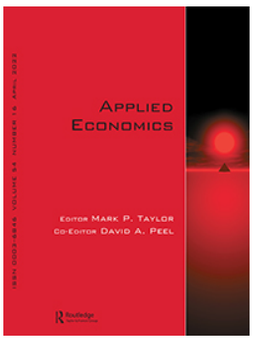

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Life expectancy in nursing homes

Robert J. Brent

Department of Economics, Fordham University, Bronx, New York, USA

ABSTRACT

It is well known that life expectancy in nursing homes (NHs) is lower for older adults than those residing elsewhere. In this paper, we attempt to discover the exact extent of this loss of life expectancy, and whether it can be explained by pre-existing health state conditions, especially the seriousness of dementia. We use a parametric survival model, on a large data set spanning up to 13 years, which covers health states and types of residence for all time periods until a person dies. In the absence of health state controls, the loss of life expectancy is 47 months. Accounting for health states still leads to a 41-month loss of life. Even those with serious dementia would live longer lives if not residing in a NH. We then value the estimated loss of life years. The losses are large, equal to $1.7 million per NH resident, and $1.87 trillion for the US NH population.

JEL CLASSIFICATION

I12 Health Production; J14 Economics of the Elderly

KEYWORDS

Life expectancy; nursing homes; dementia; loss of income

Life expectancy is rising in the US and around the world. Recently this increase has occurred more for the older age groups. Eggleston and Fuchs (2012) call this recent increase in life expectancy for older adults 'the new demographic transition'. As the population ages, more and more people will be seeking long-term care. A central part of this process involves the moving from living at home with caregiver support, to living in an institution where medical services and treatment carried out by skilled nurses and physicians are the main priority. We will refer to such medically staffed institutions as nursing homes (NH), while recognizing that there could be a wide range of medical expertise being provided under that heading.[1] With this movement into NHs, where health services are more available, there is the expectation that life expectancy will be further extended. With this expectation, it seems somewhat surprising to learn that the mortality rate over the first year of nursing home residence was 35.0%, with 16.3% deaths occurring within 100 days, Shuang et al. (2018).

The main hypothesis for why survival rates are so low in NHs would seem to be the recognition that NH residents are sicker than they were before entering the homes. This could be why they became NH residents in the first place. One is also observing persons at the end of their lives when their health is bound to be failing. This raises the research question whether the survival rates in NHs would still appear to be so low if one controlled for a person's state of health prior to entering the homes, and compared the NH mortality rates with those outside the homes who were also at the end of their lives. To provide a meaningful answer, one requires a panel data set that observes the health states and mortality outcomes of older persons prior to, and post residence in a NH (a treatment group) and one that has comparable data for those residing outside a NH (a control group).[2]

Because people are living longer in the population as a whole, there exists a second time trend to accompany the NH expansion. Dementia is a disease that is also a product of ageing. Dementia is now the third leading cause of death in the US, James et al. (2014).[3] A national survey showed that 67% of these dementia-related deaths occurred in NHs (Mitchell et al. 2005). This could imply that the main reason why NH survival rates are so low is due to the larger number of dementia patients that reside there, as they have shorter life

CONTACT Robert J. Brent Brent@fordham.edu Professor, Department of Economics, Fordham University, Bronx, NY 10458, USA.

[1]What is excluded from the NH residential category is listed in section IIB and discussed further in footnote 9.

[2]Many studies of mortality in NHs just examine survival rates after people have entered NHs, see for example, Hicks, Rabins, and Black (2010) and Vossius et al. (2018).

[3]It was thought that dementia was the sixth leading cause of death in the US, but the morality rate for dementia had to be revised upwards by a factor of three. This was because death certificates are known to underreport persons dying of dementia, see James et al. (2014).

expectancy than average. Therefore, the main hypothesis reduces to the claim that the reason why NH residents are sicker is the greater prevalence and progression of dementia in the NH treatment group, and this largely accounts for the low survival rates.

Our paper tests this main hypothesis and in the process uncovers the exact reality of low survival rates in NHs in the US. We use a large, national panel data set over a 13-year period, that: (i) covers persons with varying degrees of dementia; (ii) monitors people's place of residence; (iii) includes a wide range of socio-economic and health state variables other than dementia to be used as controls; and (iv) has been augmented with four time variables (that show the time of entry into the panel, the duration of observation, the outcome at the end of the span, and whether a particular observation is to be used) in order that survival analysis can be used to carry out the statistical estimation.[4]

Using survival analysis, we first use a nonparametric model to show how many fewer months people can be expected to live in a NH, relative to other types of residence, when not considering any possible mitigating factors. This establishes a baseline loss of life expectancy estimate of 47 months. Then we test the main hypothesis using a parametric model that allows the impact of NHs and accompanying covariates to determine survival times for all time periods prior to the time of death or censure. With this model, we will see that lost survival times are only slightly reduced from the nonparametric model. The conclusion is that we can reject the main hypothesis, as lower life expectancy in NHs cannot be explained away by allowing for lower health states and higher dementia prevalence.

Our primary results will show that the mean life expectancy difference between residence in a NH and living outside a NH is 41 months (3.4 years). We place a monetary valuation on this life years difference using the Value of a Statistical Life literature. We find that the value of the lost years of life by living in a NH is very economically significant, equal to $1.7 million per person. The total value of the lost years of life expectancy amounts to $1.87 trillion for the US NH population.

In the next section we outline the survival model we will be using and specify the main regression equation that will generate the survival estimates. Then we summarize the data set and explain how it was adapted for use with the survival model. We define the dementia measure in terms of four stages of dementia intensity and show the importance of each of these stages in the context of the NH sample. The next section presents the primary regression and survival results. This enables us to obtain the estimates of life expectancy differences between NHs and other residences, according to the various degrees of dementia intensity that we set out to discover in this paper. Also included in the results section is a sensitivity analysis, which includes two alternative sets of life expectancy estimates. The value of the lost life years is assessed in the following section, and this completes the analysis. The final section contains the summary and conclusions.

I. The survival analysis model

We will be using the Weibull parametric survival model to obtain our main statistical results. Let T be the time to an individual's death, with $f(t)$ as T's density function and $F(t)$ the cumulative distribution function. We define $S(t)$ as the survival function which is the probability of not dying at time T: $S(t) = 1 - F(t)$. Because $f(t) = \mathrm{d}F(t)/\mathrm{d}t$, we have $f(t) = \mathrm{d}[1 - S(t)]/\mathrm{dt} = -S'(t)$. Then the instantaneous rate of death at time T, which is the hazard function $h(t)$, takes the form:

$$h(t) = f(t)/S(t) = -S'(t)/S(t) \tag{1}$$

In the parametric, proportional hazards framework that we will be using, the hazard rate for the jth subject in the data is:

$$h(t|x_j) = h_0(t)\exp(\beta_0 + x_j\beta_x) \tag{2}$$

where $h_0(t)$ is the baseline hazard, and $\exp(\beta_0 + x_j \beta_x)$ is the relative hazard when the baseline hazard is the same for everyone. In the relative hazard, x_j is a row vector of independent variables that determines the death of a person. This vector will vary

[4]The purpose of adding the four new time variables to the existing NACC data set is to convert calendar time into a time span from time of entry, to time at death or right censure.

with time. β_x is a column vector of regression coefficients to be estimated from the data. The common baseline hazard will be assumed to take the Weibull form: $h_0(t) = p\ t^{p-1} \exp(\beta_0)$, in which case equation (2) becomes:

$$h(t|x_j) = p\ t^{p-1} \exp(\beta_0 + x_j\beta_x) \tag{3}$$

In the Weibull model, there are two ancillary parameters p and β_0. For the case with $p = 1$, one obtains the exponential parametric model, which is[5]

$$h(t|x_j) = \exp(\beta_0 + x_j\beta_x) \tag{4}$$

The hazard ratio (HR) is defined as the ratio of the hazard rates that correspond to the conditions described by two levels of an explanatory variable. In our analysis, the HR will be the ratio of the hazard rate of a person in a NH relative to the hazard rate of a person not living in a NH.

The special case is when there are no independent variables x_j to act as controls. This is the non-parametric model. The emphasis here is just on the survival function $S(t)$ inside and outside NHs. For $S(t)$ we will use the Kaplan-Meier (K-M), product limit estimator which calculates the survival times at any time t by:

$$S(t) = \Pi\left(\frac{(n_j - d_j)}{n_j}\right) \tag{5}$$

where the product Π is for all death times up to t, n_j is the number of individuals at risk at any time t_j, and d_j is the number of deaths at time t_j.

For the parametric model, the time till death will be estimated by the regression equation separating out the NH dummy variable from the other health state controls which we now redefine as x_j:

$$T_j = \beta_0 + \beta_{NH}NH_j + x_j\beta_x + u_j + \beta_v \tag{6}$$

where β_0 is the constant term, β_{NH} estimates the NH hazard ratio, and u_j is the random error term. For our identification strategy, we added β_v to the regression equation to represent the set of constants that are included for each visit number. This gives a one-way fixed effects interpretation to our results, as we now explain.

The vector x_j records all the main observable variables in our data set. The vector β_v is included to allow for some of the unobservable variables related to visits that may determine NH residence and time until death in our data set. Our fixed effects model assumes that, for each of the visits, many of the unobserved influences will be unchanged. So, for example, the trained clinicians undertaking the interviews for any particular visit number are the same persons, making the same clinical judgements; or the time taken to undertake, say, the first visit interviews all take uniformly longer. In addition, all persons for a specified visit number may be subject to the same national events that affects health states at a particular time (such as a virus epidemic).[6]

II. Data source and specifications for the variables

The data

The data we will be using come from the National Alzheimer's Coordinating Center (NACC). NACC has constructed a panel data set that has been operational since 2005, called the Uniform Data Set (UDS). These data consist of demographic, clinical, diagnostic, and neuropsychological information on participants with normal cognition, mild cognitive impairment, and dementia who visited 32 US Alzheimer's Disease Centers (ADC), covering up to 12 visits per client, over a thirteen-year period. This data set is fully explained elsewhere (Morris et al. 2006; Beekly et al. 2007; Weintraub et al. 2009).[7]

The UDS was reset into duration format (in months) in order to be analysed using survival models. The unit of analysis was a visit, and there were 125,994 observations available to test the non-parametric model. Time zero was set at one month prior to the first visit, at which time the person was

[5]We test for the possibility that the exponential model is relevant as a part of our results for the Weibull model.:

[6]Fixed effects model can be one-way, focusing on visits v, or two-way where both individuals j and visits v are subject to fixed effects. We were precluded from using a two-way fixed effects model since we have 30,312 different individuals in our data set. This large size would cause an incidental parameters problem, see Lancaster (2000). Note that we used visits β_v, and not the usual time version β_t, for our one-way fixed effects model. This is because, in our sample, clients occasionally made more than one visit per year. Thus, the year designation would not have been unique, which is true of the visits specification.

[7]The UDS was also the data source used for economic evaluations of four dementia interventions, see Brent (2018a, 2018b, 2019a, 2020).

assumed to be told they were at risk of dying with dementia.[8] On average, in the duration format, the origin was at 583 months, started at 21 months and concluded at 31 months. Over the time span, 6.2% of the visits ended with a death. Many of the variables in the UDS had missing observations. Therefore, depending on the selection of the independent variables in the estimation equation, the sample size would vary. For the set of variables that control for the health state of a person in our specification of equation (6), to test the parametric model, there were 87,437 observations.

The nursing home and dementia measures

A NH residence was specified as a dummy variable that was equal to 1 if a person lived in either a skilled nursing facility or a NH proper. This NACC specification of NHs makes sense as many skilled nursing facilities are housed in NHs. By contrast, a NH was set equal to 0 for all other residences, which in the NACC data set included single-family residences, retirement communities, assisted living, adult family homes and boarding homes.[9]

The instrument that we will be using to measure dementia symptoms is the Clinical Dementia Rating (CDR) scale, known as the *CDR® Dementia Staging Instrument*.[10] The CDR is based primarily on a neurological exam and informant reporting, see Morris (1997). A CDR was administered to each NACC participant at each visit by a clinician. There are six domains in the CDR: memory, orientation, judgement and problem solving, community affairs, home and hobbies, and personal care. Each domain is assessed using a 0 to 3 interval (none, mild, moderate, and severe) with a questionable response being scored as 0.5. The CDR-SB (the CDR sum of boxes) is the aggregate score across all six domains and this has a range of 0 to 18.

In this study where we are analysing life expectancy, it is important to distinguish various degrees of seriousness of dementia, as mild cases cannot be expected to significantly affect mortality rates.[11] We therefore disaggregate the 18-point CDR-SB score into four mutually exclusive categories, which we call stages. These stages roughly correspond to the four categories used by the Alzheimer's Association 2018 Report (2018), consisting of normal cognition, pre-clinical, mild cognitive impairment (MCI) and dementia. Stage 1 is when there are no dementia symptoms with CDR-SB = 0. Stage 2 has the CDR-SB interval 0.5 to 3.5. Stage 3 has the CDR-SB interval 4.0 to 6.0, and for stage 4, it is 6.5 to 18. These defining CDR-SB intervals for the stages reproduce relative frequencies that approximate the prevalence rates for the four categories that can be found in the 2018 Report.[12]

The two-way contingency table between NH residence and the four dementia stages is shown in Table 1. Very few persons (less than 1%) with no dementia, stage 1, reside in NHs; while most (86%) of those with serious dementia, stage 4, live in NHs. Those not in NHs are much more evenly split across the four dementia classes. This data supports the logic of the main hypothesis that dementia

Table 1. Numbers (%) with and without dementia in nursing homes.

Dementia score	Number (%) in NHs	Number (%) not in NHs
Stage 1	6 (0.75%)	37,944 (43.79%)
Stage 2	41 (5.15%)	26,339 (30.40%)
Stage 3	63 (7.91%)	10,596 (12.23%)
Stage 4	686 (86.18%)	11,762 (13.58%)
Total	796 (100%)	86,641 (100%)

[8]We chose the time period one month before the first visit to set left truncation because this allowed the full sample to be utilized. There is no way of knowing the exact date when a person is at risk of dying with dementia. Some people may learn this at an early age when they find out that their grandparents have dementia.

[9]Although NHs are more commonly called skilled nursing facilities, there is a distinction between them. Nursing homes provide permanent custodial assistance, while skilled nursing facilities are more often temporary. However, in either case, there is continuous care by trained medical professionals, in contrast to all the other types of residences listed by NACC. This commonality makes it appropriate for NACC to combine the two types and call them NHs.

[10]The reason why we use a definition of dementia in terms of dementia symptoms and not brain pathology is to be able to acknowledge that worthwhile non-pharmacological interventions for dementia already exist, see Brent (2019b).

[11]The average CDR-SB in our sample was 3.3, which would place the average person in our sample in dementia stage 2, which can be considered 'mild' relative to stages 3 and 4. Being in stage 2 would be considered to be pre-clinical in the Alzheimer's Association's classification system and therefore not even 'mild' cognitive impairment.

[12]See Brent (2019b), Table 4.

should play a much larger role in determining life expectances in NHs than in other types of residences.

The health state controls

All the controls listed below, together with dementia severity, determine whether someone is likely to die, or is likely to live in a NH, or is likely to have dementia at any date *t*. The selection of variables to include in the list is in line with the assumption by Hicks, Rabins, and Black (2010), that specific health states with known high mortality rates are also likely to be associated with the increased risk of death in populations in NH with dementia. We include with the health states socio-economic variables that also have been found to determine life expectancy. In this way, we follow the economics demographic literature by including many of the main determinants of adult mortality, see for example Eggleston and Fuchs (2012), Cutler, Deaton, and Lleras-Muney (2006), and Shaw, Horrace, and Vogel (2005). Finally, to be all-inclusive, we add a medications variable, on the assumption that if someone is taking any medication, there must be some (undefined) illness that they are trying to alleviate.

Age. – Age at the time of visit in years.

Female. – Sex. Female = 1, and male = 0.

White. – Race. White = 1, and Non-White = 0.

BMI. – Body Mass Index. BMI = Weight (pounds) × 703/Height (inches)^2.

Smoking Years. – Total years smoked cigarettes.

Medications. – Currently taking any medications = 1, and not taking any medications = 0.

Medicare. – Eligible for Medicare. Age ≥ 65 years = 1, and age < 65 years = 0.

Heart Rate. – Pulse. Resting heart rate.

Education. – Years of education in natural logarithms.

A data summary for all the control variables that will appear in the Weibull Parametric model is given in Table 2. This table shows that those living in NHs are more likely to be older, male, white, and have a higher heart rate; while being slightly more likely to have lower nutrition (lower BMI), have been smoking longer, taking less medications, be Medicare eligible and have less education. Overall, this data again confirms that the health states of those in NHs are lower, and so one should expect that their life expectancy would be reduced, as claimed by the main hypothesis.

Table 2. Data summary for the controls in and not in nursing homes.

Variable	In NHs	Not in NHs	Difference
Age	77.55	74.43	3.12
Female	51.88%	56.93%	– 5.05%
White	90.08%	83.29%	6.79%
BMI	25.70	26.89	– 1.19
Smoking Years	11.23	10.46	0.77
Any Medications	95.35%	95.59%	– 0.24%
Medicare Eligibility	86.31%	84.49%	1.82%
Heart Rate	72.75	68.19	4.56
Education	2.62	2.69	– 0.07

The visit numbers

To accompany the controls, there will be 7 visit numbers, as these were the visit numbers that were significant in the regressions. Note that 94% of the clients made up to seven visits, so there were very few clients who made visits 8 to 12. The mean number of visits were three and that will be the number that will be used to make the primary predictions for life expectancy for those living in, and those not living in NHs. 31% of the sample made only one visit to the clinics. Apart from those entering the sample relatively recently, someone only making one visit can be assumed much less healthy than the average. This visit number is used in the sensitivity analysis to predict life expectancy for the worst-case alternative.

III. The results

The non-parametric model

The starting point is the non-parametric estimates. This is the prima facie case against NHs as these estimates show how much shorter life expectancy is in NHs, if there are no covariates invoked to rebut the presumption of inefficiency. Table 3 gives the K-M life expectancy (survival) estimates.

We see that people, with an average age of 72 years on their first visit, clients lived a further 103 months (around 8 and a half years). They

Table 3. Life expectancy in nursing homes (months).

Total	Life Expectancy in NH	Life Expectancy not in NH	Difference
103	61	106	– 45

would live 106 months if not living in a NH, and only 61 months if living in a NH, making a difference of 45 months. Figure 1 displays the two life expectancy paths for those living, and not living, in NHs.[13]

We now turn to see whether this reduction in life expectancy observed in NHs can be explained by the lower health states that these residents have, especially in terms of the seriousness of their dementia symptoms.

The weibull parametric model

Table 4 reports the regression results for the Weibull survival model, which has the time to death as the dependent variable, and the dementia stages, the control variables, and visit numbers as possible covariates. The logarithms of the exponential coefficients are presented, which means that the coefficients are shown as HRs. The estimate of the HR for the NH is the central result. The critical value for the HR is 1. For this value, there would be no difference in life expectancy for any variable for a person being in a NH and not being in a NH. Values for the HR greater than 1 indicate an increased risk of mortality by being in the NH, and values less than 1 indicate a negative mortality risk.

Table 4 has two sets of estimates: the first containing NH mortality risk in NHs just using the stages of dementia severity and the controls as covariates. The second set of estimates is the primary result, that includes also the seven visit numbers, as set out in equation (6), based on equation (3).

As we can see from the last line in Table 4, for both set of estimates, one can reject the hypothesis that the value for $p = 1$, which means that the Weibull model is valid and not the exponential parametric model – see equation (4). We discuss here the primary results and refer to the first set of estimates in the sensitivity analysis.

The HR for NHs is 1.50, which indicates that that there is a 50% higher rate of mortality in NHs than residing elsewhere. The conclusion is that, even when one allows for many of the possible reasons why people live shorter lives, residing in a NH is an additional, large mortality risk factor. The main hypothesis must be rejected because,

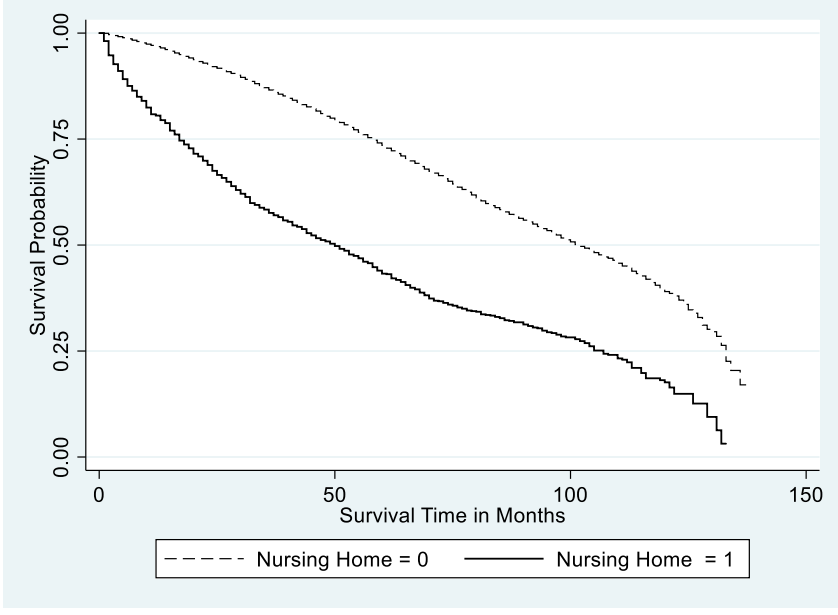

Figure 1. Kaplan-meier survival estimates.

[13]A global test of the two survival functions is the log-rank test. The test compares at each fatality time the expected versus the observed number of fatalities and then combines them over all observed fatality times. The difference between the expected and observed fatalities produces a Chi-square test statistic of 366.38, which has a *p*-value of 0.0000. We can strongly reject the hypothesis that the two survival functions are equal. NH fatalities are 2.131 times the expected number.

although dementia is indeed a major determinant of lower life expectancy, there is something about the care in NHs that exacerbates the mortality risk of dementia. To see this clearly, we have used the primary Weibull survival model estimates to break down life expectancy according to each of the dementia stages.

To carry out this part of the analysis, we predict life expectances for the four dementia stages using all the covariates when NH = 1 and NH = 0. The predicted values for each of the dementia stages are conditional on a person being female, white, eligible for Medicare and having taken any medications recently, with all the continuous variables set at their mean values. For the visit numbers, we set visit 3 = 1, and for all the other visits numbers they were = 0. This case for visits corresponds to one for a typical client in our sample. Table 5 has the breakdown (with 95% confidence intervals in brackets).

On average, people lived 41 months longer if they did not reside in a NH, controlling for many of the health state variables that generally determine life expectancy for older adults. Of this difference, 22 months is lost in NHs independently of any degree of dementia symptoms (by being in stage 1). For those with serious dementia in NHs, they would expect to live 37 months longer (111–74) than if they did not have any dementia signs.

Table 5. Life expectancy with and without dementia in nursing homes (months): primary estimates.

Dementia score	Life Expectancy in NH	Life Expectancy not in NH	Difference
Stage 1	111 (102–120)	133 (126–139)	– 22
Stage 2	98 (90–106)	117 (111–123)	– 19
Stage	(1) 87 (80–94)	104 (98–109)	– 17
Stage	(1) 74 (68–79)	88 (84–92)	– 14
Weighted Mean	77	118	– 41

Thus, dementia certainly reduces life expectancy, as the exceptionally large HRs for dementia stages in Table 4 attests. However, if people with serious dementia did not live in NHs, they would have lived 14 months longer (88–74). NHs have the effect of making the consequences of dementia symptoms worse than otherwise would have occurred.

Sensitivity analysis

We provide here two alternative sets of estimates of life expectancy that are different from the primary estimates. One set will show higher losses of life expectancy in NHs, and the other set will provide lower estimates. This will indicate the range of plausible estimates.

Table 4. Hazard rates using the weibull survival model.

	With Only the Stages and Controls			*With the Stages, Controls and Visits*		
Variable	Hazard Ratio	Std. Error	*z*-score	Hazard Ratio	Std. Error	*z*-score
NH	1.5930	0.1222	6.07***	1.5001	0.1161	5.24***
Stage 2	2.4642	0.1111	20.00***	1.3332	0.0609	6.30***
Stage 3	4.5758	0.2185	31.85***	1.4769	0.0852	11.43***
Stage 4	5.8677	0.2521	41.19***	2.5232	0.1105	21.14***
Age	1.0121	0.0020	6.06***	1.0290	0.0021	13.96***
Female	0.7002	0.0209	– 11.91***	0.6452	0.0194	– 14.54***
White	1.3713	0.0634	6.83***	1.0649	0.0497	1.35
BMI	0.9726	0.0031	– 8.62***	0.9817	0.0031	– 5.80***
Smoking	1.0070	0.0009	8.27***	1.0055	0.0008	6.67***
Medications	0.5474	0.0367	– 8.98***	1.4087	0.0958	5.04***
Medicare	0.7440	0.0453	– 4.86***	0.7855	0.0484	– 3.92***
Heart Rate	1.0078	0.0012	6.35***	1.0093	0.0013	7.24***
Education	0.7770	0.0364	– 5.38***	0.9866	0.0522	– 0.26
Visit 1				150.3493	28.7940	26.18***
Visit 2				45.7372	8.8707	19.71***
Visit 3				17.3308	3.3800	14.63***
Visit 4				8.7740	1.7349	10.98***
Visit 5				4.7750	9.729	7.62***
Visit 6				2.8714	0.6253	4.84***
Visit 7				2.1328	0.4984	3.24***
Constant	0.0001	0.0000	– 35.54***	0.0000	0.0000	– 47.56***
p	1.8097	0.0197	54.48***	2.2649	0.0215	86.28***

***Significant at the 1% level.

Table 6. Life expectancy with and without dementia in nursing homes (months): alternative 1.

Dementia score	Life Expectancy in NH	Life Expectancy not in NH	Difference
Stage	(1) 146 (132–160)	189 (180–198)	– 43
Stage 2	89 (81–97)	114 (110–120)	– 25
Stage 3	(1) 63 (57–69)	81 (78–85)	– 18
Stage 4	(1) 55 (50–60)	71 (69–74)	– 16
Weighted Mean	58	137	– 79

Table 7. Life expectancy with and without dementia in nursing homes (months): alternative 2.

Dementia score	Life Expectancy in NH	Life Expectancy not in NH	Difference
Stage 1	42 (39–46)	51 (49–53)	– 9
Stage 2	37 (35–40)	45 (43–47)	– 8
Stage 3	(1) 33 (31–36)	39 (38–41)	– 6
Stage 4	28 (26–30)	34 (33–35)	– 6
Weighted Mean	29	45	– 16

For the upper bounds, we will use the first set of estimates in Table 4, which did not include visit numbers. This corresponds to having somewhat less knowledge of the persons whose life expectancy we are trying to predict. We know their measurable health states, but not their history of NACC visits. The predicted values for each dementia stage are again conditional on a person being female, white, eligible for Medicare, and having taken any medications recently, with all the continuous variables set at their mean values. Table 6 has the revised predictions.

In this first case, people lived on average 79 months longer if they did not reside in a NH. Of this difference, 43 months is lost in NHs, independently of any degree of dementia symptoms. For those in stage 4 dementia in NHs, they would expect to live 91 months longer (146–55) than if they had been in stage 1. This group would have lived 16 months longer (71–55) if they did not live in NHs. Again, NHs have the effect of making the consequences of dementia symptoms worse by reducing life expectancy.

For the lower bound, we take the primary estimates in Table 4 and simply use visit 1 rather than visit 3 in the predictions. This involves replacing visit 1 = 0 with visit 1 = 1, and visit 3 = 1 with visit 3 = 0. As we explained in section II D, this corresponds to the experience of those that are least healthy in our sample, and thus represents the worst-case scenario. Table 7 has the resulting predictions.

In this second case, people lived on average 16 months longer if they did not reside in a NH. Of this difference, 9 months is lost in NHs, independently of any degree of dementia symptoms. For those in dementia stage 4 in NHs, they would expect to live 14 months longer (42–28) than if they had been in stage 1. This group would have lived 6 months longer (34–28) if they did not live in NHs. Once more, NHs have the effect of making the consequences of dementia symptoms worse.

To summarize, in neither of the plausible alternatives is there evidence that life expectancy does not fall by an older adult living in a NH and not elsewhere.

Valuing the life expectancy loss

The 3.4 years (41 months) of loss of life expectancy from the primary estimates, arising from residence in NHs, can be monetarized using the Value of a Statistical Life (VSL) literature – see Viscusi (2018). The VSL is mainly based on labour market data, based on revealed preferences by workers trading-off a specified (small) risk of loss of life for additional wages. Aldy and Viscusi (2008) provided VSL estimates that varied by age and cohort. The Environmental Protection Agency took a central figure from this study and undated it to 2016 prices to obtain a VSL estimate of $8.3 million.[14]

From the VSL can be derived the Value of a Statistical Life Year (VSLY) which we need to value our estimate of loss of life expectancy. The relationship between the VSL and VSLY is given by:

$$\text{VSLY} = \frac{rVSL}{1-(1+r)^{-L}} \tag{7}$$

where r is the discount rate and L is the remaining life expectancy of the person involved in the valuation. Aldy and Viscusi, as well as Hirth et al. (2000), used the standard discount rate applied in health

[14]US Department of Health and Human Services, Food and Drug Administration. (2016).

care evaluations of r = 3%, as recommended by Gold et al. (1996).[15] This leaves the number for L to be determined.

There are two ways of proceeding. The first is to use an equity approach for L, whereby every older adult's VSLY is given equal importance, irrespective of the actual life expectancy any older person has left. The oldest age cohort covered by Aldy and Viscusi in their VSL estimates was 55 to 62 years. For persons 62 years of age, their life expectancy is 23 years.[16] With VSL = $8.3 million, r = 3%, and L = 23 years, equation (7) produces a VSLY estimate of $500,000.

The second way to fix L is to use an efficiency approach, which is to derive a person's willingness to pay for a reduction in lifetime risk by the actual life expectancy a person has left. Based on a person in our sample, with their corresponding health states that we observed, Table 5 tells us that, for a person not living in a NH, L = 9.8 years (118 months). The VSLY estimate is now $990,000. The reason why the efficiency estimate is higher than the equity estimate is because, built into equation (7), is the assumption of the diminishing marginal utility of a LY; the fewer remaining life years a person has, the more is the additional value of a LY.

As a conservative estimate, we will use the equity-based valuation of $500,000. This amount is very close to the $490,000 figure recommended in the guidelines by the US Department of Health and Human Services (2016b).[17] The value of the 3.4 years of foregone life expectancy by living in a NH is $1.7 million per person. Using the McCreedy et al. (2018) estimate of 1.1 million people living in NH's in the US, society is losing $1.87 trillion by placing people in nursing homes. The importance of this valuation is that it specifies the enormous potential benefits to be obtained by implementing any kind of improvements in NH life-saving efficiency that require significant additional costs. The possible interventions could be: setting minimum staffing regulations (Matsudaira 2014); changing the current organizational structure of the industry (Lin 2015); promoting unionization (Sojourner et al. 2015); preventing private equity ownership (Huang and Bowblis 2019); or simply just refusing to send an older adult to a NH if at all feasible, as the results of our paper could imply.

IV. Summary and conclusions

It is now well known that life expectancy declines when someone is admitted to a NH. The appropriate research questions involve trying to find out the extent of this decline, and attempting to understand why this decline takes place. In this paper, we presented evidence that the life expectancy decline is large, amounting to 45 months. This initial estimate does not control for any factors that are known to affect life expectancy, such as a person's health state.

In response to the main hypothesis that any loss of life can be explained by the poorer health states of the populations residing in NHs, especially in terms of dementia prevalence, we find little support. The main hypothesis can be rejected because, even controlling for many factors that determine a person's health state, life expectancy would still be reduced by 41 months from what it otherwise would have been if residing outside a NH. Surprisingly, the skilled nursing that is supposed to take place, and justify the very existence of NHs, had a worse impact than unskilled family care, or even no care at all. One would have expected the loss of life expectancy with skilled nursing in NHs to have increased life expectancy, and not lowered it by 41 months. In neither of our plausible alternative estimates did life expectancy not fall by being in a NH.

Existing NHs are therefore grossly ineffective in preserving the lower life expectances that older adults already have. What makes our evidence convincing is the large sample size and the duration of our data set. We were able to track, for some persons over a 12-year period, both what the health states were prior to admittance to a NH, and also after residing in the NH until the time of death. Having this data available meant that we were able

[15]See Brent (2014).
[16]Based on the Social Security Actuarial Life Tables (2016) for 2013.
[17]I thank V. Kip Viscusi for drawing my attention to this DHHS estimate. This number appears in Table 3.2 of the guidelines. In a private communication, he also endorses the $500,000 valuation of a life year.

to use a parametric survival model that contained time varying covariates to accompany NH residence. In this way, we could explain the risk of dying at each time period according to a person's health state and place of residence. The effect of residency could then be isolated and its separate impact on life expectancy ascertained.

The health state variable that we focused on as the main contribution to mortality in this paper was dementia severity. Dementia is currently the number three cause of death in the US, and this is already the number one cause of death in England and Wales, see the Office for National Statistics (2016). To analyse the impact of dementia on mortality we broke down our CDR-SB measure into four categories, ranging from none to serious. We confirmed that people with serious dementia were more likely to reside in NHs, and they were more likely to have fewer years of life expectancy wherever they resided. However, they would have had 14 more months of life expectancy if they had not lived in NHs. A loss of 14 months can be important if you only otherwise would have lived 88 months. It would seem that taking advantage of the diminished cognitive capacity of those with dementia is an important mechanism that this paper has uncovered as to how NHs lower life expectancy.

The 3.4 years weighted average of lost life expectancy was valued using the VSL literature. Based on an EPA VSL of $8.3 million for 2016, a VSLY was obtain of $500,000. The value of the years of life lost was estimated to be $1.7 million per person. Aggregated across all persons living in NHs, produced a national loss of value of $1.87 trillion. This sum can be considered extremely large, given that this loss was exactly 10% of the entire national income for the US in 2016, which was around $18.7 trillion. As the population continues to live longer, more and more people will be entering NHs. Unless there is some improvement in the quality of care in NHs, and there are many studies we cited that confirm that the quality of care in NHs is lacking, one can expect that the NH loss of life expectancy will grow exponentially.

In a recent analysis of why mortality rates fall during recessions, by Stevens et al. (2015), they found that transitions to NHs rise when unemployment is higher. During recessions, employment levels in skilled nursing facilities goes up and this is a major reason why mortality rates go down at this time. Thus, what happens to older adults in NHs is the main reason why mortality is procyclical in the US. This research's finding has particular relevance for this paper. It not only shows that the increased mortality from NH residence, that we uncovered, contributes largely to the overall national mortality rate; it also explains that the staffing levels of skilled nursing in NHs helps determine NH mortality rates. NH effectiveness in preserving life expectancy would be improved if both the quantity and quality of skilled nursing care were enhanced.

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References

Aldy, J. E., and W. K. Viscusi. 2008. "Adjusting the Value of a Statistical Life for Age and Cohort Effects." *Review of Economics and Statistics* 90 (3): 573–581. doi:10.1162/rest.90.3.573.

Alzheimer's Association. 2018. "2018 Alzheimer's Facts and Figures." *Alzheimer's Dementia* 14 (3): 367–429. doi:10.1016/j.jalz.2018.02.001.

Beekly, D. L., E. M. Ramos, W. W. Lee, W. D. Deitrich, M. E. Jacka, J. Wu, J. L. Hubbard et al. 2007. "The National Alzheimer's Coordinating Center (NACC) Database: The Uniform Data Set." *Alzheimer Disease and Associated Disorders* 21 (3): 249–258. DOI:10.1097/WAD.0b013e318142774e.

Brent, R. J. 2014. *Cost-Benefit Analysis and Health Care Evaluations*. 2nd ed. Cheltenham, UK: Edward Elgar.

Brent, R. J. 2018a. "The Value of a Year's General Education for Reducing the Symptoms of Dementia." *Applied Economics* 50 (25): 2812–2823. doi:10.1080/00036846.2017.1409420.

Brent, R. J. 2018b. "Estimating the Monetary Benefits of Medicare Eligibility for Reducing the Symptoms of Dementia." *Applied Economics* 50 (58): 1–14. doi:10.1080/00036846.2018.1489519.

Brent, R. J. 2019a. "A CBA of Hearing Aids, Including the Benefits of Reducing the Symptoms of Dementia." *Applied Economics* 51 (28): 1–13. doi:10.1080/00036846.2018.1564123.

Brent, R. J. 2019b. "Behavioral versus Biological Definitions of Dementia Symptoms: Recognizing that Worthwhile Interventions Already Exist." *OBM Geriatrics* 3 (4): 1. doi:10.21926/obm.geriatr.1904079.

Brent, R. J. 2020. "A CBA of Corrective Lenses, Including the Benefits for Reducing the Symptoms of Dementia." *Applied Economics* 52 (48): 5218–5229. doi:10.1080/00036846.2020.1761533.

Cutler, D., A. Deaton, and A. Lleras-Muney. 2006. "The Determinants of Mortality." *Journal of Economic Perspectives* 20 (3): 97–120. doi:10.1257/jep.20.3.97.

Eggleston, K. N., and V. R. Fuchs. 2012. "The New Demographic Transition: Most Gains in Life Expectancy Now Realized Late in Life." *Journal of Economic Perspectives* 26 (3): 137–156. doi:10.1257/jep.26.3.137.

Gold, M. R., J. Siegel, L. Russell, and M. C. Weinstein. 1996. *Cost-Effectiveness in Health and Medicine*. New York: Oxford University Press.

Hicks, K. L., P. V. Rabins, and B. S. Black. 2010. "Predictors of Mortality in Nursing Home Residents with Advanced Dementia." *American Journal of Alzheimer's Disease & Other Dementias* 25 (5): 439–445. doi:10.1177/1533317510370955.

Hirth, R. A., E. Michael, M. E. Chernew, E. Miller, Fendrick, A.M., W. G. Weissert. 2000. "Willingness to Pay for a Quality Adjusted Life Year: In Search for a Standard." *Medical Decision-Making* 20 (3): 332–342. DOI:10.1177/0272989X0002000310.

Huang, S. S., and J. R. Bowblis. 2019. "Private Equity Ownership and Nursing Home Quality: An Instrumental Variables Approach." *International Journal of Health Economics and Management* 19 (3–4): 273–299. doi:10.1007/s10754-018-9254-z.

James, B. D., S. E. Leurgans, L. E. Hebert, P. A. Scherr, K. Yaffe, and D. A. Bennett. 2014. "Contribution of Alzheimer Disease to Mortality in the United States." *Neurology* 82 (12): 1045–1050. doi:10.1212/WNL.0000000000000240.

Lancaster, T. 2000. "The Incidental Parameters Problem Since 1948." *Journal of Econometrics* 95 (2): 391–413. doi:10.1016/S0304-4076(99)00044-5.

Lin, H. 2015. "Quality Choice and Market Structure: A Dynamic Analysis of Nursing Home Oligopolies." *International Economic Review* 56 (4): 1261–1290. doi:10.1111/iere.12137.

Matsudaira, J. D. 2014. "Government Regulation and the Quality of Healthcare: Evidence from Minimum Staffing Legislation for Nursing Homes." *Journal of Human Resources* 49 (1): 32–72. doi:10.1353/jhr.2014.0003.

McCreedy, E. M., B. E. Weinstein, J. Chodosh, and J. Blustein. 2018. "Hearing Loss: Why Does It Matter for Nursing Homes?" *Journal of the American Medical Directors Association* 19 (4): 323–327. doi:10.1016/j.jamda.2017.12.007.

Mitchell, S. L., J. M. Teno, S. C. Miller, and V. Mor. 2005. "A National Study of the Location of Death for Older Persons with Dementia." *Journal of the American Geriatrics Society* 53 (2): 299–305. doi:10.1111/j.1532-5415.2005.53118.x.

Morris, J. C. 1997. "Clinical Dementia Rating: A Reliable and Valid Diagnostic and Staging Measure for Dementia of the Alzheimer Type." *International Psychogeriatrics* 9 (Suppl.1): 173–176. doi:10.1017/S1041610297004870.

Morris, J. C., S. Weintraub, H. C. Chui, J. Cummings, C. DeCarli, S. Ferris, N. L. Foster et al. 2006. "The Uniform Data Set (UDS): Clinical and Cognitive Variables and Descriptive Data from Alzheimer Disease Centers." *Alzheimer Disease and Associative Disorders* 20 (4): 210–216. DOI:10.1097/01.wad.0000213865.09806.92.

Office for National Statistics. 2016. *Statistical Bulletin. Deaths Registered in England and Wales (Series DR): 2015*. Release date 14 November 2016.

Shaw, J. W., W. Horrace, and R. J. Vogel. 2005. "The Determinants of Life Expectancy: An Analysis of OECD Health Data." *Southern Economic Journal* 71 (4): 768–783.

Shuang, L., A. Middleton, K. J. Ottenbacher, and J. S. Goodwin. 2018. "Trajectories over the First Year of Long-term Care Nursing Home Residence." *Journal of the American Directors Association* 19 (4): 333–341. doi:10.1016/j.jamda.2017.09.021.

Social Security Actuarial Life Tables. 2016. Accessed 27 June 2018www.ssa.gov/OACT/STATS/table4c6.html .

Sojourner, A. J., B. R. Frandsen, R. J. Town, D. C. Grabowski, and M. M. Chen. 2015. "Impacts of Unionization on Quality and Productivity: Regression Discontinuity Evidence from Nursing Homes." *International Labor Relations Review* 68 (4): 771–806. doi:10.1177/0019793915586380.

Stevens, A. H., D. L. Miller, M. E. Page, and M. Filipski. 2015. "Best of Times, the Worst of Times: Understanding Procyclical Mortality." *American Economic Journal: Economic Policy* 7 (4): 279–311.

US Department of Health and Human Services. 2016b. *Guidelines for Regulatory Impact Analysis*. Office of the Assistant Secretary for Planning and Evaluation. Washington DC.

US Department of Health and Human Services, Food and Drug Administration. 2016a. "Use of Materials from Cattle in Human Food and Cosmetics." *Federal Register* 81 (53): 14718–14732.

Viscusi, W.K. 2018. Pricing Lives: Guideposts for a Safer Society. Princeton University Press

Vossius, C., G. Selbeck, J. S. Benth, and S. Bergh. 2018. "Mortality in Nursing Home Residents: A Longitudinal Study over Three Years." *PLoS One* 13 (9): e0203480. doi:10.1371/journal.pone.0203480.

Weintraub, S., D. Salmon, N. Mercaldo, S. Ferris, N. R. Graff-Radford, H. Chui, J. Cummings et al. 2009. "The Alzheimer's Disease Centers' Uniform Data Set (UDS): The Neuropsychological Test Battery." *Alzheimer Disease and Associative Disorders* 23 (2): 91–101. DOI:10.1097/WAD.0b013e318191c7dd.