***	-0.475***
BMI Categories						
(ref) BMI <=18.5 – Low	-	-	-	-	-	-
BMI 18.5-25 - Normal	-0.398***	10.002***	-0.437***	-0.235***	-0.802*	-1.374
BMI 25-30 – Overweight	-0.251***	9.344***	-0.253*	-0.237***	-0.381	-0.850
BMI >=30 – Obesity	0.031	5.567***	0.157	-0.177***	0.507	1.141
Household Composition						
(ref) Living together without children at home	-	-	-	-	-	-
Living together with children at home	-0.113***	2.144***	-0.128***	-0.044***	-0.446***	-1.392***
One parent Household	-0.035	-1.262**	-0.135***	0.099***	-0.401**	0.001
Single	0.104***	-3.3844***	0.067**	0.145***	0.091	0.351
Other	-0.020	1.080	0.021	-0.016	-0.407	0.125
Household Finance						
	-0.120***	3.274***	-0.159***	-0.101***	-0.541***	-0.970***
Work						
(ref) Employed	-	-	-	-	-	-
Self-Employed	-0.066***	3.321***	-0.045	-0.029***	-0.277**	-3.134***
Not Working	0.586***	-9.468***	0.745***	0.284***	2.941***	
Gender						
	0.008	-0.941***	0.086***	-0.001	1.337***	0.257
Age						
	-0.012***	0.611***	0.010***	-0.012***	-0.061***	0.004
Education						
	-0.065***	0.889***	-0.091***	-0.028***	-0.540***	-0.550***
Year						
(ref) 2010	-	-	-	-	-	-
2011	-0.013*	0.584***	-0.055***	-0.001	-0.114***	-0.477***
2012	-0.042***	0.608***	-0.108***	-0.007	-0.227***	-0.924***
2013	-0.065***	1.433***	-0.205***	-0.031***	-0.434***	-1.022***
_cons	4.339	12.933	1.317	2.733	9.017	10.704
R-squared	0.129	0.0929	0.052	0.104	0.091	0.014

[a] reference category *Indicates significance of $p<0.1$. **Indicates significance of $p<0.05$. ***Indicates significance of $p<0.01$

4.4 Analysis on intensity of informal care

To estimate the impact of intensity of informal care on the health state of the caregiver I provided a pooled regression and a fixed-effect model, as illustrated in Table 10. I exchanged the dependent variable 'providing informal care' for 'intensity of informal care' in the same regression models as in the main analysis. The intensity of providing of care is divided in the following three categories: 'not providing care', 'providing one to four hours of care' and 'providing more than four hours of care'.

4.4.1 Pooled OLS regression of intensity

The pooled OLS shows that providing informal care with a higher intensity (>4 hours) has significant negative effect on the self-reported health compared to non-caregivers of the respondent. Providing care with a higher intensity has a significant negative effect on the SF36 compared to not providing care as well. Furthermore, on the physical health the pooled OLS regression shows that providing informal care with a higher intensity has a significant negative impact on longstanding diseases and increases the number of longstanding diseases by 0.189 and lower intensity (1≤4 hours) with 0.086. In addition, the intensity of informal care for both low and high shows to have a significant negative effect on musculoskeletal complaints as well compared to not providing care. The results of the OLS regression show that providing care have an impact on the mental health as well and show to have a significant negative effect on the CES-D. However this effect did not show with providing of care on a low intensity compared to not providing care. Lastly, providing care with a high intensity shows to have a significant effect on sick leave with 1.221 days, where providing care with a low intensity did not show to have a significant effect on sick leave.

Table 10. Results of intensity of informal care

Intensity of providing care	Self-reported Health	Vitality	Longstanding Diseases	Depression	Musculoskeletal complaints	Sick Leave
	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Pooled OLS regression						
(ref) not providing care	-	-	-	-	-	-
1≤4 hours providing care	-0.016	-0.555*	0.086***	0.010	0.270***	0.087
>4 hours providing care	0.051***	-1.911***	0.189***	0.068***	0.478***	1.221***
R-squared	0.163	0.152	0.136	0.166	0.163	0.021
Fixed Effect Model						
(ref) not providing care						
1≤4 hours providing care	-0.007	-0.164	-0.002	0.003	0.069	-0.085
>4 hours providing care	0.005	-0.963***	0.021	0.0316***	-0.019	0.827***
R-squared	0.007	0.033	0.025	0.085	0.054	0.009

*Indicates significance of p<0.1. **Indicates significance of p<0.05. ***Indicates significance of p<0.01

4.4.2 Fixed-effect model of intensity

The analysis showed a significant negative effects for more than four hours of informal care on the SF36, depression and sick leave. However, the fixed-effect model does not show a significant effect on the self-reported health and on the physical health (longstanding diseases and musculoskeletal complaints).

5. Discussion and conclusion

The demand for care is increasing because of an ageing population (1). Due to this aging population, the collective finances required for long-term care (LTC) in Europe might increase from 2% to 4% of the GDP by 2060, which was shown by the "European Commission" (4). To prevent this, many countries are willing to reform their current collectively financed LTC system by shifting from formal care to informal care (5). However, policy makers need to consider the different consequences of providing informal care on the informal caregivers' health before reforming the financial LTC system from formal care to informal care.

The current study makes a contribution to creating a better understanding of the consequences of providing informal care on the informal care providers' health by using panel data (n=15118) over four waves of respondents living in the Netherlands. The focus is on the impact of providing informal care on both mental and physical health by using multiple outcome measures to represent the mental and physical health. The use of panel data allows to correct, at least partially, for endogeneity bias.

Overall, the results of the current study show that providing informal care impacts the providers' health. In particular, the results of the pooled ordinary least squared analysis (OLS) regression, fixed effect model and the Two-Stage Least Squares (2SLS) show that providing informal care significantly increases depressive symptoms of the informal care giver. These results can be confirmed by Coe and Van Houtven (2005), who found a significant increase of depressive complaints for both men and women (7). Similar to Schmitz and Westphal (2015), who found that providing more than two hours a week of informal care results in a temporary reduction of the informal caregivers' mental health (24). However, Schmitz and Westphal (2015) concluded that providing informal care has a complex impact on the mental health state of the informal care provider (24). The authors assume that the impact of informal care provision is underestimated, because providing informal care could be also psychological rewarding (24). This positive effect on the mental health fades away due to the worse impact of providing informal care on the mental health.

The current study shows a significant effect of informal care on the physical health in the pooled OLS regression and the 2SLS. The results show a robust relation between providing informal care and physical health, number of longstanding diseases and musculoskeletal complaints. Do et al. (2015), showed an association between providing informal care and the physical health of informal care provider. However there were issues with endogeneity and a small sample (11). In the current study, the fixed-effect model does not show any significant effect on the physical health when controlling for the unobserved time-invariant.

The analysis on the effect of intensity of informal care on the caregivers' health found an association with both the physical and mental health of the respondent. Participants who provided informal care with a higher intensity had a decreased health state compared to non-caregivers. These findings were similar to the findings of Pinquart and Sörensen (2003) who found that the depressive symptoms increases of the caregivers with the informal caregiving hours (35). Moreover, the fixed-effect analysis of the current study shows that the individual effect of informal care only negatively affects the vitality, depressive symptoms and the sick leave of work. However, the fixed-effect model in the current study did not show any significant effect on the physical health when controlling for the unobserved time-invariant variables.

A limitation of the current study is the assumption that the instrumental variable 'health shock' is exogenous and the changes in 'providing informal care' are associated with 'health shock' and do not have an indirect influence other than through 'providing informal care' on the health state of the respondent. Even though Heger et al. (2016) argue that the impact of declining mental health could be associated with a change in health of a spouse, family member or friend (10). However, the relevance test of the pooled OLS regression showed a statistical significant negative effect of health shock on both the physical and mental health, the F-statistics showed to be significant and when including the instrumental variable in the model the R-squared increased. Unfortunately, the study could not deal with heterogeneity of the informal care tasks because the specific task was not registered in the STREAM database. The informal care task could be an important variable which could influence the health state of the respondent. For example, helping someone with the groceries is very different than taking care of someone with severe dementia. However, the current study used the hours spent on informal care to represent the intensity of informal care providing. The pooled OLS regression showed that people who provide informal care with a higher intensity have a decreased physical health and mental health state.

Despite the limitations, results of the current study suggest that providing informal care has an effect on both the mental and physical health of the informal caregivers' health. Several tests showed the instrumental variable health shock among spouses, family and friends as a robust instrument to indicate this effect. In addition, the negative outcome on the health state of the informal care provider increases if the informal caregiver provides more than four hours care per week. Furthermore, the analysis shows an effect on the informal caregivers' mental health and vitality within each individual.

Given the empirical results, the current study has a policy implication on the consideration of reforming the collectively finances LTC system from formal care to informal care and motivating a

growth in responsibility of citizens in regard to helping others and self-management. This study lacks a cost-benefit analysis, thus, based on these results, any assumption on the provision of informal care cannot be made. Earlier, Schmitz and Westphal (2015) showed that informal care leads to higher expenditures for healthcare services and drugs (24). Moreover, Do et al. (2015) found that the healthcare costs of the caregiver increased due to the provision of informal care (11). However, it is unknown if these costs outweigh the saved formal care costs. Future research should include a cost-benefit analysis and show the actual care usage of the respondent by using the individuals' insurance claims in the analysis in order to review if informal care leads to higher expenditures. Ultimately, it is important to make certain that the people who provide informal care are not going to be the future patients themselves because of the burden of giving informal care.

6. References

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Appendices:

Appendix 1.

Type variable		Specification
Explanatory variable	1. Providing Informal Care 2. Intensity of Providing Care	*1.* *AA03 Have you spent part of your time on one of the following activities in the past 12 months?* *2* *AA05. How many hours per week have you spent on volunteer aid in the past 12 months?*
Controlling variable	1. Demographic characteristics 2. Financial situation 3. Life style and BMI (SCALE)	*1.* *(Sex; Ethnicity; Date of birth; Level of education; Household compositions)* *2.* *I07 Do you contribute most to the household income?* *I08 What is the financial situation of your household now?* *I09 What is the financial situation of your company now?* *3.* *H34 What is your height?* *H35 What is your weight?* *+ Date of birth* *H36 Do you smoke?*
Instrumental variable	Health Shock	*H49 Please indicate whether one or more of the following events happened to you in the past 12 months? (Partner got a serious disease, Close family member or friend got a serious disease)*
Dependent variable	1. Health of the potential care giver 2. Vitality (+AH11) (SCALE) 3. Longstanding Diseases 4. Depression (SCALE) 5. Musculoskeletal complaints (SCALE) 6. Sick leave and presentism (SCALE)	*1* *AH01 In general, would you say your health is…* *2* *AH02 Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf* *AH03 Climbing several flights of stairs* *AH04 Accomplished less than you would like* *AH05 Were limited in the kind of work or other activities* *AH06 Accomplished less than you would like* *AH07 Didn't do work or other activities as carefully as usual* *AH08 has your physical health or emotional problems interfered with your normal social activities with family, friends, neighbours, or groups?* *AH09 how much did pain interfere with your normal work (including both work outside the home and housework)?* *AH10 have you felt calm and peaceful?* *AH11did you have a lot of energy?* *AH12 have you felt downhearted and blue?* *AH13. How much of the time during the **past 4 weeks*** *AH14. Did you feel worn out?* *AH15. did you feel tired?3* *3* *H26 Do you have one or more of the following longstanding diseases, conditions, or handicaps, and if yes, please indicate which one? (several answers possible)* *H27 Does your disease, condition, or handicap limit your performance at work?* *4* *AH16. Below is a list of the ways you might have felt or behaved. Please indicate how often you have felt this way during the past week.* *H17. I had trouble keeping my mind on what I was doing* *H18. I felt depressed* *H19. I felt that everything I did was an effort* *H20. I felt hopeful about the future* *H21. I felt fearful* *H22. my sleep was restless* *H23. I was happy* *H24. I felt lonely* *H25. I could not get going* *5* *H28 In the past 12 months, have you suffered (pain, discomfort) from your: Back* *H29 In the past 12 months, have you suffered (pain, discomfort) from your: neck/shoulders*

		H30 In the past 12 months, have you suffered (pain, discomfort) from your: Arms/hands *H31 In the past 12 months, have you suffered (pain, discomfort) from your: Legs* *6* *E23 Sick leave refers to working fewer hours or days than normal due to illness, an accident, or other health conditions.* *E24 How often have you been on sick leave in the past 12 months* *E25 About how many days, in total, have you been on sick leave in the past 12 months?* *E25A About how many days, in total, have you been on sick leave in the past 4 weeks?* *E25B During your work in the past 4 weeks, were you hindered by physical or mental problems?* *E25C How many working days were you hindered by physical or mental problems in the past 4 weeks?* *E25D On the days you were hindered by physical or mental problems you probably could not finish the same quantity of work you usually do. How much work could you handle?*