Economics Bulletin

Volume 36, Issue 1

Effects of mental illness on the labor supply of family members: analysis of Japanese anonymized data

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Abstract

The main aim of this study is to examine the causal effect of mental illness on the labor supply of family members. Our main purpose is to determine how family members address the burden and hardships that mental illness imposes on the patient and family. We analyze a unique Japanese anonymized data set collected from individual households. We find that, after matching, there is no significant difference in the means of the weekly work hours of family members between the treated and the untreated groups. In contrast to the US and the UK, in Japanese households we do not observe significant labor market effects of mental illness on family members. Our results might have been caused by different social situations and cultural norms across countries.

The author would like to thank the Japan Society for the Promotion of Science (JSPS), which supports this research through scientific research grant 231145. The author would also like to thank the Ministry of Health, Labour and Welfare (MHLW) for providing the anonymized data set under Article 36 of the Statistics Act of Japan. The statistics obtained in this study are produced and processed independently by the author, and these results are different from those produced and published by the MHLW.
Citation: Bing Niu, (2016) "Effects of mental illness on the labor supply of family members: analysis of Japanese anonymized data", *Economics Bulletin*, Volume 36, Issue 1, pages 35-51
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Submitted: October 05, 2015. **Published:** February 04, 2016.

1. Introduction

The WHO's Mental Health Atlas reported in 2011 that one in four individuals would develop some type of mental illness (MI) at some point in their lives. As with other OECD countries, Japan also has a high prevalence of MI. The number of patients has dramatically increased to 3.2 million and it continues to rise. In fact, the number of certified workers' compensation cases due to MI reached its highest recorded value in 2014.

The cost of illness to labor market outcomes has been extensively studied across many countries. However, we know little about its "hidden costs" for family members of the afflicted. Because the family usually becomes the major provider of support and care to the mental patient (MP), our main focus in this study is on the effects of the presence of MI on family labor decisions. We are interested not only in the actual or potential caregivers, but in all individuals in the family so that we can observe which choices are made regarding "work" or "care" when MI patients are present in the family. In this study, we present new findings from our analyses of a unique Japanese anonymized data set collected from individual households.

Most previous studies have focused on the behavior of the afflicted, but few have examined the effects of MI on the families of MPs. Roberts (1999) found in US households that work hours were significantly reduced for family members when the MP was afflicted with an additional illness. Wilcox-Gok and McNamee (2010) found that older MPs were associated with a decreased labor supply among young family members, especially men, in British households.[1]

In examining the associations between MI and labor market outcomes, causality issues have arisen in many studies. The causal connection between the two factors is complex (Frank and McGuire, 2000). While some previous studies[2] have documented the negative effects of MI on employment, earnings, and labor force participation, others[3] have found inverse effects of these labor market outcomes. To address causality issues, some studies have used instrumental variables or propensity score matching (PSM) technique to control for the endogeneity of MI.[4]

Hence, it is also necessary to control for the endogeneity problem when examining

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[1] Not limited to MI, there have been studies that examined the effects of health status or care of the elderly on the labor supply of family members (Berger and Fleisher, 1984; Bittman, Hill and Thomson, 2007; Ettner, 1995a; Ettner, 1995b; Salkever, 1982; Wolf and Soldo, 1994).

[2] Bartel and Taubman, 1986; Ettner, Frank and Kessler, 1997; Lu et al., 2009; Nelson and Kim, 2011.

[3] Antonio, 2004; Clark, Georgellis and Sanfrey, 2001; Hamilton, Merrigan and Dufresne, 1997; Theodossiou, 1998; Wildman and Jones, 2002.

[4] Ettner, Frank and Kessler (1997) used information about the family history of MI and the timing of the onset of symptoms of the illness as instrumental variables for MI. Lu et al. (2009) relied on instruments that measured the average mental health status by ZIP code, rather than the observed individual. Nelson and Kim (2011) used propensity score matching techniques to construct similar comparison groups in multivariate Cox regressions.

the impact of MI on the family member labor supply. On the one hand, unobservable household traits might affect both MI and decisions about family labor at the same time. On the other hand, the presence and severity of MI could also be affected by work situations such as unemployment or the working of overtime by other family members.

In contrast to other previous studies in this field, in which the endogeneity problem of MI has not been controlled in the estimation processes, we replicated the setting of a randomized experiment by assigning a MP to a household. By applying PSM, we generated a comparison group for the treated group and then calculated the ATT[5], which measures the impact of the MP on family labor supply.

2. Theoretical background

We apply Becker's (1976) theory of the allocation of time to analyze the behavior of family members faced with MI. When one of the family members becomes unable to work because of MI, two countervailing effects occur that impact the work hours of the others: the *income effect* versus the *care effect*.

Because these theoretical effects work against each other, the sign of the total effect of MI on the work hours of other family members is uncertain, and is left as an empirical question. We further attempt to distinguish between these two effects based on the relationship of the MP with other family members (i.e., "who becomes sick" in the family). When a certain person becomes sick, family members make decisions about the optimal allocation of time between "labor" and "care." Because the ratio of the relative price of consuming time-intensive versus goods-intensive commodities changes as earnings change, different members make different choices depending on their *productivity* in the family, which is predicted by the relative wage rate, shifting consumption away from commodities with higher prices.

We summarize our hypotheses of the effect of MI on work hours in Table 1. When the main income earner becomes sick, the work hours of the second earner with a higher relative wage will increase because the time spent on time-intensive commodities will decrease due to the higher relative price of consuming them, while the third earner would increase consumption of time-intensive commodities instead and thus decrease work hours. Among family members, MI effects on earners with higher relative wages would capture the *income effect*, whereas the effects on earners with lower wages would capture the *care effect*. The cases in which the second or third earner becomes sick could be considered in the same manner.

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[5] *Average treatment effect on the treated (ATT)* = $E(Y_1 - Y_0 | D=1) = E(Y_1 | D=1) - E(Y_0 | D=1)$.

3. Data and variables

We have access to a unique data set, an anonymized data set constructed from the 2004 Comprehensive Survey of Living Conditions (CSLC).[6] These data are subject to censoring such as re-sampling and top coding for privacy protection.[7] They consist of household and health data sheets for 99,299 individuals from 36,568 households.

The descriptive statistics of the main variables and the results of the t-test for households with and without MI appear in Table 2.[8] Based on the results, we observed significant differences in the means for most of the variables between these two groups.

4. Measurement and treatment

Our main focus is on the labor supply of family members of MPs. We examine the impact of MI on the weekly work hours of those who have already participated in the labor market.

There are various definitions of "MI" in different surveys across countries. In our data, it is difficult to infer the severity of MI based on a scale because psychology-related items are inaccessible in the data set due to privacy considerations. Instead, we use the criterion of "patients who are diagnosed with MI and are currently visiting hospitals for treatment because of the illness" to identify the presence of MI in the household.[9]

The treatment status is then defined as "there is family member with MI in the household." We further identify "who became sick" in the family, among the "head of household," "spouse," or "child." We compare whether the effects of the MI differ across these relationship groups.

5. Evaluation framework

Our estimation strategy is to replicate the setting of a randomized experiment by assigning a MP to a household as a treatment status. The main task is to correct for selection bias and to obtain an estimate of ATT, measuring the impact of the treatment on the family members whose households are affected. For this purpose, we apply PSM along the following steps: (1) we choose a list of covariates that affect both the treatment and labor outcome (working hours); however, there should be no inverse

[6] This data set became available in 2011, and its access is strictly limited to research purposes. The newest data set is a one-year cross-sectional data set for 2004. Our proposal for using CSLS in this research was approved by the Ministry of Health, Labour and Welfare (MHLW) of Japan under Article 36 of the Statistics Act of Japan, with permission number 11002. The statistics obtained were produced and processed independently in this study, and these results were different from those produced and published by the MHLW.

[7] It is constructed from 2004 CSLC and is provided in accordance with the Article 36 of the Statistics Act of Japan.

[8] The statistics obtained were produced and processed independently in this study, and these results are different from those produced and published by the MHLW.

[9] Our definition might underestimate the true number of mental patients. Further discussion on this follows.

causality. By controlling for these covariates, our estimated propensity scores satisfy the balancing property;[10] (2) the chosen covariate set must satisfy the overlap condition, which ensures that there is sufficient overlap in the characteristics of the treatment and control units to find adequate matches. Our estimated scores also satisfy the common support condition.[11]

To match each treated unit with the control unit to generate an "untreated group" for comparison, we attempt to use several algorithms to perform matching using their propensity scores, as shown in Table 3.[12] The purpose of applying different matching algorithms is to evaluate the robustness of the obtained estimates.

We assess the quality of matching by two tests. First, we assess the balance between the groups before and after matching. We perform t-tests for the equality of the means for each matching algorithm. In Table 3, we can observe clear evidence of covariate imbalance between the treated and control groups before matching.[13] After matching, most of the differences are no longer significant, suggesting that matching helps to reduce the bias associated with the observable characteristics. Because differences in mean for the relationship-type dummy variable remain significant, even after matching by nearest neighbor and caliper, we adjust for these covariates in the propensity score model specification.

Second, we assess the common support conditions before and after matching. We plot the distributions of the scores for treated and control/untreated groups to determine whether the matching renders their distributions more similar. As shown in Figure 1, the densities of the scores are more similar after matching. These plots reveal a clear overlap of the distributions between the treated and untreated groups.

6. Estimation results

The average treatment effect (ATE) before matching and ATT after matching with different matching algorithms are shown in Table 4.[14] The ATEs across relationship groups are significant, but after matching, only the ATTs of the normal kernel matching appear to be consistent with the ATEs in magnitude, sign, and significance. However, the significances decrease in the three other algorithms and the effects become much smaller. We also compare ATTs across subgroups in Table 5 and summarize the details

[10] The balancing property condition and the common support condition are both tested by the STATA computer program.
[11] The estimation results of PS from the logistic regression of each treatment status and the distribution of the estimated PSs by block and treatment status are summarized in the supplemental materials, Table S-1 and S-2. "Block" is a division that ensures that the mean of the PSs within it are the same between the treated and control units.
[12] We use "control group/units" to identify those individuals without treatment before matching and "Untreated group/units" for individuals in the control group chosen by the matching, using the propensity score.
[13] The treatment status for Table 3 is "MP is arbitrary family member in the household."
[14] *Average treatment effect (ATE)* $=E(Y_1-Y_0)=E(Y_1)-E(Y_0)$, which is the mean difference between the potential outcome in case of treatment and the potential outcome in the absence of treatment.

for each case in Table 6.

From the estimates, we find the following results. First, in cases in which the head of the household is the patient, family members' work hours will increase due to the total effect of the MI. However, we need to examine each separate effect and its impact. Since children work more than spouses do (by more than 12 hours weekly), we consider children to be the second income earners and spouses the third. Empirical results show that the children's work hours increase but the spouses' hours decrease. These results are consistent with the theory that MI will increase the work hours of the second earner due to the income effect, while those of the third will decrease due to the care effect. In this case, children work more to "substitute" for the head of household, while spouses work less to care for the patient, but family members work hours will increase as a whole due to a stronger income effect.

Second, in the case of children, the head of the household's work hours increase, but those of the spouse decrease. The total effect of MI negatively impacts family members due to a stronger care effect. When the child is mentally ill, mothers may spend more time caring for the child instead of working. The empirical results of the separate effect are partially consistent with our theoretical prediction.

Third, in the case of spouses, the work hours of both the heads of households and children increase, pushing the MI total effect upward. The ill spouse might not be able to receive sufficient care from other family members. The results in this case are also partially consistent with our prediction.

Although the signs of the effects are almost consistent with the theory, the significance does not perform well in most of the proper algorithms. Therefore, we do not observe robust evidence of the ATT of MI on work hours, even across relationship groups.

7. Discussion

7.1. Comparisons with previous studies

Our theoretical background is based on the time allocation model of labor supply, similar to previous studies such as those of Roberts (1999) and Wilcox-Gok and McNamee (2010). However, we observe different results from these. In contrast to the US and the UK, in Japanese households we do not observe significant labor market effects of MI on family members. This difference may occur for several reasons: (1) the data are different, although we employ similar variables that could be compared for both MI and work hours; (2) the estimation methods are different, and previous studies do not control for the endogeneity problem of MI; and (3) the social situation and cultural

norms across countries; we will discuss these factors in greater detail in sections 7.2. and 7.3.

Nevertheless, our findings are consistent with other studies, such as that of Wolf and Soldo (1994), who examine the effects of general illness. They find that the presence of potential care receivers, such as elderly parents, does not significantly affect the working hours of married women or the probability of their labor force participation.

7.2. Female labor force participation rates in Japan

Many previous studies place a special focus on women because they are more likely to become the caregivers and provide informal care for family members once they become patients. Therefore, we would expect a significant reduction in female work hours. However, in Japan, the female labor force participation rate is generally low; therefore, women are predominately the caregivers since they are not working. Thus, in the Japan, we would not expect as much impact on the family labor supply.

Based on our data, we find the following results for Japanese households.[15] (1) The female labor force participation rates are much lower than those of men in all age groups are. The female group shares M-shaped participation rates, as there is a tendency for women to quit their jobs and become housewives once they marry or have children. (2) The proportion of housewives is high. Because housewives are the potential MP caregivers, this higher proportion might explain why we have found an insignificant impact on the family labor supply. (3) Compared with full-time workers, the proportion of part-time workers continues to rise among workers in their 20s to 60s. Because part-time workers are able to adjust working schedules more freely, their numbers of work hours might not be affected as much in total.

Hence, the fact that there are lower female labor force participation rates and a growing part-time worker proportion might help explain why we found an insignificant impact on family member work hours.

7.3. Stigma associated with MI in Japan

Because the data are survey data, the self-reporting of MI could be affected by bias (the perceived stigma of MI). If the stigma associated with mental illness is greater in Japan than other places, we should consider that the answers from Japanese respondents might reflect a response bias.

We have reviewed several studies[16] of stigma associated with MI, and we find that stigmatizing attitudes in Japan are stronger than in other places such as Taiwan or

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15 Refer to Figure S-1 in the supplemental materials for detailed estimates of labor force participation rates for men and women in this data set.

16 Desapriya and Nobutada , 2002; Griffiths et al., 2006; Ando et al., 2013; Furnham and Murao, 2000.

Australia. The stronger stigma in Japan could be the cause of the lower rates of visiting doctors among the respondents, and thus might reflect response bias in the survey data.

7.4. Limitations

Our study might suffer from several limitations, the first of which is the measurement of mental health. We used "diagnosed mental patients who visit hospitals for treatment" to confirm the presence of MI. This measurement might understate the true number of people suffering from MI because, due to self-reporting, patients might misrepresent themselves, and this underestimation could be from the perceived stigma, as already discussed. On the other hand, if hospital-treated patients improve, the burden on other family members might decrease. Thus, the impacts of MI on work hours might be smaller. It is important to improve the measurements based on an objective context that enables us to observe the type and severity of MI.

The second limitation is the data availability. Although we did not observe significant negative impacts of MI on the labor supply of family members, we expected that MI caused a burden on the family, for example, on time for leisure, time for care, and the well-being and physical and mental health of caregivers. Moreover, these family burdens would be directly related to the quantity and quality of care provided to the patients. Richer and more elaborate data sources would enable us to examine these impacts in greater detail.

8. Conclusion

In this study, we examined the causal effects of MI on the labor supply of family members. The main purpose of this study was to determine how family members addressed the burden and hardship that MI imposed on the patient and family.

Despite the results showing that the work hours of family members were not negatively impacted by the presence of a mentally ill family member, there are undoubtedly burdens placed on the family such as time for leisure, time for family care versus market care, the quality of care, well-being, and physical and mental health of family members. Richer data sources that provide such information would enable us to observe the impact of MI on family from other aspects in greater detail in the future.

Although clarifying the effects of MI on family members is the most important issue for future policy recommendations on improving the care and support of patients and their families, there has not been much empirical evidence accumulated in this field. We are the first to access this new anonymized data set to conduct such a study and disseminate our findings.

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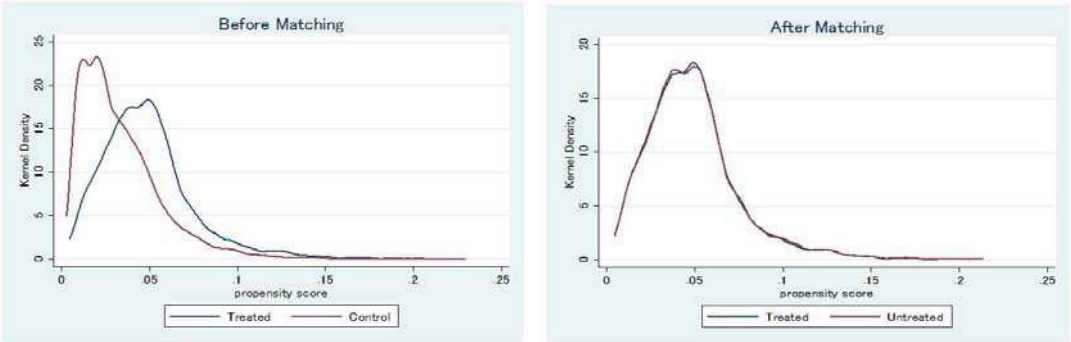
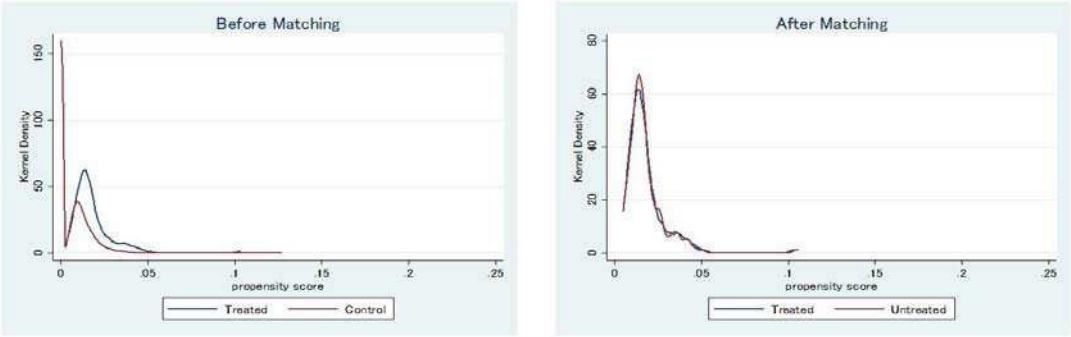
Figure 1: Assessment of common support conditions: propensity score distributions

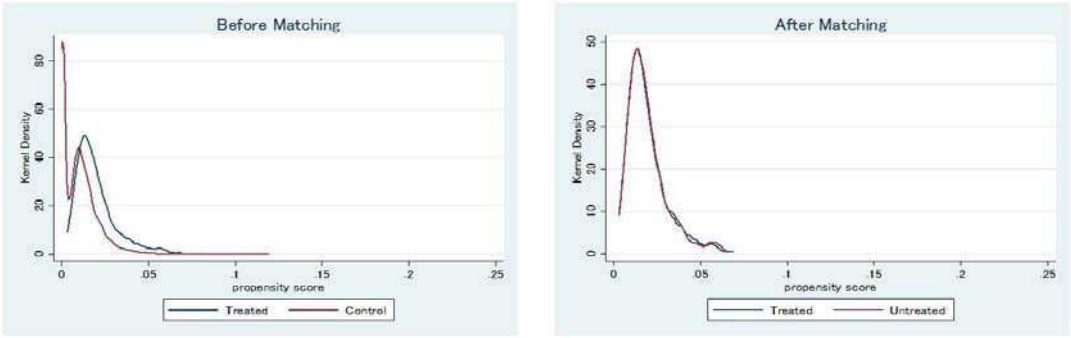
(1) Treatment status: MP is an arbitrary family member in the household



(2) Treatment status: MP is head of the household



(3) Treatment status: MP is spouse



(4) Treatment status: MP is child

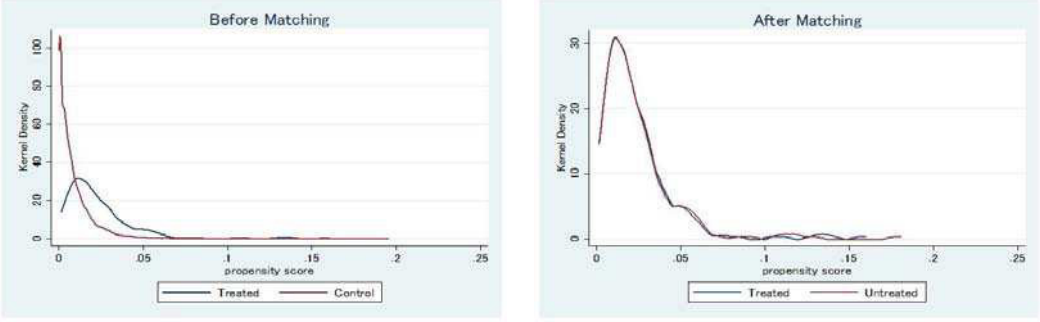


Table 1: MI's effects on the work hours of family members regarding "*who becomes sick*" in the family

MP	**Family member**	**Relative wage compared with other working family members**	**Substitution between working family members**					**Implications of MI's effects**
			(P_1/P_2)	**Z_1**	**Z_2**	**T_c**	**T_w**	
Main income earner	2nd earner	Higher	↑	↓	↑	↓	↑	Income effect
	3rd earner	Lower	↓	↑	↓	↑	↓	Care effect
Second income earner	1st earner	Higher	↑	↓	↑	↓	↑	Income effect
	3rd earner	Lower	↓	↑	↓	↑	↓	Care effect
Third income earner	1st earner	Higher	↑	↓	↑	↓	↑	Income effect
	2nd earner	Lower	↓	↑	↓	↑	↓	Care effect

Note: Following Becker's (1976) theory of the allocation of time, the variables are defined as follows. (P_1/P_2) is the ratio of the relative price of consuming the two commodities Z_1 and Z_2. Z_1 is assumed to be a more time-intensive commodity and Z_2 to be a more goods-intensive commodity. T_c denotes the total consumption time of the consumption possibility set $\boldsymbol{Z}$ (Z_1, Z_2) and T_w, the work hours of family members.

Table 2: Descriptive statistics and results of the t-test for the main variables between households with versus without MI

Variables for *Non-patient* Family Member	Households with MI			Households without MI			t-test
	Obs	Mean	SE	Obs	Mean	SE	t-value
Characteristics of individual							
Weekly work hours	1465	40.795	0.415	42631	41.549	0.075	1.83 *
Age cohort: under 19	3356	0.189	0.007	93940	0.202	0.001	1.78 *
Age cohort: 20-29	3356	0.106	0.005	93940	0.115	0.001	1.63
Age cohort: 30-39	3356	0.091	0.005	93940	0.137	0.001	7.72 ***
Age cohort: 40-49	3356	0.111	0.005	93940	0.126	0.001	2.60 ***
Age cohort: 50-59	3356	0.182	0.007	93940	0.154	0.001	-4.39 ***
Age cohort: 60-69	3356	0.157	0.006	93940	0.132	0.001	-4.19 ***
Age cohort: 70 and above	3356	0.164	0.006	93940	0.134	0.001	-5.05 ***
Gender (male=1, female=0)	3359	0.533	0.009	94024	0.484	0.002	-5.57 ***
Marriage: married	3359	0.575	0.009	94024	0.539	0.002	-4.10 ***
Marriage: single	3359	0.362	0.008	94024	0.359	0.002	-0.30
Marriage: separated	3359	0.064	0.004	94024	0.102	0.001	7.26 ***
Employment: regular	2398	0.312	0.009	66103	0.354	0.002	4.19 ***
Employment: part-time	2398	0.106	0.006	66103	0.111	0.001	0.73
Employment: other types	2398	0.036	0.004	66103	0.036	0.001	-0.08
Employment: non worker	2398	0.546	0.010	66103	0.500	0.002	-4.43 ***
Firm size: small to medium	2277	0.289	0.010	62596	0.302	0.002	1.31
Firm size: large	2277	0.097	0.006	62596	0.130	0.001	4.50 ***
Firm size: government	2277	0.039	0.004	62596	0.041	0.001	0.52
Firm size: non worker	2277	0.575	0.010	62596	0.528	0.002	-4.42 ***
Employment duration (year)	1490	14.942	0.357	43343	13.510	0.062	-4.17 ***
Physical health status(37 items): good	3190	0.588	0.009	87927	0.673	0.002	10.02 ***
Physical health status(37 items): fair health	3190	0.242	0.008	87927	0.210	0.001	-4.36 ***
Physical health status(37 items): bad health	3190	0.170	0.007	87927	0.117	0.001	-9.06 ***
Characteristics of household							
Number of household members	3359	4.018	0.025	94024	3.468	0.005	-21.04 ***
Household structure(type1): one-person	3359	0	0	94024	0.087	0.001	17.93 ***
Household structure(type2): only a couple	3359	0.121	0.006	94024	0.161	0.001	6.24 ***
Household structure(type3): parent(s) with unmarried child	3359	0.417	0.009	94024	0.499	0.002	9.38 ***
Household structure(type4): other types	3359	0.462	0.009	94024	0.252	0.001	-27.36 ***
Dwelling type: own house	3359	0.858	0.006	94024	0.740	0.001	-15.38 ***
Number of rooms	3332	5.991	0.038	92866	5.152	0.007	-22.33 ***
Household expenditure (in May, in 10,000 yen)	2668	35.043	0.764	71613	32.121	0.147	-3.77 ***
Relationship (type1): household head	3359	0.324	0.008	94024	0.369	0.002	5.41 ***
Relationship (type2): spouse	3359	0.210	0.007	94024	0.244	0.001	4.48 ***
Relationship (type3): child	3359	0.347	0.008	94024	0.310	0.002	-4.50 ***
Relationship (type4): others	3359	0.119	0.006	94024	0.076	0.001	-9.13 ***

Note: The asterisks *, ** and *** mean significance level at the 10%, 5% and 1%, respectively.

Table 3: Assessment of the balancing between groups: differences in the mean before and after matching (*Outcome*: weekly work hours of non-mentally ill; *Treatment Status*: MP is an arbitrary family member)

	Before matching			After matching											
				Nearest neighbor (1)			Caliper (0.001)			Radius (0.001)			Normal kernel		
Variable	Treated	Control	T-test	Treated	Untreated	T-test	Treated	Untreated	T-test	Treated	Untreated	T-test	Treated	Untreated	T-test
Age cohort: 20-29	0.106	0.116	-1.68 *	0.204	0.212	-0.39	0.204	0.211	-0.32	0.204	0.212	-0.38	0.204	0.199	0.23
Age cohort: 30-39	0.091	0.141	-8.22 ***	0.184	0.191	-0.33	0.185	0.192	-0.33	0.185	0.189	-0.22	0.184	0.241	-2.66 ***
Age cohort: 40-49	0.111	0.129	-3.00 ***	0.204	0.209	-0.26	0.204	0.210	-0.26	0.204	0.197	0.33	0.204	0.226	-1.04
Age cohort: 50-59	0.182	0.155	4.15 ***	0.301	0.294	0.29	0.300	0.293	0.29	0.300	0.298	0.07	0.301	0.239	2.65 ***
Age cohort: 60-69	0.157	0.131	4.40 ***	0.083	0.072	0.78	0.084	0.073	0.78	0.084	0.080	0.27	0.083	0.069	1.00
Age cohort: 70 and above	0.164	0.125	6.62 ***	0.011	0.008	0.54	0.010	0.008	0.28	0.010	0.009	0.09	0.011	0.008	0.67
Gender (male=1, female=0)	0.533	0.484	5.49 ***	0.575	0.561	0.53	0.575	0.558	0.69	0.575	0.569	0.25	0.575	0.571	0.14
Marriage: married	0.575	0.543	3.60 ***	0.620	0.612	0.32	0.621	0.610	0.43	0.621	0.604	0.65	0.620	0.642	-0.88
Marriage: separated	0.064	0.098	-6.52 ***	0.044	0.044	-0.00	0.044	0.044	0.00	0.044	0.042	0.14	0.044	0.062	-1.55
Employment: regular	0.312	0.362	-4.99 ***	0.680	0.689	-0.34	0.679	0.689	-0.39	0.679	0.679	0.02	0.680	0.698	-0.71
Employment: part-time	0.106	0.113	-1.09	0.239	0.234	0.25	0.240	0.237	0.12	0.240	0.241	-0.06	0.239	0.227	0.55
Firm size: small to medium	0.289	0.308	-1.90 *	0.664	0.687	-0.95	0.663	0.688	-1.01	0.663	0.669	-0.25	0.664	0.637	1.09
Firm size: large	0.098	0.134	-5.07 ***	0.246	0.240	0.24	0.247	0.240	0.3	0.247	0.244	0.12	0.246	0.274	-1.21
Employment duration (year)	14.942	13.473	4.29 ***	12.145	11.583	0.93	12.088	11.553	0.88	12.088	11.936	0.25	12.145	11.156	1.66 *
Physical health status(37 items): good health	0.588	0.676	-10.43 ***	0.674	0.693	-0.79	0.674	0.692	-0.73	0.674	0.680	-0.23	0.674	0.713	-1.65 *
Physical health status(37 items): fair health	0.242	0.209	4.55 ***	0.219	0.202	0.77	0.218	0.203	0.71	0.218	0.214	0.19	0.219	0.191	1.32
Number of household member	4.018	3.474	20.81 ***	4.083	4.097	-0.20	4.077	4.078	-0.02	4.077	4.047	0.43	4.083	3.417	9.59 ***
Household structure(type2): only a couple	0.121	0.160	-6.07 ***	0.059	0.055	0.34	0.059	0.055	0.34	0.059	0.050	0.72	0.059	0.126	-4.46 ***
Household structure(type3): parent(s) with unmarried child	0.417	0.504	-9.93 ***	0.493	0.519	-0.99	0.495	0.519	-0.94	0.495	0.519	-0.93	0.493	0.550	-2.19 **
Dwelling type: own house	0.858	0.740	15.39 ***	0.869	0.881	-0.71	0.868	0.882	-0.79	0.868	0.877	-0.48	0.869	0.722	7.06 ***
Number of rooms	5.991	5.149	22.43 ***	5.992	6.038	-0.42	5.988	6.003	-0.14	5.988	5.967	0.18	5.992	5.066	8.25 ***
Household expenditure (in May, in 10,000 yen)	35.043	32.108	3.80 ***	34.456	33.443	0.58	34.489	34.063	0.23	34.489	34.659	-0.09	34.456	31.577	1.55
Relationship (type1): household head	0.324	0.371	-5.63 ***	0.366	0.328	1.54	0.367	0.326	1.65 *	0.367	0.356	0.44	0.366	0.490	-4.83 ***
Relationship (type2): spouse	0.210	0.246	-4.78 ***	0.209	0.202	0.32	0.210	0.207	0.13	0.210	0.208	0.09	0.209	0.221	-0.57
Relationship (type3): child	0.347	0.310	4.46 ***	0.391	0.441	-1.96 *	0.390	0.438	-1.86 *	0.390	0.403	-0.48	0.391	0.268	5.05 ***

Table 4: ATE before matching and ATTs by different matching algorithms

Outcome	Weekly work hours of non-mentally ill family member								
			After Matching						
Treatment	Before Matching		Nearest Neighbor (1)		Caliper (0.001)		Radius (0.001)		Normal Kernel	
MP is arbitrary family member (100%)	**Unmatched**		**ATT**		**ATT**		**ATT**		**ATT**	
Treated	40.878		40.878		40.851		40.851		40.878	
Control/Untreated	41.507		40.881		40.997		40.816		41.409	
Difference	-0.629		-0.003		-0.147		0.035		-0.530	
t-statistic	-1.17		-0.00		-0.19		0.06		-0.95	
S.E.	-0.538		(0.753)		(0.770)		(0.566)		(0.557)	
Bootstrap S.E.	-		[0.866]		[0.826]		[0.813]		[0.920]	
Obs of Treated	3,359		732		730		730		732	
MP is head of household (24%)	**Unmatched**		**ATT**		**ATT**		**ATT**		**ATT**	
Treated	38.757		38.757		38.850		38.850		38.757	
Control/Untreated	41.505		37.405		37.272		38.505		41.440	
Difference	-2.748		1.35		1.578		0.345		-2.684	
t-statistic	-2.33		0.82		0.94		0.28		**-2.22**	
S.E.	(1.181)	**	(1.658)		(1.674)		(1.223)		(1.208)	**
Bootstrap S.E.	-		[1.901]		[2.104]		[1.846]		[2.153]	
Obs of Treated	797		148		147		147		148	
MP is spouse (32%)	**Unmatched**		**ATT**		**ATT**		**ATT**		**ATT**	
Treated	44.225		44.225		44.225		44.225		44.225	
Control/Untreated	41.459		43.498		43.380		43.795		41.545	
Difference	2.766		0.728		0.845		0.430		2.680	
t-statistic	2.81		0.56		0.65		0.44		**2.77**	
S.E.	(0.986)	***	(1.290)		(1.307)		(0.972)		(0.966)	***
Bootstrap S.E.	-		[1.473]		[1.567]		[1.281]	*	[1.518]	
Obs of Treated	1,075		213		213		213		213	
MP is child (22%)	**Unmatched**		**ATT**		**ATT**		**ATT**		**ATT**	
Treated	38.716		38.716		38.890		38.890		38.716	
Control/Untreated	41.509		40.617		40.702		39.675		41.489	
Difference	-2.794		-1.902		-1.812		-0.786		-2.773	
t-statistic	-2.63		-1.28		-1.22		-0.69		**-2.48**	
S.E.	(1.063)	***	(1.488)		(1.490)		(1.134)		(1.120)	**
Bootstrap S.E.	-		[1.550]		[1.552]		[1.826]		[1.644]	
Obs of Treated	749		183		181		181		183	

Note: each column in "After Matching" reports the matching estimator with a different matching algorithm (1) nearest neighbor matching using 1 nearest neighbor; (2) Caliper matching with a caliper of 0.001; (3) radius matching with a caliper of 0.001; (4) Kernel matching using normal density function.

Standard errors in parentheses, bootstraped (100 replications) standard errors in brackets. Bootstrapped standard errors are calculated to remove potential bias on outcomes due to small treatment samples.

The asterisks *, ** and *** mean significance level at the 10%, 5% and 1%, respectively.

Sources: Author's calculation based on the anonymized data of 2004 Comprehensive Survey of Living Conditions.

Table 5: ATE before matching and ATTs by different matching algorithms across relationship groups

Treatment	Outcome	Before Matching	After Matching			
			Nearest Neighbor (1)	Caliper (0.001)	Radius (0.001)	Normal Kernel
MP is head of household	**Weekly work hours of spouse**	**Unmatched**	**ATT**	**ATT**	**ATT**	**ATT**
	Treated	31.255	31.255	31.255	31.255	31.255
	Control/Untreated	31.493	35.145	35.145	31.983	31.475
	Difference	-0.239	-3.891	-3.891	-0.728	-0.22
	t-statistic	-0.13	-1.47	-1.47	-0.35	-0.11
	S.E.	(1.829)	(2.642)	(2.642)	(2.064)	(2.047)
	Bootstrap S.E.	-	[2.727]	[2.996]	[3.461]	[3.033]
	Obs of Treated	91	55	55	55	55
	Weekly work hours of child	**Unmatched**	**ATT**	**ATT**	**ATT**	**ATT**
	Treated	43.746	43.922	44.026	44.026	43.922
	Control/Untreated	42.513	43.065	43.158	43.160	42.532
	Difference	1.231	0.857	0.868	0.867	1.39
	t-statistic	0.86	0.46	0.46	0.58	0.96
	S.E.	(1.437)	(1.863)	(1.882)	(1.488)	(1.453)
	Bootstrap S.E.	-	[2.256]	[2.512]	[2.400]	[2.314]
	Obs of Treated	143	77	76	76	77
MP is spouse	**Weekly work hours of head**	**Unmatched**	**ATT**	**ATT**	**ATT**	**ATT**
	Treated	47.252	47.716	47.716	47.716	47.716
	Control/Untreated	47.072	46.618	46.814	47.520	47.071
	Difference	0.180	1.098	0.902	0.196	0.645
	t-statistic	0.14	0.64	0.53	0.15	0.49
	S.E.	(1.274)	(1.704)	(1.713)	(1.325)	(1.313)
	Bootstrap S.E.	-	[2.253]	[2.255]	[2.146]	[2.349]
	Obs of Treated	251	102	102	102	102
	Weekly work hours of child	**Unmatched**	**ATT**	**ATT**	**ATT**	**ATT**
	Treated	41.337	41.337	41.352	41.352	41.337
	Control/Untreated	42.555	39.775	40.489	41.418	42.531
	Difference	-1.218	1.562	0.864	-0.066	-1.194
	t-statistic	-0.90	0.74	0.42	-0.04	-0.79
	S.E.	(1.347)	(2.100)	(2.070)	(1.552)	(1.513)
	Bootstrap S.E.	-	[2.218]	[2.473]	[2.114]	[2.451]
	Obs of Treated	158	89	88	88	89
MP is child	**Weekly work hours of head**	**Unmatched**	**ATT**	**ATT**	**ATT**	**ATT**
	Treated	43.405	43.405	43.494	43.494	43.405
	Control/Untreated	45.523	42.532	42.779	42.710	45.487
	Difference	-2.118	0.873	0.714	0.783	-2.082
	t-statistic	-1.42	0.39	0.31	0.46	-1.29
	S.E.	(1.486)	(2.262)	(2.326)	(1.703)	(1.611)
	Bootstrap S.E.	-	[2.323]	[2.288]	[2.574]	[2.820]
	Obs of Treated	167	79	77	77	79
	Weekly work hours of spouse	**Unmatched**	**ATT**	**ATT**	**ATT**	**ATT**
	Treated	28.510	28.510	28.047	28.047	28.510
	Control/Untreated	31.415	29.755	30.186	31.111	31.372
	Difference	-2.905	-1.245	-2.14	-3.064	-2.862
	t-statistic	-1.51	-0.49	-0.79	-1.47	-1.50
	S.E.	(1.928)	(2.527)	(2.717)	(2.080)	(1.902)
	Bootstrap S.E.	-	[3.222]	[3.385]	[3.293]	[3.326]
	Obs of Treated	85	49	49	43	49

Note: each column in "After Matching" reports the matching estimator with a different matching algorithm (1) nearest neighbor matching using 1 nearest neighbor; (2) Caliper matching with a caliper of 0.001; (3) radius matching with a caliper of 0.001; (4) Kernel matching using normal density function.

Standard errors in parentheses, bootstraped (100 replications) standard errors in brackets. Bootstrapped standard errors are calculated to remove potential bias on outcomes due to small treatment samples.

Sources: Author's calculation based on the anonymized data of 2004 Comprehensive Survey of Living Conditions.

Table 6: Summary of ATT regarding "*who becomes sick*" in the family

MP	Family member	Relative wage compared with other working family members	Implications of MI's effects	Empirical results				Compared with theory
				Total effects/w.o. identification (Table 4)	Sig. level	Separate effect/ w. identification (Table 5)	Sig. level	
Household head (Husband)	Child	Higher	Income effect	↑ (↓ only for normal kernel)	5% only for normal kernel	↑	None	Consistent
	Spouse	Lower	Care effect			↓		Consistent
Child	Household head	Higher	Income effect	↓	5% only for normal kernel	↑ (↓ only for normal kernel)		Mix
	Spouse	Lower	Care effect			↓		Consistent
Spouse (Wife)	Household head	Higher	Income effect	↑	1% only for normal kernel	↑		Consistent
	Child	Lower	Care effect			↑ (↓ for radius and normal kernel)		Mix