Article:

Turner, AJ, Nikolova, S and Sutton, M (2016) The effect of living alone on the costs and benefits of surgery amongst older people. Social Science and Medicine, 150. pp. 95-103. ISSN 0277-9536

https://doi.org/10.1016/j.socscimed.2015.11.053

ABSTRACT

Older people who live alone are a growing, high-cost group for health and social services. The literature on how living alone affects health and the costs and benefits of healthcare has focused on crude measures of health and utilisation and gives little consideration to other cost determinants and aspects of patient experience. We study the effect of living alone at each stage along an entire treatment pathway using a large dataset which provides information on pre-treatment experience, treatment benefits and costs of surgery for 105,843 patients receiving elective hip and knee replacements in England in 2009 and 2010. We find that patients who live alone are healthier prior to treatment and experience the same gains from treatment. However, living alone is associated with a 9.2% longer length of in-hospital stay and increased probabilities of readmission and discharge to expensive destinations. These increase the costs per patient by £179.88 (3.12%) and amount to an additional £4.9 million per annum. The post-discharge support of this population group requires further examination.

KEY WORDS

England; living alone; benefits; costs; post-discharge support.

1. INTRODUCTION

Since 1950, the number and proportion of the elderly population that are living alone has increased considerably (Bureau of the Census, 1989; Grundy, 2000; United Nations, 2005) and the living arrangements of older people have been recognised as a pressing concern (United Nations, 2005). Recent work by Laporte et al., (2008) suggests that the costs generated by living alone are likely to be exacerbated in future cohorts of older people as individual social capital continues to erode for each succeeding age group down to early adulthood.

Much of the literature on living alone has focused on its effects on health. However, evidence regarding these health effects is mixed. Several studies have found that older adults who live alone are more likely to experience poor physical and emotional health (Kharicha et al., 2007), cognitive decline (van Gelder et al., 2006), death (Lund et al., 2002), multiple falls and several chronic conditions (Kharicha et al., 2007), and are less likely to improve in Activities of Daily Living (ADL) following discharge (Mahoney, Eisner, Havighurst, Gray, & Palta, 2000). Men living alone are also less likely to survive following a myocardial infarction (Kilpi, Konttinen, Silventoinen, & Martikainen, 2015). Other studies suggest that living alone at older ages is associated with lower mortality risk (Davis & Moritz, 1997; Li, Zhang, & Liang, 2009; Walter-Ginzburg, Blumstein, Chetrit, & Modan, 2002), lower risk of declines in mental health (Michael, Berkman, Colditz, & Kawachi, 2001), fewer functional disabilities and higher cognitive competence (Lawton, Moss, & Kleban, 1984), and better quality of life (Cantor & Little, 1985). Further studies have found no assoication between living alone and changes in self-rated health (Hughes & Waite, 2002), and the number of major physical diagnosis (Iliffe et al., 1992).

Unmeasured heterogeneity may partially account for the discrepancies in results. Associations between living arrangements and health may be the result of unobserved characteristics that are related to both an individual's health and to the individual's choice to live alone (Lawton et al., 1984). Thus, longitudinal studies that control for baseline health characteristics, have more power than cross-sectional studies to identify the causal relationship. In addition, findings regarding the impact of living arrangements on health could be subject to reverse causality, since health might affect an individual's decision to live alone (Steinbach, 1992;

Wolinsky, Callahan, Fitzgerald, & Johnson, 1993). However, Li *et al.* (2009) repeated their analysis on a sample of elderly people who had no health problems at baseline, and find no evidence of reverse causality.

The evidence of the effect of living alone on healthcare utilisation is much clearer. Living alone has been found to be associated with significantly higher physician visits amongst older adults (Cafferata, 1987; Guzman, Sohn, & Harada, 2004). Both longitudinal studies (Hastings & George, 2008) and cross-sectional studies (Wakabayashi et al., 2011) have found that the elderly living alone visit emergency departments more frequently. Older people living alone have also been found to be at an increased risk of admission to a nursing home following hospitalisation (Mahoney et al., 2000). The limited number of studies examining the effect of living alone on other determinants of healthcare costs have found it to be associated with extended length of stay (Lim, Doshi, Castasus, Lim, & Mamun, 2006; Schwanhaeuser, Murray, & Ormiston, 2002), and more frequent readmissions (Murphy et al., 2008).

Previous studies have focused primarily on measures of utilisation to study the effects of living alone on healthcare costs. However, healthcare costs are not only determined by the frequency of contact with health services, but also the cost of a treatment episode which depends on a variety of cost-drivers. In addition, previous studies have focused on a single indicator of health as the measure of patient benefit. Although health is arguably the most important outcome of treatment, other factors such as time spent waiting for treatment and/or in sub-optimal health, patient experience and patient satisfaction are also important outcomes for patients (Darzi, 2008). Furthermore, no previous study has evaluated the effects of living alone on costs and benefits in the same group of patients. This study extends the literature on living alone amongst older people by following the same group of patients along an entire treatment pathway and assessing the effect of living alone on a wide set of costs and benefits.

The limitations in the previous literature may be due to a lack of information at an individual level in administrative datasets. Since 1 April 2009, all providers of publicly-funded inpatient care in England have been required to collect data on a range of patient-reported outcome measures (PROMs) for all patients undergoing four elective interventions: unilateral hip replacements; unilateral knee replacements; varicose vein surgery; and groin hernia repairs. Data are collected via two paper-based questionnaires, one completed prior to surgery and the other approximately six months after surgery (Appleby & Devlin, 2004). The inclusion of a question on living arrangements presents a unique opportunity to follow patients along the entire treatment pathway, and study the effects of living alone on a wide range of indicators of costs and benefits in the same patient population.

We focus on patients undergoing a hip or knee replacement and identify whether older patients who live alone have different levels of health prior to treatment, experience different levels of treatment benefit, and generate greater costs to the health service compared to those who live with others. The availability of a wide range of baseline health measures collected in the pre-operative questionnaire means that estimates of the effects of living alone on many outcomes are plausibly causal.

2. DATA

Patient-level PROMs data were obtained from the NHS Health and Social Care Information Centre (HSCIC) (HSCIC, 2013c) for all patients in England undergoing hip or knee replacement paid for by the NHS in the financial years 2009/10 and 2010/11. These data were linked at patient level to administrative data in Hospital Episode Statistics (HES) (HSCIC, 2013a). The PROMs programme requires all providers of publicly-funded inpatient care to offer a pre-operative survey to all patients deemed fit for surgery. This occurs either on the day of admission or at any time in the interval between a patient being considered fit for surgery and the intervention taking place (Department of Health, 2008). Post-treatment data for hip and knee replacement patients are collected by the HSCIC via a postal survey approximately six months after surgery. The pre-operative questionnaire includes several health measures, including disability, symptom severity, general health, health-related quality of life, and co-morbid conditions. It also records responses to a range of non-health-related questions such as whether they have been assisted in completing the questionnaire. The post-operative questionnaire records responses for the same set of questions as the pre-operative questionnaire, and a range of questions assessing both the success of treatment and the patient's overall experience with the services they received. Patients also record their current living arrangements in both the pre-operative and post-operative questionnaires. A full list of variables included in both questionnaires is available online (HSCIC, 2010).

The main variable of interest, living alone, was taken from a question asking patients to report their living arrangements from a list of four options: living alone; living with a partner/spouse/family/friend; living in a nursing home, hospital or other long-term care home; or, "other" living arrangement. Those with living arrangements other than "living alone" (LA) are banded into one broad category, "not living alone" (NLA). To mitigate concerns over possible reverse causality, the living alone indicator was defined on pre-operative living arrangements. Conditioning on pre-treatment living arrangements creates "temporal separation of living arrangements from the assessment of health" (Hughes and Waite, 2002; p.6), which is a necessary, but not sufficient, condition for exogeneity in the presence of reverse causality (Antonakis, Bendahan, Jacquart, & Lalive, 2010).

Pre-operative health was measured using the Oxford Hip Score (OHS) and Oxford Knee Score (OKS). These measure symptom severity for hip and knee problems through a series of 12 questions (Dawson, Fitzpatrick, Carr, & Murray, 1996; Dawson, Fitzpatrick, Murray, & Carr, 1998). Responses to these questions are scored from 0 (most severe symptoms) to 4 (no symptoms) and were summed to create an overall score ranging from 0 (worst health state) to 48 (best health state).

Pre-treatment benefits were measured using the duration over which patients experience symptoms prior to treatment and the waiting time for treatment. Patients reported the duration of their symptoms in the pre-operative questionnaire in one of four categories: less than 1 year; 1-5 years; 5-10 years; or more than 10 years. The waiting time between the date on which the specialist decided to admit the patient and the admission date was obtained from HES. Lower values of these measures were assumed to be beneficial to patients.

Costs were measured using patients' lengths of in-hospital stay (LOS) and the probabilities of discharge to an expensive location, readmission, repeat surgery, and treatment-related complications. Information on readmissions and further surgeries were taken from the post-operative PROMs questionnaire, which asks patients whether they have been readmitted to hospital and whether they have required surgery on their hip or knee following discharge. HES records information on both the destination from which patients are admitted and the destination of discharge. A discharge was deemed expensive if the latter places greater costs on the State than the former. We defined this as being admitted either from home or from a temporary place of residence and discharged to an NHS, local authority, or non-NHS nursing home. Complications are self-reported in the post-operative PROMs questionnaire under four categories: allergic reaction to drugs; bleeding after surgery; urinary problems; and wound problems.

Finally, we examined whether older patients who live alone receive different levels of benefit from treatment, measured by health improvement, patient satisfaction, and their perception of treatment success in the post-operative PROMs questionnaire. Health improvement was measured using post-operative OHS or OKS after conditioning on their pre-operative values. Satisfaction with treatment was recorded on a scale of "excellent", "very good", "good", "fair", or "poor". Perceptions of treatment success were determined through asking patients how their hip/knee problems are now compared to before their operation, on a scale of "much better", "a little better", "about the same", "a little worse", or "a lot worse". Figure 1 shows the timings of the key outcomes.

< INSERT FIGURE 1 HERE >

In line with the age of inclusion in the English Longitudinal Study of Aging (ELSA), we defined older patients as those older than 50 years (95% of the sample) (NatCen, 2012). Observations with waiting times greater than two years (0.08%) and lengths of stay exceeding 200 days (0.003%) were dropped as these were most likely coding errors. This resulted in 105,843 observations. For all outcomes, a complete case analysis was conducted, and so only observations with complete data on both the outcomes and all control variables were used.

3. METHODS

3.1. REGRESSION METHODS

We specified the following generalized linear model:

$$\boldsymbol{E(Y_i) = g^{-1}(\beta' X_i + \gamma LA_i)} \qquad (1)$$

where $E(Y_i)$ is the expected value of a key outcome of interest for individual i and $g^{-1}(.)$ is a link function. $LA_i = 1$ if patient i reports living alone in the pre-operative questionnaire, and 0 otherwise. $\boldsymbol{X_i}$ represents a vector of health and socio-demographic characteristics, collected in both HES and PROMs, which pre-determine the outcome.

Given the variation in the time at which outcomes are recorded, the set of characteristics used as controls differed between outcomes (see Table I). Patient characteristics, such as age, gender, ethnicity and local-area deprivation were controlled for in all outcome equations, as were whether the patient was undergoing a revision surgery, or had had previous surgery on their hip/knee. All outcomes were also adjusted for the measures of baseline health that could plausibly be viewed as independent of the baseline severity of hip/knee problems, namely dummy variables for a number of self-reported comorbidities.

The analyses of the pre-operative OHS and OKS and length of symptoms were not adjusted for baseline measures of health that could be correlated with the baseline severity of hip/knee problems, namely self-reported disability, dimensions of the EQ-5D, the EQ-VAS and self-reported general health, as there was a concern over reverse causality. All analyses of the post-operative cost and benefit outcomes were adjusted for all pre-operative outcomes, as well as all measures of baseline health. The month of questionnaire completion and whether a patient was assisted in completing the questionnaire were included amongst the covariates. All outcomes derived from HES, namely waiting times, LOS and expensive discharge, were adjusted for the month of admission. Cubic functions of the pre-operative OHS and OKS were included in the models for the post-operative OHS and OKS. Given that data for hip and knee replacement patients were pooled for non-condition-specific post-operative outcomes, resulting in missing data for either the pre-operative OHS or OKS, these post-operative outcomes were not adjusted for pre-operative OHS and OKS. However, controlling for these variables in separate analyses on hip and knee replacement patients had no effect on the results.

In all cases the primary interest was γ, the coefficient on the living alone indicator, LA_i. Given no temporal separation between the pre-operative outcomes and the living alone indicator, this coefficient is unlikely to represent a causal effect for these outcomes. However, for post-operative outcomes causality is more plausible. Given that a wide-range of patient and provider characteristics were controlled for, including a rich set of baseline health measures, bias due to omitted variables is unlikely.

< INSERT TABLE I HERE >

Equation (1) was estimated using different techniques depending on the nature of the dependent variable. Ordinary Least Squares (OLS) was used for waiting times, LOS, and the pre- and post-operative OHS and OKS. For waiting times and LOS, a logarithmic transformation was applied due to the skewness of their distributions. For readmission, further surgery, experiencing any post-operative complication, and expensive discharge, a probit regression was estimated. For the post-operative complications, the data were reshaped to the patient-complication level. An ordered probit model was used for satisfaction with surgery, success of the procedure, and the length of symptoms. Marginal effects were calculated, which assessed the effect of living alone on the probability of "excellent" satisfaction, "much better" treatment success and length of symptoms of "less than 1 year".

3.3. QUANTIFYING COSTS

Where living alone was found to have a statistically significant effect on cost indicators, a costing exercise was conducted taking the NHS and social services as the primary perspective (NICE 2013). Additional costs which fall on providers were also considered, in line with frameworks adapted for assessing the cost-effectiveness of pay-for-performance schemes (Meacock, Kristensen, & Sutton, 2014). Costs were divided between those which fall on the payer and those which fall on providers.

In the English NHS, healthcare providers are paid a fixed tariff per hospital episode based on the healthcare resource group (HRG) assigned to the primary condition treated (HSCIC, 2013b). Costs for LOS up to a HRG-specific trim-point are covered by this tariff and therefore fall on providers. For each day exceeding the trim-point, providers receive an additional "per diem" payment. Therefore, costs for extended LOS fall on the payer.

As readmissions and further surgery amount to a separate hospital episode, the costs of these fall on the payer. The NHS pays providers a higher tariff for patients with complications, with this increase differing depending on HRG, and so the costs of complications again fall on the payer. Due to lack of data on unit-costs, the costs of discharge to a more expensive location were not included in our calculations.

The cost figures were extracted from the National Reference Cost dataset and were linked to the PROMs-HES dataset using HRG codes. The 2009/10 and 2010/11 tariffs were applied to patients admitted in the respective financial years.

The average per-patient effect of living alone on readmission costs was calculated by multiplying the estimated marginal effect of living alone on the probability of readmission by the average cost of a readmission, which is a weighted average of the tariffs for the relevant HRGs. A similar method was used for the average per-patient costs of further surgery and complications.

The average per-patient effect of living alone on LOS costs was obtained by regressing provider- and payer-attributed costs on the living alone indicator and all of the controls used in the original LOS regression (Table I). The estimated coefficient on the living alone indicator captures the average per-patient effect of living alone on LOS costs.

The total effect of living alone for each cost indicator was calculated by multiplying the average per-patient costs by the total number of patients in our sample who live alone.

4. RESULTS

4.1. DESCRIPTIVE STATISTICS

Patients living alone account for 26.67% of the sample. They tend to be older, from more deprived areas, are less likely to be male, and are more likely to receive assistance with the pre-operative questionnaire (Table II). Levels of baseline health are also lower, with lower levels of general health and higher probabilities of depression, circulation problems and disability.

< INSERT TABLE II HERE >

Those living alone report slightly less severe pre-operative severity of their hip/knee symptoms. They also report shorter symptom duration, but differ little from those with other living arrangements in terms of waiting time for treatment (Table III). They report similar benefits from treatment, but seem to be more costly, with longer LOS and higher probabilities of readmission and expensive discharge.

< INSERT TABLE III HERE >

4.2. REGRESSION RESULTS

The multivariate regressions show that patients living alone are in better pre-operative health, scoring on average 0.61 and 0.26 points higher on the OHS and OKS, respectively (Table IV). No statistically significant differences between those living alone and those not living alone are found for waiting times for treatment. The results also indicate that those living alone do not experience symptoms for a statistically significant longer period of time.

< INSERT TABLE IV HERE >

The regression results for the cost outcomes confirm that patients who live alone are significantly more costly to the healthcare system. These patients have 9.2% longer LOS, are 0.6 percentage points more likely to be readmitted, and are 0.5 percentage points more likely to be discharged to a destination more expensive than the destination from which they were admitted. Given baseline rates of readmission and expensive discharge of 8.56% and 0.18% for those not living alone, respectively, these absolute effects represent relative risk increases of 7% and 278%, respectively. However, no statistically significant differences in rates of treatment-related complications or rates of further surgery were found.

Despite imposing greater costs on the NHS, patients living alone do not derive greater benefit from treatment, with no statistically significant differences found in health improvement (on both the OHS and OKS), the probability of reporting a satisfaction rating of "excellent", and the probability of reporting that their condition had become "much better".

4.3. COSTS

The total cost of treating all patients in our dataset is £515million, equating to £5,758 per patient. Living alone increases healthcare costs by £179.88, representing a 3.12% increase per patient. The majority of these costs fall on the provider through extended LOS within the HRG-specific trim-points (£163.27), with the rest falling on the payer through extended LOS above these trim-points (£6.22), and an increased rate of readmission (£10.39). Applying this to all patients living alone generates a total cost to providers and the NHS of approximately £4.9million. This impact does not include the increased probability of an expensive discharge, so this cost estimate is likely to underestimate the total effect of living alone on costs.

5. DISCUSSION

This study extends the literature on living alone amongst older people by following a large nationally-representative sample of patients along an entire treatment pathway in order to assess the impact of living alone on a wider set of costs and benefits amongst the same group of patients.

We find that older patients who live alone are healthier when they receive surgery relative to those with other living arrangements. Individuals who live alone may be more sensitive to deteriorations in health and thus seek medical care at higher levels of health (Iliffe et al., 1992; Walter-Ginzburg et al., 2002). However, conditional on their pre-operative health, providers do not schedule these patients in later for treatment. Patients' living arrangements do not routinely influence consultants' decisions regarding waiting time for surgery. Consistent with other studies, our findings suggest that those who live alone experience extended in-hospital stay (Lim et al., 2006; Schwanhaeuser et al., 2002). Providers may be reluctant to discharge patients back to their home environment, as they perceive no community support structures in place to counteract the absence of support from cohabitants (Forrest, Roque, & Dawodu, 1999).

In line with previous literature, after controlling for health at baseline, post-operative self-reported health does not differ significantly between those who do and do not live alone (Davis & Moritz, 1997; Hughes & Waite, 2002). Similar results emerge for patient satisfaction and self-reported success of treatment. In terms of clinical outcomes, no statistically significant differences in rates of treatment-related complications and further surgery were found, but readmission rates were significantly higher for those living alone. This is consistent with results in Murphy *et al.* (2008). However, higher rates of readmission cannot be solely attributed to the provider (Garrison, Mansukhani, & Bohn, 2013), and thus these results may not be a sign of inequitable treatment. Although the quality of in-hospital care is one factor influencing readmissions, this also depends on recovery out of hospital. It could be that a lack of community-based support means patients living alone are more susceptible to health shocks which require hospital admission. However, these health shocks appear to be independent of patients' hip/knee problems, as living alone is not associated with either poorer health improvements or higher rates of further surgery.

Although this study represents a considerable extension of the previous literature, a number of limitations remain. Firstly, a primary concern with the use of PROMs is that of missing data. The PROMs dataset suffers from two types of non-response: unit non-response, where missing data is generated from patients failing to complete either the pre-operative or post-operative questionnaire; and item non-response, where patients complete each questionnaire but fail to provide data on all variables required for estimation. We assumed that the data were missing at random (MAR), implying that non-response is determined only by observable factors. Under MAR, a complete case analysis can return unbiased estimates of the true effects of living alone, as long as all observed determinants of non-response are controlled for. We included a wide range of provider and patient characteristics, including all of those used by Hutchings et al (2012), to minimise the potential for unobserved determinants of non-response. The use of the MAR assumption is consistent with previous work on PROMs, where missing data have been addressed through multiple imputation methods (Gomes, Gutacker, Bojke, & Street, 2015).

Secondly, although the possibility of reverse causality is mitigated through defining the living alone indicator on pre-operative living arrangements, the possibility of its presence remains. However, only 2.6% of the sample switched live alone status between the pre and post-operative questionnaires and the magnitude of the improvements in health between the pre and post-operative questionnaires did not predict switching behaviour. As a result, it seems unlikely that the results are confounded by reverse causality.

Thirdly, we define our older population as those aged 50+. As a robustness check, we examined whether the results were robust to a change in the age cut-off used to define the older population. The results were qualitatively similar in terms of coefficient sign and significance for the populations aged 50-64 years and 65 years and over.

There is substantial heterogeneity in living arrangements in the non-living alone category, with this category covering those living with a partner/spouse/family/friend, those living in a care establishment and those with some undefined "other" living arrangement. Thus our definition may not reflect the full complexity of contemporary household structure. This is a limitation common in much of the previous literature on living arrangements (Hughes & Waite, 2002). As a robustness check we repeated our analysis using only living with a partner/spouse/family/friend as the base category. The results were unchanged.

The social capital literature suggests that substantial heterogeneity may also exist within the living alone category. Social capital has been interpreted both as a community-level concept, often proxied by area-level rates of engagement in voluntary organisations (Putnam, 2001), and an individual-level concept, often proxied by the number and presence of friends (Rose, 2000). Previous studies suggest that higher community-level social capital/lower individual-level social capital increases visits to general practitioners for elderly individuals, although no effects have been found on the intensity of hospital use (Laporte et al., 2008). A lack of data on measures of social capital precludes similar analysis with the PROMs dataset. However, although levels of social capital may be high irrespective of whether a patient lives alone, living alone indicates that immediate family support is missing, and so represents a good predictor of low levels of social capital (Laporte et al., 2008).

This study only examined the effects of living alone on the probability of a single readmission or further surgery and not the possibility of multiple readmissions or further procedures. Finally, due to a lack of data in the PROMs dataset, only cost impacts on the NHS were considered. Impacts on social care costs are therefore not measured, but represent an interesting avenue for further research.

6. CONCLUSION AND IMPLICATIONS FOR POLICY

We find that living alone increases healthcare costs significantly. The costs of extended LOS and higher rates of readmission fall on both healthcare providers and the payer. Cumulatively these costs amount to £4.9million, and represent an £180 (3.12%) increase in cost for each patient living alone.

Both of these impacts suggest a lower level of support for people who live alone. Delayed discharges and emergency hospital readmissions are caused, in part, by a lack of social care support and availability of home care. There has been a range of recent initiatives in England to respond to this challenge. In 2011, the Department of Health in England announced that commissioners were to be made responsible for securing post-discharge support for patients. A “post-discharge” fund, set up using savings from withholding reimbursement for emergency readmissions within 30 days of discharge, was to be reinvested for, amongst other things, homecare re-ablement and rehabilitation services (Department of Health, 2011). This policy was tightened in 2012/13, introducing transparency rules regarding the use of funds, and setting out local plans between PCTs, acute providers, GPs and local authorities, to provide seamless care to patients upon discharge (Department of Health, 2012). It also introduced post-discharge tariffs for four conditions (of which hip and knee replacement are two) transferring responsibility for rehabilitation services from PCTs and commissioners to the integrated provider trust from which the patient is discharged, and providing funding for rehabilitation pathways beyond 30 days. In 2013, a new £3.8 billion pooled budget for health and social care services was announced for 2015-16, accounting for 0.51% of all government spending for this period (HM Treasury, 2013). These additional funds aim to deliver more joined-up services to older and disabled individuals (HM Treasury, 2013).

However, none of these initiatives appears tailored specifically for the additional needs of older people who live alone. The risk-rating of emergency readmissions does not take account of patients’ living arrangements and the indicative care packages contained within the rehabilitation tariffs are not differentiated by whether patients live alone. Our findings suggest that specific attention should be given to this population group in these and future initiatives, including the possibility of increasing the post-discharge rehabilitation tariff for patients who live alone and negotiation of multilateral gain/loss sharing contracts.

6. REFERENCES

Antonakis, J., Bendahan, S., Jacquart, P., & Lalive, R. (2010). On making causal claims: A review and recommendations. *The Leadership Quarterly*, *21*(6), 1086–1120. doi:http://dx.doi.org/10.1016/j.leaqua.2010.10.010

Appleby, J., & Devlin, N. (2004). *Measuring success in the NHS: using patient assessed health outcomes to manage performance of healthcare provider*. London: Dr Foster.

Bureau of the Census. (1989). *Marital Status and Living Arrangements, Current Population Reports, Population Characteristics*. Washington, DC: United States Department of Commerce.

Cafferata, G. L. (1987). Marital status, living arrangements, and the use of health services by elderly persons. *Journal of Gerontology*, *42*(6), 613–618. doi:http://dx.doi.org/10.1093/geronj/42.6.613

Cantor, M., & Little, V. (1985). Aging and social care. In *Handbook of Aging and the Social Sciences* (pp. 745–781). New York: Van Nostrand Reinhold.

Darzi, A. (2008). *High quality care for all: NHS Next Stage Review final report*. London: Department of Health.

Davis, M. A., & Moritz, D. J. (1997). Living arrangements, changes in living arrangements, and survival among community dwelling older adults. *American Journal of Public Health*, *87*(3), 371–377.

Dawson, J., Fitzpatrick, R., Carr, A., & Murray, D. (1996). Questionnaire on the perceptions of patients about total hip replacement. *Journal of Bone & Joint Surgery, British Volume*, *78*(2), 185–190.

Dawson, J., Fitzpatrick, R., Murray, D., & Carr, A. (1998). Questionnaire on the perceptions of patients about total knee replacement. *Journal of Bone & Joint Surgery, British Volume*, *80*(1), 63–69.

Department of Health. (2008). *Guidance on the Routine Collection of Patient Reported Outcome Measures (PROMs)*. London: Department of Health.

Department of Health. (2011). *Department of Health Payment by Results team: Payment by Results Guidance for 2011-12*. London: Department of Health.

Department of Health. (2012). *Department of Health Payment by Results team: Payment by Results Guidance for 2012-13*. London: Department of Health.

Forrest, G. P., Roque, J. M., & Dawodu, S. T. (1999). Decreasing length of stay after total joint arthroplasty: effect on referrals to rehabilitation units. *Archives of Physical Medicine and Rehabilitation*, *80*(2), 192–194. doi:http://dx.doi.org/10.1016/S0003-9993(99)90120-X

Garrison, G. M., Mansukhani, M. P., & Bohn, B. (2013). Predictors of thirty-day readmission among hospitalized family medicine patients. *The Journal of the American Board of Family Medicine*, *26*(1), 71–77. doi:http://dx.doi.org/10.3122/jabfm.2013.01.120107

Gomes, M., Gutacker, N., Bojke, C., & Street, A. (2015). Addressing Missing Data in Patient Reported Outcome Measures (PROMS): Implications for the Use of PROMS for Comparing Provider Performance. *Health Economics*, *Early View*. doi:http://dx.doi.org/10.1002/hec.3173

Grundy, E. (2000). Living arrangements and the health of older persons in developed countries. *Population Bulletin of the United Nations*, *42*, 311–329.

Guzman, J. S., Sohn, L., & Harada, N. D. (2004). Living alone and outpatient care use by older veterans. *Journal of the American Geriatrics Society*, *52*(4), 617–622. doi:http://dx.doi.org/10.1111/j.1532-5415.2004.52172.x

Hastings, S. N., & George, L. K. (2008). Does lack of social support lead to more ED visits for older adults? *The American Journal of Emergency Medicine*, *26*(4), 454–461. doi:http://dx.doi.org/10.1016/j.ajem.2007.07.005

HM Treasury. (2013). *Spending Round 2013*. London: HM Treasury.

HSCIC. (2010). Data Dictionary: PROMs. Retrieved November 11, 2013, from http://www.hesonline.nhs.uk/Ease/servlet/ContentServer?siteID=1937&categoryID=289

HSCIC. (2013a). Hospital Episode Statistics home page. Retrieved November 11, 2013, from http://www.hscic.gov.uk/hes

HSCIC. (2013b). NHS Business Definitions. Retrieved November 10, 2013, from http://www.datadictionary.nhs.uk/data_dictionary/nhs_business_definitions/h/healthcare_resource_group_de.asp

HSCIC. (2013c). NHS information centre indicator portal. Retrieved November 11, 2013, from https://indicators.ic.nhs.uk/webview/

Hughes, M. E., & Waite, L. J. (2002). Health in household context: Living arrangements and health in late middle age. *Journal of Health and Social Behavior*, *43*(1), 1–21.

Iliffe, S., Tai, S. S., Haines, A., Gallivan, S., Goldenberg, E., Booroff, A., & Morgan, P. (1992). Are elderly people living alone an at risk group? *British Medical Journal*, *305*(6860), 1001–1004.

Kharicha, K., Iliffe, S., Harari, D., Swift, C., Gillmann, G., & Stuck, A. E. (2007). Health risk appraisal in older people 1: are older people living alone an “at-risk”group? *British Journal of General Practice*, *537*(57), 271–276.

Kilpi, F., Konttinen, H., Silventoinen, K., & Martikainen, P. (2015). Living arrangements as determinants of myocardial infarction incidence and survival: A prospective register study of over 300,000 Finnish men and women. *Social Science & Medicine*, *133*, 93–100. doi:http://dx.doi.org/10.1016/j.socscimed.2015.03.054

Laporte, A., Nauenberg, E., & Shen, L. (2008). Aging, social capital, and health care utilization in Canada. *Health Economics, Policy, and Law*, *3*(4), 393–411. doi:http://dx.doi.org/10.1017/S1744133108004568

Lawton, M. P., Moss, M., & Kleban, M. H. (1984). Marital status, living arrangements, and the well-being of older people. *Research on Aging*, *6*(3), 323–345. doi:http://dx.doi.org/10.1177/0164027584006003002

Li, L. W., Zhang, J., & Liang, J. (2009). Health among the oldest-old in China: Which living arrangements make a difference? *Social Science & Medicine*, *68*(2), 220–227. doi:http://dx.doi.org/10.1016/j.socscimed.2008.10.013

Lim, S. C., Doshi, V., Castasus, B., Lim, J. K. H., & Mamun, K. (2006). Factors causing delay in discharge of elderly patients in an acute care hospital. *Annals Academy Of Medicine Singapore*, *35*(1), 27–32.

Lund, R., Due, P., Modvig, J., Holstein, B. E., Damsgaard, M. T., & Andersen, P. K. (2002). Cohabitation and marital status as predictors of mortality—an eight year follow-up study. *Social Science & Medicine*, *55*(4), 673–679. doi:http://dx.doi.org/10.1016/S0277-9536(01)00219-2

Mahoney, J. E., Eisner, J., Havighurst, T., Gray, S., & Palta, M. (2000). Problems of older adults living alone after hospitalization. *Journal of General Internal Medicine*, *15*(9), 611–619. doi:http://dx.doi.org/10.1046/j.1525-1497.2000.06139.x

Meacock, R., Kristensen, S. R., & Sutton, M. (2014). The Cost-Effectiveness Of Using Financial Incentives To Improve Provider Quality: A Framework And Application. *Health Economics*, *23*(1), 1–13. doi:http://dx.doi.org/10.1002/hec.2978

Michael, Y. L., Berkman, L. F., Colditz, G. A., & Kawachi, I. (2001). Living arrangements, social integration, and change in functional health status. *American Journal of Epidemiology*, *153*(2), 123–131. doi:http://dx.doi.org/10.1093/aje/153.2.123

Murphy, B. M., Elliott, P. C., Le Grande, M. R., Higgins, R. O., Ernest, C. S., Goble, A. J., … Worcester, M. U. (2008). Living alone predicts 30-day hospital readmission after coronary artery bypass graft surgery. *European Journal of Cardiovascular Prevention & Rehabilitation*, *15*(2), 210–215. doi:http://dx.doi.org/10.1097/HJR.0b013e3282f2dc4e

NatCen. (2012). *English Longitudianl Study of Ageing. Wave One to Wave Five. User Guide to the Datasets.*

National Institute for Health and Care Excellence. (2013). Guide to the methods of technology appraisal. London: NICE.

Putnam, R. (2001). Social Capital Measurement and Consequences. *ISUMA: Canadian Journal of Policy Research*, *2*(1), 41–51.

Rose, R. (2000). How Much Does Social Capital Add to Individual Health? A Survey Study of Russians. *Social Science and Medicine*, *51*(9), 1421–1435. doi:http://dx.doi.org/10.1016/S0277-9536(00)00106-4

Schwanhaeuser, K., Murray, M., & Ormiston, M. (2002). A prospective audit of bed blocking in surgery. *Bulletin of The Royal College of Surgeons of England*, *84*(10), 340–341.

Steinbach, U. (1992). Social networks, institutionalization, and mortality among elderly people in the United States. *Journal of Gerontology*, *47*(4), 183–190. doi:http://dx.doi.org/10.1093/geronj/47.4.S183

United Nations. (2005). *Living Arrangements of Older Persons Around the World*. New York: United Nations.

Van Gelder, B. M., Tijhuis, M., Kalmijn, S., Giampaoli, S., Nissinen, A., & Kromhout, D. (2006). Marital status and living situation during a 5-year period are associated with a subsequent 10-year cognitive decline in older men: the FINE Study. *Journal of Gerontology Series B: Psychological Sciences & Social Sciences*, *61*(4), 213–219.

Wakabayashi, R., Motegi, T., Yamada, K., Ishii, T., Gemma, A., & Kida, K. (2011). Presence of In-Home Caregiver and Health Outcomes of Older Adults with Chronic Obstructive Pulmonary Disease. *Journal of American Geriatrics Society*, *59*(1), 44–49. doi:http://dx.doi.org/10.1111/j.1532-5415.2010.03222.x

Walter-Ginzburg, A., Blumstein, T., Chetrit, A., & Modan, B. (2002). Social Factors and Mortality in the Old-Old in Israel The CALAS Study. *The Journals of Gerontology Series B: Psychological Sciences & Social Sciences*, *57*(5), 308–318. doi:http://dx.doi.org/10.1093/geronb/57.5.S308

Wolinsky, F. D., Callahan, C. M., Fitzgerald, J. F., & Johnson, R. J. (1993). Changes in functional status and the risks of subsequent nursing home placement and death. *Journal of Gerontology*, *48*(3), 94–101.

Table I: Description of explanatory variables and the outcomes for which they are employed

Variable	Definition	Waiting times	Length of symptoms	Pre-op OHS	Pre-op OKS	Length of stay	Readmission	Further surgery	Complication	Expensive discharge	Post-op OHS	Post-op OKS	Satisfaction	Success
Age	Age categories: 50-59, 60-69, 70-79, and ≥80 years old.	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Gender	Indicator for whether a patient is male	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Ethnicity	3 ethnic groups: White; Asian, Asian British or Asian Mixed; Black, Black British or Black Mixed	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Socioeconomic status	Income domain of the Index of Multiple Deprivation 2010. This measures the proportion of people in lower-level super output areas living in households receiving means-tested benefits.	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Pre-op questionnaire assistance	Indicator for whether the patient received any assistance in the completion of the pre-operative questionnaire.		✔	✔	✔									
Post-op questionnaire assistance	Indicator for whether the patient received any assistance in the completion of the post-operative questionnaire.						✔	✔	✔		✔	✔	✔	✔
Disability	Indicator for whether the patient considers themselves disabled.	✔				✔	✔	✔	✔	✔	✔	✔	✔	✔
Previous surgery	Indicator for whether the patient has had previous surgery of the same type.	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Revision procedure	Indicator of whether the patient was admitted for a revision surgery.	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Pre-op EQ5D Usual Activities	Measures ability to perform usual activities on the scale of no/some/unable.	✔				✔	✔	✔	✔	✔	✔	✔	✔	✔
Pre-op EQ5D Anxiety/Depression	Measures level of anxiety/depression on the scale of no/moderately/extremely anxious or depressed.	✔				✔	✔	✔	✔	✔	✔	✔	✔	✔
Pre-op EQ5D Pain/Discomfort	Measures level of pain/discomfort on the scale of no/moderate/extreme pain or discomfort.	✔				✔	✔	✔	✔	✔	✔	✔	✔	✔
Pre-op EQ5D Mobility	Measures mobility on the scale of no problems with walking/some problems with walking/confined to bed.	✔				✔	✔	✔	✔	✔	✔	✔	✔	✔
Pre-op EQ5D Self-care	Measures ability to care for themselves on the scale of no/some/unable.	✔				✔	✔	✔	✔	✔	✔	✔	✔	✔
Pre-op EQ-VAS: level, square, cubic	Measures health on a 100-point visual scale ranging from 0 (worst possible health) to 100 (best possible health)	✔				✔	✔	✔	✔	✔	✔	✔	✔	✔
Pre-op General health	Measures general health on a five-point scale ranging from 1 (excellent) to 5 (poor).	✔				✔	✔	✔	✔	✔	✔	✔	✔	✔

✔ : Used as a control

Table I (continued): Description of explanatory variables and the outcomes for which they are employed

Variable	Definition	Waiting times	Length of symptoms	Pre-op OHS	Pre-op OKS	Length of stay	Readmission	Further surgery	Complication	Expensive discharge	Post-op OHS	Post-op OKS	Satisfaction	Success
Self-reported comorbidities	Separate indicators for whether the patient reports having been told by a doctor that they have: heart disease, high blood pressure, problems caused by stroke, leg pain due to poor circulation, lung disease, diabetes, liver disease, kidney disease, disease of the nervous system, cancer, depression, and arthritis.	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Admission month	Month in which the patient is admitted for surgery.	✔				✔				✔				
Pre-op questionnaire completion month	Month in which the patient completes the pre-operative PROMs questionnaire.		✔	✔	✔									
Post-op questionnaire completion month	Month in which the patient completes the post-operative PROMs questionnaire.						✔	✔	✔		✔	✔	✔	✔
Provider type	Type of provider where the patient is treated: Foundation Trust, ISTC*, ISTC site, PCT, NHS Trust, NHS treatment centre.	✔	✔			✔	✔	✔	✔	✔	✔	✔	✔	✔
Pre-op OHS/OKS: level, squared, cubic	Pre-operative OHS or OKS	✔				✔	✔	✔	✔	✔	✔	✔	✔	✔
Waiting times	The time (in days) between the date on which a specialist decides to admit a patient and the admission date.					✔	✔	✔	✔	✔	✔	✔	✔	✔
Length of symptoms	Categories for duration of patient's symptoms: <1 year, 1-5 years, 5-10 years, or >10 years.			✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔

✔ : Used as a control; *Independent sector treatment centre
Notes: OHS = Oxford Hip Score. OKS = Oxford Knee Score

Table II: Descriptive statistics for the control variables

Variable	Not live alone (73.33%)		Live alone (26.67%)	
	N (%) or Mean (SD)		N (%) or Mean (SD)	
Male[a]	36,333	(48.54%)	6,666	(24.48%)
Had a previous surgery[b]	6,674	(8.92%)	2,499	(9.18%)
Having a revision surgery[b]	4,758	(6.36%)	1,711	(6.28%)
Pre-operative questionnaire assistance[b`]	15,187	(20.29%)	6,812	(25.02%)
Post-operative questionnaire assistance[b]	5,369	(8.23%)	1,967	(8.47%)
Pre-operative Self-reported disability[b]	43,166	(57.66%)	17,137	(62.93%)
Age (years) [a]	68.25	(8.42)	73.38	(8.85)
IMD - income deprivation[a]	0.12	(0.09)	0.14	(0.1)
Pre-operative EQ-VAS[b]	67.04	(20.86)	64.55	(21.4)
Ethnic Group[a]				
White	65,089	(96.96%)	24,031	(98.07%)
Asian, Asian British or Asian Mixed	1,457	(2.17%)	201	(0.82%)
Black, Black British or Black Mixed	583	(0.87%)	273	(1.11%)
Pre-operative EQ-5D Anxiety/Depression[b]				
No problems	44,557	(61.17%)	14,499	(55.04%)
Some problems	25,237	(34.65%)	10,374	(39.38%)
Severe problems	3,050	(4.19%)	1,469	(5.58%)
Pre-operative EQ-5D Mobility[b]				
No problems	4,721	(6.43%)	1,418	(5.32%)
Some problems	68,351	(93.13%)	25,102	(94.23%)
Severe problems	320	(0.44%)	120	(0.45%)
Pre-operative EQ-5D Self care[b]				
No problems	41,847	(57.07%)	14,338	(53.94%)
Some problems	30,607	(41.74%)	11,926	(44.86%)
Severe problems	870	(1.19%)	318	(1.2%)
Pre-operative EQ-5D Usual Activities[b]				
No problems	5,525	(7.54%)	2,104	(7.93%)
Some problems	55,101	(75.18%)	19,765	(74.47%)
Severe problems	12,663	(17.28%)	4,671	(17.6%)
Pre-operative EQ-5D Pain/Discomfort[b]				
No problems	760	(1.04%)	301	(1.14%)
Some problems	42,814	(58.78%)	14,728	(55.76%)
Severe problems	29,266	(40.18%)	11,386	(43.1%)
Pre-operative General health[b]				
Excellent	3,049	(4.24%)	942	(3.63%)
Very good	19,334	(26.86%)	6,249	(24.05%)
Good	32,120	(44.62%)	11,613	(44.7%)
Fair	14,720	(20.45%)	6,046	(23.27%)
Poor	2,756	(3.83%)	1,129	(4.35%)

[a]These variables were derived from Hospital Episode Statistics and therefore had no missing data. Statistics for these variables are therefore calculated using all 105,843 observations.
[b]These variables were derived from the PROMs dataset, and were therefore subject to item non-response. The number of observations used to calculate statistics therefore differ by variable.

Table II (continued): Descriptive statistics for the control variables

Variable	Not live alone (73.33%)		Live alone (26.67%)	
	N (%) or Mean (SD)		N (%) or Mean (SD)	
Pre-operative Comorbidities[b]				
Heart Disease	7,882	(10.53%)	3,215	(11.81%)
High Blood Pressure	32,268	(43.11%)	12,708	(46.67%)
Stroke	1,186	(1.58%)	516	(1.89%)
Circulation problems	5,582	(7.46%)	2,888	(10.61%)
Lung Disease	4,843	(6.47%)	2,003	(7.36%)
Liver disease	368	(0.49%)	148	(0.54%)
Kidney Disease	1,221	(1.63%)	528	(1.94%)
Disease of the Nervous System	685	(0.92%)	233	(0.86%)
Cancer	3,367	(4.5%)	1,182	(4.34%)
Depression	5,102	(6.82%)	2,484	(9.12%)
Arthritis	55,507	(74.15%)	20,844	(76.55%)
Diabetes	8,332	(11.13%)	2,913	(10.7%)
Provider type[a]				
Foundation trust	34,841	(46.54%)	12,422	(45.62%)
ISTC*	5,118	(6.84%)	1,758	(6.46%)
ISTC site	5,697	(7.61%)	1,786	(6.56%)
Primary care trust	409	(0.55%)	181	(0.66%)
NHS trust	28,603	(38.21%)	11,042	(40.55%)
NHS treatment centre	189	(0.25%)	42	(0.15%)

*ISTC: Independent sector treatment centre
[a]These variables were derived from Hospital Episode Statistics and therefore had no missing data. Statistics for these variables are therefore calculated using all 105,843 observations.
[b]These variables were derived from the PROMs dataset, and were therefore subject to item non-response. The number of observations used to calculate statistics therefore differ by variable.

Table III: Descriptive statistics: outcome variables

	Not live alone (73.33%)			Live alone (26.67%)		
	Pre-op	Post-op	diff	Pre-op	Post-op	diff
<u>**Pre-treatment variables**</u>						
Waiting time (days) [a]	85.494	.	.	85.612	.	.
Length of symptoms[b]						
Less than 1 year	0.092	.	.	0.110	.	.
1-5 years	0.581	.	.	0.606	.	.
5-10 years	0.170	.	.	0.154	.	.
More than 10 years	0.157	.	.	0.130	.	.
<u>**Costs**</u>						
Length of stay (days) [a]	5.276	.	.	6.576	.	.
Readmitted[b]	.	0.086	.	.	0.091	.
Further surgery[b]	.	0.031	.	.	0.031	.
Had a complication[b]	.	0.404	.	.	0.415	.
Expensive discharge[a]	.	0.002	.	.	0.010	.
<u>**Post-treatment Benefits**</u>						
Oxford Hip Score[b]	18.160	38.454	20.294	17.589	36.974	19.385
Oxford Knee Score[b]	18.721	33.950	15.230	18.121	33.247	15.126
Satisfaction with surgery[b]						
Excellent	.	0.299	.	.	0.271	.
Very good	.	0.344	.	.	0.344	.
Good	.	0.223	.	.	0.245	.
Fair	.	0.102	.	.	0.108	.
Poor	.	0.032	.	.	0.031	.
Perceived success of surgery[b]						
Much better	.	0.766	.	.	0.757	.
A little better	.	0.143	.	.	0.149	.
About the same	.	0.041	.	.	0.045	.
A little worse	.	0.029	.	.	0.029	.
Much worse	.	0.022	.	.	0.021	.

[a]These variables were derived from Hospital Episode Statistics and therefore had no missing data. Statistics for these variables are therefore calculated using all 105,843 observations.
[b]These variables were derived from the PROMs dataset, and were therefore subject to item non-response. The number of observations used to calculate statistics therefore differ by variable.

Table IV: Marginal effects of living alone on all outcomes

Dependent variable	Marginal effect [b]	Std. err.	N
Pre-treatment variables			
Waiting time (days, logged) [a]	0.004	(0.01)	73644
Length of symptoms	-0.003	(0.00)	86435
Pre-operative Oxford Hip Score	0.608***	(0.09)	40704
Pre-operative Oxford Knee Score	0.263**	(0.08)	45246
Costs			
Length of stay (days, logged) [a]	0.092***	(0.00)	71767
Readmitted	0.006*	(0.00)	62309
Further surgery	0.003	(0.00)	62309
Had a complication	-0.001	(0.00)	249236
Expensive discharge	0.005***	(0.00)	69648
Post-treatment benefits			
Post-operative Oxford Hip Score	-0.121	(0.12)	29010
Post-operative Oxford Knee Score	-0.084	(0.12)	31638
Satisfaction with surgery	-0.002	(0.00)	60576
Perceived success of surgery	0.002	(0.00)	60543

*p<0.05, **p<0.01, ***p<0.001

[a] A logarithmic transformation was used to normalise these outcomes prior to estimation

[b] Marginal effects of the effects of living alone on waiting times, length of stay, pre-operative and post-operative Oxford Hip Scores and Oxford Knee Scores were estimated from an ordinary least squares (OLS) model. Marginal effects of living alone on the probability of readmission, further surgery, complications and expensive discharge were estimate from probit models. For length of symptoms, satisfaction with surgery and perceived success of surgery, marginal Effects represent the effect of living alone on the probability of duration of symptoms “less than 1 year”, “excellent” satisfaction, and “much better” treatment success. These were estimated from an ordered probit model.

8. FIGURES

Figure 1: Timing of key outcomes throughout the treatment pathway