Corresponding Author:
Laura Carter, PhD student
Centre for Economic and Social Research on Dementia,
Institute for Lifecourse and Society,
National University of Ireland, Galway,
Galway, Ireland.
Email: l.carter1@nuigalway.ie
Tel: 35391-524411

Extended length of stay and related costs associated with dementia in acute care hospitals in Ireland

Carter, L., Yadav, A, O'Neill, S. and O'Shea, E.

Laura Carter, PhD candidate, Centre for Economic and Social Research on Dementia, Institute for Lifecourse and Society, National University of Ireland, Galway, Galway, Ireland, l.carter1@nuigalway.ie

Anil Yadav, PhD candidate, J.E. Cairnes School of Business and Economics, Upper Newcastle, National University of Ireland, Galway, Galway, Ireland, a.yadav4@nuigalway.ie

Dr Stephen O'Neill, PhD, Department of Health Services Research and Policy, London School of Hygiene & Tropical Medicine, London, United Kingdom, stephen.oneill@lshtm.ac.uk

Professor Eamon O'Shea, PhD, Centre for Economic and Social Research on Dementia, Institute for Lifecourse and Society, National University of Ireland, Galway, Galway, Ireland, eamon.oshea@nuigalway.ie

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Objective: To estimate the additional impact of dementia on inpatient length of stay (LOS) and related costs in Irish acute hospitals. Both principal and secondary diagnosis effects are estimated and valued.

Methods: This is a cross-sectional study based on administrative data collected on all public hospital inpatient discharges in Ireland for people aged 65 years and older in 2019. Coarsened exact matching was undertaken to account for observed confounders between dementia and non-dementia groups, while generalized linear modelling was used to compare differences in LOS.

Results: Patients with a principal diagnosis of dementia spent on average 17.5 (CI: 15.42, 19.56; $p<0.01$) days longer in hospital than similar patients with no principal diagnosis of dementia. LOS was 6.7 (CI: 6.31, 7.14; $p<0.01$) days longer for patients with a secondary diagnosis of dementia compared to similar patients with no secondary diagnosis of dementia. The additional annual cost of care for patients in hospitals with a secondary (primary) diagnosis of dementia was €62.0m (€13.2m).

Conclusion: This study highlights the economic impact of extended LOS for patients with dementia in Irish acute hospitals. Addressing specific dementia-related needs of people in hospital is likely to optimize resource use and decrease health care costs in acute care settings.

Key words
Dementia, acute hospitals, length of stay, costs

Introduction

Ireland has one of the fastest rates of population ageing in Europe, with significant increases in older age cohorts expected in the coming decades (Kane et al., 2015). Population projections from the Central Statistics Office (2016) in Ireland suggest that the older population (i.e., those aged 65 years and over) will increase significantly from 629,800 persons in 2016 to between 1.51 and 1.60 million by 2051. The impact of future demographic ageing on the demand for health and social care and on capacity requirements will, therefore, be more keenly felt in Ireland than in many other countries, especially in the acute care sector, where bed numbers, occupancy rates, and waiting lists are an ongoing concern for the government (Department of Health, 2019; Houses of the Oireachtas Committee on the Future of Healthcare, 2017; Organisation for Economic Co-operation and Development, 2018). Approximately 1 in 3 patients aged 70 and older admitted to Irish hospitals are estimated to have dementia, and this figure will increase annually as the population ages in the coming years (Bracken-Scally et al., 2020). Quantifying the clinical and financial implications of dementia in the acute care sector is, therefore, an important, if difficult task, given that many people with dementia remain undiagnosed before, during, and after their hospital admission (Connolly & O'Shea, 2015).

There is evidence from different countries that people with cognitive impairment and/or dementia experience a longer length of stay (LOS) in hospital (King et al., 2006; Möllers et al., 2019; Motzek et al., 2018; Tropea et al., 2017). A study by Tropea et al. (2017) on inpatient admissions at a Melbourne hospital showed that adjusted median LOS was longer for patients with cognitive impairment compared to those without cognitive impairment. Not surprisingly, costs were also found to be significantly higher among hospitalised patients who were cognitively impaired. Another Australian study found that mean LOS for dementia patients was double that of non-dementia patients (King et al., 2006). More recently, a systematic review of observational studies on length of hospital stay and dementia found that fifty-two of

the sixty included studies reported longer LOS for people with dementia compared to those without dementia (Möllers et al., 2019). In Ireland, Connolly and O'Shea (2015) reported that people with a recorded diagnosis of dementia (either principal or secondary) had a significantly longer LOS in hospital than those without a recorded diagnosis of dementia. Similarly, Briggs et al. (2016) examined LOS over a 3-year period, from 2010 to 2012, in one 600-bed university hospital in Ireland for people with and without a diagnosis of dementia and found significant differences in LOS and costs of care.

Multiple studies have shown poorer health outcomes for hospitalized patients with dementia, which inevitably leads to an increase in LOS, resulting in significant additional costs on the health care system. Hospitalisation is associated with higher risks of morbidity, mortality, and an increased risk of institutionalization (Fogg et al., 2018; Sampson et al., 2009; Tropea et al., 2017). More specifically, patients with dementia are at an increased risk of falls, pressure ulcers, and functional decline while receiving treatment in acute hospital settings (George et al., 2013; Tropea et al., 2017; Watkin et al., 2012). It is not surprising, therefore, that, in many countries, reducing hospital LOS for dementia patients is a prospective strategy designed to decrease health care costs and to ensure the sustainability of health care systems (Jensen et al., 2019; Vetrano et al., 2014). Part of the problem is that dementia is not always acknowledged or recognised within acute care settings. Only 40% of dementia patients in Ireland have cognitive testing carried out during their hospital admission, while only 22% of hospitals have a dementia recognition system in place so that staff is aware of a person's dementia while in hospital (Bracken-Scally et al., 2020).

The objective of this paper is to estimate inpatient LOS and related costs of care for patients with dementia in Irish acute hospitals relative to similar patients without dementia. This paper builds on previous research (Briggs et al., 2016; Connolly & O'Shea, 2015) by controlling for

the influence of case-mix on LOS and incorporating predictors that were not previously controlled for, including source of admission, proxy measures for socioeconomic status, and whether or not the patient was treated by a consultant geriatrician. Moreover, the paper estimates the impact of both a principal and secondary diagnosis of dementia on LOS and related care costs, with extensive efforts to match dementia and non-dementia patients. Heterogeneity in the impact of a secondary diagnosis of dementia on LOS is also addressed by separately considering a number of principal diagnosis disease categories identified using ICD-10-AM codes (National Centre for Classification in Health, 2000). This will help to identify those specific principal diagnosis disease categories that are more susceptible to increased LOS for people with dementia.

Data and statistical methods

Setting and participants

This study analyses anonymised individual patient-level data obtained from the Hospital In-Patient Enquiry (HIPE) administrative data set, which captures data on all public hospital inpatient discharges in Ireland (Hospital In-Patient Enquiry, 2021). HIPE is a national health information system that collects demographic, clinical, and administrative data on discharges and deaths in public acute hospitals (Healthcare Pricing Office, 2020). In this study, inpatient discharges in 2019 for patients aged 65 years and older are examined in detail. While much of the policy concern is often focused on resource allocation activity on the margin between home care and acute care settings (Gaughan et al., 2015; Walsh et al., 2020), patients who died while in hospital were also included in the analysis for this paper since proximity to death has been identified as a significant driver of health care costs among older people (Breyer & Lorenz, 2021). Moreover, in the Irish context, a recently published paper by Matthews et al. (2021) found that serious life-limiting conditions ending in death accounted disproportionately for

LOS in Irish acute hospitals. Unfortunately, the absence of a unique patient identifier in the HIPE data means it is not possible to analyse certain parameters of potential interest, such as the number of hospitalizations per patient, nor to consider information on historic admissions that may be informative in relation to the patients' health status. The analysis is conducted at the discharge-level rather than patient-level.

Ethics

Accessing HIPE data requires a detailed application to be made by researchers to the Healthcare Pricing Office (HPO), which is under the auspices of the Health Service Executive in Ireland. The HPO will only supply data if they deem that the request conforms with their obligations of confidentiality under the Data Protection Acts 1988 to 2018 and the General Data Protection Regulation. The application process is comprehensive and is similar in form and structure to a conventional ethics application, with questions on the use of the data, aggregation, disclosure, risk, safety, and dissemination. All applicants, including the authors of this paper, have to demonstrate that their use of data will not be disclosive or harmful to individual patients before an application is successful.

Diagnosis and dependent variables

The dependent variables in the analysis were LOS for patients with (i) a principal or (ii) a secondary diagnosis of dementia, measured in days for each inpatient episode of care. For all inpatient discharges, HIPE records information on up to 30 diagnosis codes (one principal and up to 29 additional diagnosis codes) using the International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification (ICD-10-AM) coding system (National Centre for Classification in Health, 2000). HIPE only records hospital

stay, so the principal diagnosis is the hospital-acquired diagnosis (Healthcare Pricing Office, 2021).

It is the responsibility of the hospital clinician to record and provide accurate principal diagnosis and procedures. However, if the clinical information is deemed inadequate, the hospital coder responsible for transferring the information to HIPE is required to get clarification from the clinician before assigning the diagnosis code primarily responsible for causing the episode of admission to hospital. Secondary diagnosis refers to conditions or complaints, either coexisting with the principal diagnosis or arising during the episode of admitted patient care. These are interpreted in HIPE reporting as conditions that affect patient management. Patients with a secondary diagnosis represent the most common scenario of patients with dementia hospitalized for organic issues, for example, congestive heart failure, while the group with a principal diagnosis of dementia are, more than likely, patients hospitalized because of agitation and other behavioural and psychological symptoms of dementia (we cannot tell precisely from the data available). Thus, these groups may describe very different patients, but for this study, the focus is on LOS and associated costs only.

Patients with a principal or secondary diagnosis of dementia were identified using the ICD-10-AM codes F00 (dementia in Alzheimer's disease), F01 (vascular dementia), F02 (dementia in other diseases classified elsewhere), F03 (unspecified dementia), G300 (dementia in Alzheimer's disease with early-onset), G301 (dementia in Alzheimer's disease with late-onset), G308 (dementia in Alzheimer's disease, atypical or mixed type) and G309 (dementia in Alzheimer's disease, unspecified). Those without such diagnoses were categorised as non-dementia patients.

Three comparisons were undertaken in the paper. The first comparison was between patients with a principal diagnosis of dementia and those without a principal or secondary diagnosis of

dementia (Comparison 1). After observations with incomplete information on the variables of interest were excluded, there were 803 (0.45%) inpatient discharges with a principal diagnosis of dementia and 177,491 (99.55%) inpatient discharges without a principal diagnosis of dementia. Comparison 2 focused on patients with a secondary diagnosis of dementia and those without a secondary diagnosis of dementia across all discharges, excluding the group with a principal diagnosis of dementia. Before matching, there were 9,859 (5.23%) patients with a secondary diagnosis of dementia and 178,704 (94.77%) patients without a secondary diagnosis of dementia. Discharges were also analysed separately for a number of principal diagnosis disease categories to examine heterogeneity in the impact of a secondary diagnosis of dementia on LOS and related care costs (Comparison 3). In order to examine the subgroups of diagnoses, total discharges for the year 2019 were grouped into a number of principal diagnosis categories using the first letter and first two digits from each ICD-10-AM diagnosis code (Healthcare Pricing Office, 2020) (See A.1 in Appendix A for further details).

Independent variables

In this study, a range of potential influences on LOS were controlled for, including gender, age group (65-74, 75-84, >85), marital status (married or not), admission source (admitted from home, admitted from long-stay accommodation, transferred from other source), consultant specialty (geriatric or other), whether the admission was emergency or elective, and whether or not time was spent in an intensive care environment during the hospital admission. As there are no explicit measures of socioeconomic status within the HIPE data set, medical card status was used as a proxy for socioeconomic deprivation, on the basis that medical card holders in Ireland are more likely to come from lower income households (Walsh et al., 2019). The variable discharge status (whether treatment was carried out by a consultant on a private or public basis) was also used to act as a proxy for whether or not a patient is covered by private

health insurance (Keegan & Smith, 2013; Walsh et al., 2019). Using ICD-10-AM codes on additional diagnoses provided by HIPE, it was possible to use the Elixhauser Comorbidity Index (excluding dementia) to generate comorbid conditions (Quan et al., 2005). This index is commonly used to predict in-hospital mortality, hospital resource utilisation, LOS, and adverse events (Chang et al., 2016; Elixhauser et al., 1998; Menendez et al., 2014).

It was not feasible to control for all comorbid conditions generated by the Elixhauser Comorbidity Index due to the small number of observations present in some of the comorbidities, which creates potential problems of identifiability. Therefore, the focus is on the comorbid conditions with a sufficient sample size ($N > 5$). For Comparison 1 (principal diagnosis) and Comparisons 2 and 3 (secondary diagnosis; and subgroups of diagnoses), the comorbid conditions controlled for are outlined in Table 1. For all Comparisons (1, 2, and 3), the Elixhauser non-weighted comorbidity score was included; this is a simple sum of the number of Elixhauser comorbidities recorded for each observation in the data set, i.e., it is a comorbidity count (Elixhauser et al., 1998; Quan et al., 2005). While the weighted version of the Elixhauser comorbidity score assigns risk weights to each comorbidity (Sharma et al., 2021), the use of such weighting systems are generally based on a specific region (predominantly the US), health system, and patient group, raising concerns about generalizability to the Irish context, where there have been no comorbidity weighting adjustments specifically designed for use on a national data set such as HIPE. The study results are unlikely to be sensitive to the use of the non-weighted comorbidity score since matching incorporates a number of individual comorbidities, thereby achieving good balance. Furthermore, the use of individual comorbidities tends to have better predictive discriminative ability (Goltz et al., 2019).

Table 1: List of comorbid conditions included as independent variables in Comparisons 1, 2 and 3

Comparison 1 (principal diagnosis)	**Comparisons 2 and 3 (secondary diagnosis; and subgroups of diagnoses)**
Congestive heart failure	Congestive heart failure
Cardiac arrhythmias	Cardiac arrhythmias
Peripheral vascular disorders	Valvular disease
Hypertension, uncomplicated	Hypertension, uncomplicated
Other neurological disorders	Paralysis
Chronic pulmonary disease	Other neurological disorders
Diabetes, uncomplicated	Chronic pulmonary disease
Diabetes, complicated	Diabetes, uncomplicated
Hypothyroidism	Diabetes, complicated
Renal failure	Renal failure
Solid tumour without metastasis	Metastatic cancer
Weight loss	Solid tumour without metastasis
Fluid and electrolyte disorders	Weight loss
Psychoses	Fluid and electrolyte disorders
Depression	Deficiency anaemia
	Alcohol abuse

Statistical methods

When comparing LOS between dementia and non-dementia groups, it should be recognised that the composition of the two groups may differ, leading to potential biases (Zhao & Percival, 2017). Therefore, it is important to account for potential confounders to the extent possible when making such comparisons. A feature of the data in this paper is that it offers a much larger number of potential controls (non-dementia) than treated units (dementia). It is possible, therefore, to identify patients among the control group that are similar to those in the treated group, *ceteris paribus*. Matching patients allows for a more robust comparison between the groups, allowing for greater balance in the distribution of covariates across the treated and control groups (Macchioni Giaquinto et al., 2021). As a result, model dependence is reduced, and subsequent parametric regression modelling is less dependent on restrictive assumptions about the model specification and is more likely to identify causal effects (Jones et al., 2020).

Although there are many available matching approaches, such as propensity score matching or nearest neighbour matching (Rosenbaum & Rubin, 1983; Rubin, 1973), coarsened exact matching (CEM) (Blackwell et al., 2009) was used to match on the covariates described above. This approach aims to locate exact matches by sorting the data into strata (Jones et al., 2020), whereby an observation in strata *i* of the treatment group is matched to at least one observation in strata *i* from the control group, which has an identical value. All unmatched observations within any stratum are then discarded from the analysis (Blackwell et al., 2009). Importantly, CEM has a monotonic imbalance bounding property, meaning that the balance of each covariate can be adjusted without having any effect on the others (Blackwell et al., 2009; Macchioni Giaquinto et al., 2021). Furthermore, balance is achieved in the full joint distribution of the confounding variables, which includes interactions and non-linearities (Jones et al., 2020). This approach removes extreme observations and restricts the matched data to common areas of empirical support (Blackwell et al., 2009). In the context of the study, this could imply that more complex/high burden dementia patients would be excluded from the study if individuals with similar covariates in the broader population of admissions are not available.

Since the dependent variable LOS (count) is positively skewed and strictly positive, a Generalized Linear Model (GLM) was chosen to analyse predictors of LOS (Deb et al., 2014). The model estimates the mean of y, conditional on covariate (*X)*, which is defined as:

$$g\{E(y_j)\} = X_j\beta, y_j \sim F$$

The link function (*g*) characterises how the linear index is related to the conditional mean. The family, *F*, specifies a distribution from the exponential family that reflects the mean-variance relationship of the data (Deb et al., 2014; StataCorp, 2021). The key covariate of interest was

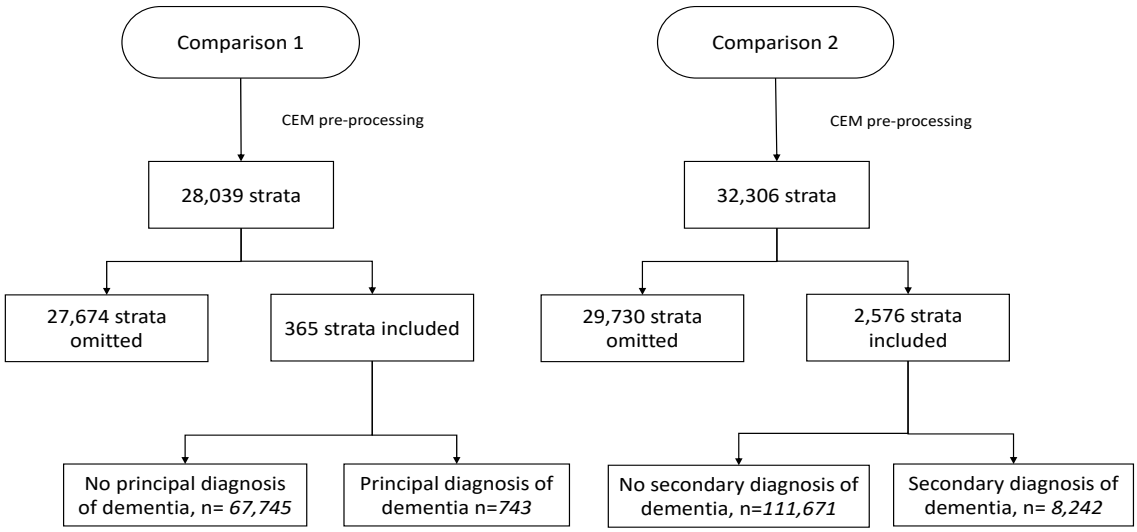
an indicator for whether the unit was in the treatment or control group, furthermore the set of independent variables described above were controlled for, in addition to using CEM.

For each of the models, the Modified Park Test was used to identify the most suitable family (Deb et al., 2017). The appropriate link was chosen using a combination of three tests, namely, the Pregibon Link Test, the Modified Hosmer Lemeshow Test, and Pearson's Correlation (Deb et al., 2017). For Comparison 1, the preferred GLM model used a gamma distribution with a power 0.5 link function. For Comparisons 2 and 3, the tests identified the power 0.2 link as the most appropriate. To estimate LOS for each comparison, a GLM was used on the pre-processed data using the weights obtained as an output from CEM (Jones et al., 2020). Average treatment effects on the treated (ATTs) were then obtained as the average marginal effect (AME) of the treatment variable included in the GLM model, estimated using the matched sample, although these should not be interpreted as causal effects. Instead, they can be viewed as differences between the groups that are not explained by differences in the groups' covariates. Finally, a generic unit cost for Ireland, representing the average cost across all nights in all Irish hospitals and in all types of inpatient cases, of €938 (Hospital In-Patient Enquiry, 2019) was used to calculate the costs attributable to LOS for patients with dementia. The analyses were performed using Stata 16 (StataCorp, 2019).

Results

In Comparison 1, pre-processing through CEM resulted in the stratification of the sample into 28,039 strata. For 365 of these strata, there were 743 (1.08%) patients with a principal diagnosis of dementia (treatment group) and 67,745 (98.92%) with no principal diagnosis of dementia (control group). The remaining 27,674 strata were omitted from the analysis since they had characteristics that differed from those of the treatment group (Figure 1).

Figure 1: Sample stratification after coarsened exact matching



In Comparison 2, CEM led to a stratification of the sample into 32,306 strata. For 2,576 of these strata, there were 8,242 (6.87%) patients with a secondary diagnosis of dementia (treatment group) and 111,671 (93.13%) patients with no secondary diagnosis of dementia (control group). The remaining 29,730 strata were omitted from further analysis (Figure 1). Tables A.2 and A.3, in Appendix A, show the means of each group for each comparison before and after CEM. Reassuringly, equality of the sample means for all covariates is evident between the treated and control groups, suggesting that comparisons between groups should not be affected by any observed confounding post-CEM. Comparing the means before and after matching (Tables A.2 and A.3 in Appendix A) indicates that the retained pool of treated units tends to have better health than the full treated pool (e.g., having lower Elixhauser scores).

Table 2 presents key descriptive statistics for each group in Comparisons 1 and 2 after CEM[1], using medians and interquartile range (IQR) for continuous variables and (%) for categorical

[1] Table A.1, in Appendix A, presents key descriptive statistics for each group in Comparisons 1 and 2 before CEM.

variables. The median LOS for patients with a principal diagnosis of dementia was 20 (IQR: 5 to 40) days, while patients with no principal diagnosis of dementia had a median LOS of 5 (IQR: 2 to 10) days. For patients with a secondary diagnosis of dementia, the median LOS was 8 (IQR: 4 to 19) days compared to 2 (IQR: 6 to11) days for patients with no secondary diagnosis of dementia. In each group, over half of the discharged patients were female, with the largest proportion of inpatient discharges aged between 75-84 years. Across all groups, between 42% and 44% were married. With regard to the proxy variables for socioeconomic status, over 80% of patients were in receipt of a medical card (free public care, including general practitioner visits), while approximately 90% of patients were treated by a consultant on a public basis.

Table 2: Descriptive statistics for inpatient discharges with and without a principal or secondary diagnosis of dementia

Variable	**Principal diagnosis of dementia (n=743)**	**No principal diagnosis of dementia (n=67,745)**	**Secondary diagnosis of dementia (n=8,242)**	**No secondary diagnosis of dementia (n=111,671)**
Length of stay in hospital, median (interquartile range)	20 (5, 40)	5 (2,10)	8 (4, 19)	2 (6,11)
Gender, n (%)				
Male	337 (45.36)	30,727 (45.36)	3,534 (42.88)	47,882 (42.88)
Female	406 (54.64)	37,018 (54.64)	4,708 (57.12)	63,789 (57.12)
Age 65-74, n (%)				
Yes	120 (16.15)	10,941 (16.15)	981 (11.90)	13,292 (11.90)
No	623 (83.85)	56,804 (83.85)	7,261 (88.10)	98,379 (88.10)
Age 75-84, n (%)				
Yes	393 (52.89)	35,833 (52.89)	3,755 (45.56)	50,877 (45.56)
No	350 (47.11)	31,912 (47.11)	4,487 (54.44)	60,794 (54.44)
Age 85+, n (%)				
Yes	230 (30.96)	20,971 (30.96)	3,506 (42.54)	47,503 (42.54)
No	513 (69.04)	46,774 (69.04)	4,736 (57.46)	64,168 (57.46)
Married, n (%)				
Yes	327 (44.01)	29,815 (44.01)	3,471 (42.11)	47,029 (42.11)
No	416 (55.99)	37,930 (55.99)	4,771 (57.89)	64,642 (57.89)
Medical card holder, n (%)				
Yes	634 (85.33)	57,807 (85.33)	6,951 (84.34)	94,179 (84.34)
No	109 (14.67)	9,938 (14.67)	1,291 (15.66)	17,492 (15.66)
Public patient status, n (%)				
Yes	689 (92.73)	62,821 (92.73)	7,452 (90.41)	100,967 (90.41)
No	54 (7.27)	4,924 (7.27)	790 (9.59)	10,704 (9.59)

In Comparison 1, LOS between patients with a principal diagnosis of dementia and patients with no principal, or any other, diagnosis of dementia was examined (Table 3). The estimated AME for dementia suggests that patients with a principal diagnosis of dementia spent on average 17.6 (95% CI: 14.99 to 20.28; $p<0.001$) days longer in hospital than similar patients without any diagnosis of dementia. This finding reduced marginally after the model was adjusted to control for a range of covariates (AME: 17.5, 95% CI: 15.42 to 19.56; $p<0.001$). Age, being treated by a consultant geriatrician, and time spent in intensive care had significantly positive marginal effects on LOS. A number of comorbidities also had significant positive marginal effects on LOS. The AMEs for the individual comorbidities is the additional effect of that condition, above the effect one would see for a person with the same score without the condition. So, for example, a person with congestive heart failure would have a LOS of 7.7 days longer, all other things equal to a person without this condition. The AME of the Elixhauser score is the effect of a one unit increase in the Elixhauser score on LOS, holding all other variables constant, including the comorbid conditions.

Table 3: Average additional length of stay (days) for inpatient discharges with a principal diagnosis of dementia (Comparison 1)[2]

Variable	Average marginal effect (95% CIs)	P-value	Average marginal effect (95% CIs)	P-value
Principal Dementia	17.64 (14.99, 20.28)	<0.001***	17.49 (15.42, 19.56)	<0.001***
Male			0.42 (0.20, 0.64)	<0.001***
Age 75-84			0.99 (0.72, 1.27)	<0.001***
Age 85+			3.31 (2.95, 3.66)	<0.001***
Married			-1.28 (-1.50, -1.06)	<0.001***
Medical card holder			1.12 (0.84, 1.39)	<0.001***
Admission source: home			-3.51 (-4.45, -2.57)	<0.001***
Admission source: long-stay accommodation			-2.77 (-3.55, -2.00)	<0.001***
Public patient status			-1.51 (-1.96, -1.05)	<0.001***
Emergency admission to hospital			-5.51 (-6.65, -4.37)	<0.001***
Treated by consultant geriatrician (1=Yes, 0=No)			3.38 (3.08, 3.69)	<0.001***
Time spent in intensive care environment (1=Yes, 0=No)			4.28 (2.44, 6.12)	<0.001***
Elixhauser comorbidities				
Congestive heart failure			7.71 (3.70, 11.72)	<0.001***
Cardiac arrhythmias			7.63 (4.11, 11.15)	<0.001***
Peripheral vascular disorders			17.11 (11.23, 22.98)	<0.001***
Hypertension, uncomplicated			13.24 (8.97, 17.51)	<0.001***
Other neurological disorders			18.50 (13.85, 23.14)	<0.001***
Chronic pulmonary disease			6.41 (2.81, 10.00)	<0.001***
Diabetes, uncomplicated			4.54 (1.40, 7.69)	<0.001***
Diabetes, complicated			5.42 (2.06, 8.79)	<0.001***
Hypothyroidism			6.34 (2.62, 10.06)	<0.001***
Renal failure			6.66 (3.13, 10.19)	<0.001***
Solid tumour without metastasis			13.75 (9.09, 18.42)	<0.001***
Weight loss			7.40 (3.66, 11.15)	<0.001***
Fluid and electrolyte disorder			10.11 (6.29, 13.92)	<0.001***
Psychoses			9.29 (4.97, 13.61)	<0.001***
Depression			18.95 (13.48, 24.41)	<0.001***
Other comorbidities			12.05 (7.75, 16.34)	<0.001***
Elixhauser comorbidity score			-4.62 (-7.27, -1.96)	<0.001***

[2] The base category for admission source is transferred from other source. The base category for age is 65-74 years. The base category for Elixhauser comorbidities is those patients with no comorbidities. ***Denotes significant at 1% level; **Denotes significant at 5% level.

Table 4: Average additional length of stay (days) for inpatient discharges with a secondary diagnosis of dementia (Comparison 2)[2]

Variable	Average marginal effect (95% CIs)	P-value	Average marginal effect (95% CIs)	P-value
Secondary Dementia	6.73 (6.28, 7.18)	<0.001***	6.73 (6.31, 7.14)	<0.001***
Male			-0.08 (-0.27, 0.11)	0.41
Age 75-84			1.15 (0.85, 1.44)	<0.001***
Age 85+			2.94 (2.62, 3.25)	<0.001***
Married			-0.63 (-0.82, -0.44)	<0.001***
Medical card holder			0.50 (0.25, 0.75)	<0.001***
Admission source: home			-5.24 (-5.95, -4.52)	<0.001***
Admission source: long-stay accommodation			-5.18 (-5.66, -4.71)	<0.001***
Public patient status			-0.66 (-1.00, -0.32)	<0.001***
Emergency admission to hospital			-4.89 (-5.77, -4.01)	<0.001***
Treated by consultant geriatrician (1=Yes, 0=No)			4.59 (4.25, 4.93)	<0.001***
Time spent in intensive care environment (1=Yes, 0=No)			7.40 (6.34, 8.46)	<0.001***
Elixhauser comorbidities				
Congestive heart failure			-1.55 (-4.51, 1.41)	0.31
Cardiac arrhythmias			-2.80 (-5.63, 0.01)	0.05**
Valvular disease			-4.61 (-6.80, -2.42)	<0.001***
Hypertension, uncomplicated			-3.82 (-6.32, -1.32)	<0.001***
Paralysis			-1.21 (-4.28, 1.85)	0.44
Other neurological disorders			0.65 (-2.77, 4.07)	0.71
Chronic pulmonary disease			-2.92 (-5.54, -0.29)	0.03**
Diabetes, uncomplicated			-5.31 (-7.52, -3.11)	<0.001***
Diabetes, complicated			-3.00 (-5.68, -0.33)	0.03**
Renal failure			-4.18 (-6.61, -1.75)	<0.001***
Metastatic cancer			-2.99 (-5.62, -0.35)	0.03**
Solid tumour without metastasis			-1.98 (-4.84, 0.86)	0.17
Weight loss			-1.85 (-4.76, 1.06)	0.21
Fluid and electrolyte disorders			-2.10 (-5.06, 0.86)	0.17
Deficiency anaemia			-1.55 (-4.51, 1.40)	0.30
Alcohol abuse			-2.22 (-5.08, 0.62)	0.13
Other comorbidities			-0.56 (-3.81, 2.67)	0.73
Elixhauser comorbidity score			5.71 (2.44, 8.99)	<0.001***

Comparison 2 examines LOS for patients with a secondary diagnosis of dementia compared to patients with no secondary diagnosis of dementia (Table 4). The results of this model indicate

that patients with a secondary diagnosis of dementia spent on average 6.7 (95% CI: 6.28 to 7.18; p<0.001) days longer in hospital than similar patients with no secondary diagnosis of dementia. The difference in LOS (AME: 6.7, 95% CI: 6.31 to 7.14; p<0.001) remained unchanged when other factors were taken into account. The covariates should again be interpreted with caution as they represent associations, but time spent in an intensive care environment had a significant positive marginal effect on LOS of 7.4 days, perhaps reflecting differences in severity of the patients. In interpreting AMEs for a particular comorbidity profile, both the AME for the comorbidities of interest and the AME for the Elixhasuer score corresponding to that profile should be considered. For instance, for a patient with one comorbidity, the impact on LOS would be the AME on the Elixhauser score plus the AME on that comorbidity; thus, for those with fluid and electrolyte disorders, the LOS is 3.6 days longer than patients with no fluid and electrolyte disorders.

Comparison 3 analysed subgroups of fifteen principal diagnosis disease categories to examine the impact of a secondary diagnosis of dementia on LOS. Based on the AMEs from the adjusted models presented in Table 5, a secondary diagnosis of dementia increased LOS for all principal diagnosis disease categories (all statistically significant at 1%). The effect of a secondary diagnosis of dementia varied from 1.6 (95% CI: 0.49 to 2.75; p<0.001) days for patients with 'diseases of the digestive system' to 24.7 (95% CI: 17.36 to 31.99; p<0.001) days for patients with 'factors influencing health status and contact with health services.' In regard to the latter, the highest volume of cases is in the dialysis, chemotherapy, and radiotherapy categories. The results also show that patients with a principal diagnosis of 'mental and behavioural disorders' and a secondary diagnosis of dementia spent on average 15.8 (95% CI: 7.61 to 23.97; p<0.001) days longer in hospital than similar individuals without a secondary diagnosis of dementia.

Table Error! No text of specified style in document.**:** Category description, length of stay median, and average additional length of stay (days), for selected inpatient discharges with and without a secondary diagnosis of dementia (Comparison 3)[3]

Category description	Secondary dementia, (n) – before matching	Secondary dementia, (n) – after matching	LOS, median (interquartile range)	No secondary diagnosis of dementia, (n) - before matching	No secondary diagnosis of dementia, (n) – after matching	LOS, median (interquartile range)	Average marginal effect (95% CIs)	P-value
Certain infectious and parasitic diseases | A00–B99	330	178	7 (4,15)	4,767	1,118	6 (3,11)	3.14 (1.56, 4.72)	<0.001***
Neoplasms | C00–D48	274	148	10.5 (4.5, 23.5)	15,458	2,275	7 (3,14)	9.16 (6.35, 11.96)	<0.001***
Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism| D50–D89	64	33	8 (3,13)	1,966	289	2 (1,9)	6.60 (3.51, 9.69)	<0.001***
Endocrine, nutritional and metabolic diseases | E00–E89	291	158	8 (4,16)	4,106	1,011	4 (2,10)	6.42 (4.41, 8.43)	<0.001***
Mental and behavioural disorders | F00–F99	168	71	14 (7,35)	1,424	346	7 (2,27)	15.79 (7.61, 23.97)	<0.001***
Diseases of nervous system | G00–G99	421	281	9 (4,26)	4,274	1,568	4 (1,9)	11.39 (8.74, 14.04)	<0.001***
Diseases of the circulatory system | I00–I99	1,013	607	8 (3,19)	29,906	8,478	5 (2,11)	6.65 (5.38, 7.91)	<0.001***
Diseases of the respiratory system | J00–J99	2,342	1,723	7 (4,14)	31,416	15,585	3 (6,10)	4.61 (3.96, 5.27)	<0.001***
Diseases of the digestive system | K00–K93	557	372	6 (3, 12.5)	13,166	4,831	5 (2,10)	1.62 (0.49, 2.75)	<0.001***
Diseases of the skin and subcutaneous tissue | L00–L99	123	78	7.5 (3, 17)	3,188	667	7 (3, 12)	8.66 (5.32, 12.01)	<0.001***
Diseases of the musculoskeletal system and connective tissue | M00–M99	198	124	9 (4, 28.5)	8,438	1,928	4 (1, 11)	13.69 (9.97, 17.42)	<0.001***
Diseases of the genitourinary system | N00–N99	1,288	849	8 (4, 19)	12,626	5,340	6 (3, 10)	6.67 (5.45, 7.90)	<0.001***
Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified | R00–R99	1,123	877	5 (2, 13)	22,500	13,097	2 (0, 6)	6.25 (5.20, 7.30)	<0.001***
Injury, poisoning and certain other consequences of external causes | S00–T98	1,373	1,034	10 (4, 23)	18,258	10,011	6 (2, 14)	6.83 (5.64, 8.03)	<0.001***
Factors influencing health status and contact with health services | U00–U49, Z00–Z99	272	173	25 (9, 54)	5,378	1,108	14 (5,35)	24.68 (17.36, 31.99)	<0.001***

[3] ***Denotes significant at 1% level.

Hospital care costs

Applying a generic unit cost of €938 to an inpatient day suggests that the estimated cost associated with extended LOS for patients with a principal diagnosis of dementia was, on average, €16,415 more than similarly matched patients without a diagnosis of dementia in 2019. The results also indicate that patients with a secondary diagnosis of dementia had an average excess cost of €6,285 compared to similarly matched patients with no secondary diagnosis of dementia. If excluded dementia patients are assumed to be equally as costly as those dementia patients retained after matching, the additional annual total cost of those presenting with a principal diagnosis of dementia in acute hospitals in 2019 was estimated to be €13.2 million. The additional annual total cost of those presenting with a secondary diagnosis of dementia in acute hospitals was estimated to be €62.0 million. The findings from the subgroup analyses suggest that the additional average cost associated with having a secondary diagnosis of dementia varied from €1,501 for patients with 'diseases of the digestive system' to €23,169 for patients with 'factors influencing health status and contact with health services.' The annual additional total cost for these two categories were, therefore, €0.8 million and €6.3 million, respectively.

Sensitivity analysis

Uncertainty associated with the vagaries of the health and social care system in relation to balance of care decision-making was explored by including discharge destination as an additional predictor variable. In Comparison 1, LOS for patients with a principal diagnosis of dementia decreased by 3.9 (AME: 13.6, 95% CI: 11.65 to 15.51; $p<0.001$) days on average (Table A.4 in Appendix A) when compared to the main analysis. Similarly, LOS reduced by an average of 1.9 (AME: 4.8; 95% CI: 4.41 to 5.28; $p<0.001$) days for Comparison 2 (Table A.5 in Appendix A). Assuming the excluded dementia patients have the same additional LOS as those dementia patients retained after matching, the additional annual cost of care for patients in hospitals with a secondary diagnosis of dementia decreased to €44.4 million and €10.2 million for those with a principal diagnosis.

Discussion

The findings from this study are consistent with previous research, which has found that people with a diagnosis of dementia experience significantly longer LOS (King et al., 2006; Möllers et al., 2019; Tropea et al., 2017) and higher care costs while in the hospital setting (Briggs et

al., 2016; Connolly & O'Shea, 2015; Jensen et al., 2019). Patients with a principal diagnosis of dementia spent on average 17.5 (95% CI: 15.42 to 19.56; $p<0.001$) days longer in hospital than similar patients with no principal diagnosis of dementia. LOS was 6.7 days longer (95% CI: 6.31 to 7.14; $p<0.001$) for patients with a secondary diagnosis of dementia compared to similar patients with no secondary diagnosis of dementia. The additional annual cost of care for patients in hospitals with a secondary diagnosis of dementia was €62.0 million and €13.2 million for those with a principal diagnosis. Given that Ireland has one of the fastest rates of ageing population in Europe (Kane et al., 2015; O'Shea et al., 2017), the costs identified in this paper will grow rapidly and persistently over the coming decade.

These findings have implications for the process of care within the hospital setting, especially the importance of identifying and addressing cognitive impairment across all patients in hospitals, given the importance of dementia as a secondary diagnosis (Turner et al., 2017). The HIPE data does not, however, facilitate forensic examination of processes in acute care settings, leaving some questions unanswered. For example, one curiosity was that emergency admission to hospital had a significant negative marginal effect on LOS relative to those who had an elective admission. The proportions being transferred out of hospital to other hospitals, home and residential care from the emergency and elective admissions group were checked, but nothing notable emerged. However, emergency admissions tend to have more comorbidities requiring more intensive resource use that may lead to these patients being discharged from hospital quicker due to more concentrated care relative to those with elective admission. Some emergency admissions with comorbidities may also only require short-term observation before being discharged again relatively quickly. More generally, much more information is needed on the relationships between dementia, comorbidities, and LOS in acute care, including a deeper understanding of clinical and *a priori* theoretical associations, incorporating care pathways, and balance of care decision-making.

There is evidence that inadequate staff training and an absence of dementia specific knowledge within acute care settings may contribute to extended LOS for patients with dementia (Bracken-Scally et al., 2020; George et al., 2013; Jensen et al., 2019). Jurgens et al. (2012) found that carers of people with dementia attributed changes in the condition of their loved one, particularly deterioration, to the quality of hospital care received, and, more specifically, linked poor outcomes to staff education and training in relation to dementia. Ultimately, the needs of people with dementia are complex, requiring an increased level of awareness and better response from hospital staff to heterogeneity amongst a patient group who may not be able to fully communicate their needs (Røsvik & Rokstad, 2020). For example, people with dementia find it more difficult to maintain nutrition and hydration while in the hospital setting (Fogg et al., 2018), while it is also common for people with dementia to experience difficulties while eating or swallowing. Relatively straightforward improvements in communication could help to alleviate some of these problems, for example, better knowledge sharing at handovers among staff working on different shifts (Jensen et al., 2019). The creation of a more homelike psychosocial environment around the person with dementia might also enhance the personhood dimension of care within an acute setting and contribute to a reduction in LOS (Grey et al., 2018; Hung et al., 2017; Pinkert et al., 2018; Prato et al., 2019).

Expertise in dementia care within the acute care setting also matters, particularly for those in medical and nursing leadership roles. The 2006 'A Vision for Change' mental health policy framework for Ireland recommended that '*everybody aged 65 years and over with primary mental health disorders or with secondary behavioural and affective problems arising from dementia, should be cared for by a mental health services for older people team*' (Expert Group on Mental Health Policy, 2006). Unfortunately, that recommendation has not yet been implemented, and expertise on dementia is not as strong as it should be in the acute hospital sector. A National Audit of Dementia Care in Irish Acute Hospitals published in 2014

highlighted significant gaps in service provision for older people with mental health issues in acute care (De Siún et al., 2014). Shortcomings included inadequate representation of old age psychogeriatric expertise on multidisciplinary teams, as well as an absence of specialised dementia assessment and treatment in many acute care settings in the country.

Finally, it is impossible to reflect on dementia in acute care without considering wider balance of care issues (Carter et al., 2019; Carter et al., 2020). In response to an acknowledged weakness of community-based care for older people (Walsh & Lyons, 2021), the Irish government has committed to a significant expansion of home care services and supports in the coming decade (Department of Health 2018; Department of Health, 2019; Houses of the Oireachtas Committee on the Future of Healthcare, 2017). There is good evidence that personalised community-based services can reduce hospital admission for people with dementia (Cahill et al., 2012). Additional funding for the provision of intensive home care packages has also been shown to support people with very high levels of need who might otherwise be unable to live at home; especially people recently discharged from acute care settings (Keogh et al., 2018; Timmons et al., 2016).

Caregiver burden and the associated stress have been identified as predictors of prolonged LOS in acute hospitals (Lang et al., 2010; Toh et al., 2017). In addition, admission to acute care may lead to a major change in the relationship between the carer and person with dementia in a way that directly impacts on discharge. Sometimes, people with dementia remain in the acute care setting for longer than necessary in order to alleviate some of the stress for overburdened caregivers (Hickey et al., 1997), or, in the extreme, carers sometimes use admission as an opportunity to stop caring entirely. Therefore, ongoing support for carers may impact positively on LOS for people with dementia in acute care settings by relieving burden and allowing home-based caring to recommence on discharge (Teahan et al., 2021).

Strengths and limitations

This is the first study in Ireland to robustly account for observed differences in patients when assessing inpatient LOS and related care costs for patients with dementia in Irish acute hospitals. A major strength of this study is the relatively large number of observations in the control group, thereby allowing us to perform CEM on a richer set of covariates than previously explored, making it more likely that comparisons between groups are not affected by observed confounding. The inclusion of people with a comprehensive secondary diagnosis of dementia allows differential analyses on the impact of dementia on the cost of care across a wide range of conditions.

There are, however, limitations to the present study. First, in the HIPE instruction booklet (Healthcare Pricing Office, 2021), the definition for those with a principal diagnosis is as follows: *'the diagnosis established after study to be chiefly responsible for occasioning the episode of admitted patient care.'* However, it should be acknowledged that several factors related to hospitalization and clinical status, for example, delirium, may cause potentially transient cognitive impairment in acute hospitals. Ideally, the person should be examined after several weeks in an appropriate setting to determine if a diagnosis of dementia is warranted.

Undiagnosed dementia remains an issue in both the community and acute care settings (Briggs et al., 2016; Connolly & O'Shea 2015; Jensen et al., 2019). Moreover, researchers have been critical in the past of incomplete coding on HIPE's part in relation to capturing people with dementia (Curley, 2003, as cited in Health Service Executive, 2019). As a result, it is likely that a number of undiagnosed patients with dementia have been placed into the control group; therefore, estimates are likely to be lower bounds and under-represent the true impact of LOS and related care costs in Irish acute hospitals.

The total annual cost estimates produced in this study assume that excluded dementia patients had the same additional LOS and thus were equally as costly as those dementia patients retained after matching. Since comparable control units with which to compare dementia patients excluded from the analysis are not available, it is impossible to be confident how many (if any) additional days these admissions would have generated relative to a person with dementia included in the analysis. Therefore, it is possible that costs are overestimated. Equally, however, the excluded group of dementia patients may be the more difficult cases, leading to an underestimation of the total annual cost of hospital care for people with dementia in Ireland.

It is important to remember that the purpose of covariates was to act as controls, and one should be cautious in over-interpreting their AMEs as causal effects. Moreover, despite controlling for a rich set of covariates in this study, the results may be subject to the influence of unobserved confounding as information was not available on important variables such as physical dependency, cognitive functioning, disease severity, caregiver burden, and private care provision. Therefore, the estimated differences between groups cannot be causally attributed to the dementia diagnosis.

Conclusion

This paper highlights an additional cost of care of €13.2 million for people with a principal diagnosis of dementia in acute hospitals in Ireland. Extended LOS, associated with a secondary diagnosis of dementia, also places significant additional costs on the health care system, estimated to be €62.0 million in 2019. Dementia has differential LOS effects across a wide range of illnesses and conditions for those with a secondary diagnosis. Dementia care in acute hospitals is undoubtedly professionally challenging, and there are many structural and environmental obstacles to ensuring a positive hospital experience for patients with the condition. At the very least, this paper highlights the need for greater attention to be paid to

dementia within acute hospitals, given the impact on LOS and costs. Change is required in the form of the delivery of more person-centred care by staff trained in the nuances and complexity of dementia care. The likely benefit would be a reduction in LOS for patients with principal and secondary diagnoses of dementia in acute care settings and an associated reduction in the cost of care.

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