Associations between cognitive function, hospital admissions and costs in nursing homes: a cross-sectional study

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**ABSTRACT**

In an Australian nursing home population, associations between cognitive function and 12-month hospitalizations and costs were examined. Participants with dementia had 57% fewer hospitalizations compared to those without dementia, with 41% lower mean hospitalization costs; poorer cognition scores were also associated with fewer hospitalizations. The cost per admission for those with dementia was 33% greater, due to longer hospital stays (5.5 days versus 3.1 days for no dementia, P=0.05). People with dementia were most frequently hospitalized for fractures. These findings have policy implications for increasing investment in accurate and timely diagnosis of dementia and fall and fracture prevention strategies to further reduce associated hospitalization costs.

**Keywords**

Dementia, cognitive impairment, hospitalizations, costs, nursing homes

# Introduction

People living with dementia have significant healthcare needs which impact their healthcare utilization and associated costs ([Bynum et al., 2004](#_ENREF_9); [Phelan, Borson, Grothaus, Balch, & Larson, 2012](#_ENREF_28); [Prince, Comas-Herrera, Knapp, Guerchet, & Karagiannidou, 2016](#_ENREF_30)). The estimated worldwide cost of dementia US$818 billion in 2015, reaching two trillion by 2030([Wimo et al., 2017](#_ENREF_38)). In Australia the most recent per capita direct expenditure estimate was US$67,000 per year for individuals living in nursing homes([Gnanamanickam et al., 2018](#_ENREF_19)).

In high income countries, an estimated 34% of individuals living with dementia live permanently in nursing homes or residential care([Gnanamanickam, et al., 2018](#_ENREF_19)). Between 85-100% of all direct costs for people living with dementia in nursing homes are attributed to their cost of care; the remainder is health care utilization([Schaller, Mauskopf, Kriza, Wahlster, & Kolominsky-Rabas, 2015](#_ENREF_32)). The largest contributor to direct healthcare costs is hospitalizations ([Brown, Hansnata, & La, 2017](#_ENREF_7); [Gnanamanickam, et al., 2018](#_ENREF_19)). For people living with dementia in Australia, this is estimated to be AUD$4.8(US$3.7) billion and these figures are predicted to rise ([Brown, et al., 2017](#_ENREF_7)).

People living with dementia and those living in nursing homes are at a high risk of hospitalization ([Arendts and Howard, 2010](#_ENREF_3); [Gimm and Kitsantas, 2016](#_ENREF_18)). Hospitalization for those living with dementia is often associated with worse outcomes including increased length of stay, delayed discharge and functional decline during hospitalization ([Mukadam and Sampson, 2011](#_ENREF_27)), an increased risk of other complications including urinary tract infections, pressure ulcers, pneumonia and delirium ([Bail et al., 2015](#_ENREF_5)) and an increased risk of mortality ([Fong et al., 2012](#_ENREF_17)). A complete understanding of patterns of hospitalizations among this population with dementia or cognitive impairment living in nursing homes is valuable for policy and program development to optimize resource use, potentially reducing associated costs and improving health outcomes including quality of life. Previous work to address this gap in knowledge has mainly been conducted in North American populations and few studies have focussed on the nursing home population ([Burton et al., 2001](#_ENREF_8); [Daras, Feng, Wiener, & Kaganova, 2017](#_ENREF_11); [Fillenbaum, Heyman, Peterson, Pieper, & Weiman, 2001](#_ENREF_16); [Wiener, Feng, Coots, & Johnson, 2014](#_ENREF_37)).

In Australia, nursing home care is primarily funded by the Australian Government through subsidies to approved providers with means tested individual contributions ([Grove, 2016](#_ENREF_20)). Entry into nursing homes is upon a comprehensive assessment and approval for care by an Aged Care Assessment Team (ACAT), with universal coverage for care. Providers are funded to provide care by the government based on assessment of residents with the Aged Care Funding Instrument (ACFI). While individuals are free to choose their nursing home the ability to self-select is restricted by availability and unmet need in terms of demand and supply of spaces in nursing homes ([Access Economics, 2011](#_ENREF_1)). Similarly admitted hospital services are also primarily funded by the government through public hospitals and universally covered through Medicare with options to receive private care in private or public hospitals ([Biggs, 2013](#_ENREF_6)).

Within the context of predominantly publicly funded nursing home and hospitalization services, the aim of this analysis was to determine the association between dementia and cognitive impairment and hospitalizations and costs in a nursing homes population. We also present the most common diagnostic reasons for hospitalizations in this population.

# Materials and methods

## Study and participants

The current study is a secondary analysis of data from participants in the INSPIRED (INvestigating Services Provided In the Residential care Environment for Dementia) study, a cross-sectional study of people living in nursing homes in Australia ([Dyer et al., 2018](#_ENREF_15)). Participants were individuals permanently resident (for 12 months or longer) in 17 not-for-profit care facilities across 4 states in Australia at a single time point between January 2015 and February 2016. The majority (14 of 17) of the facilities provided specialized dementia care either as an entire facility or through a specialized unit.

The INSPIRED study collected a large range of data including cognitive status, quality of life, quality of care, functional status, activities of daily living, neuro-psychiatric symptoms, hospitalization, medical diagnosis etc. The burden on the individual participants was minimised by collecting data from the facility records and from proxy respondents and care givers as appropriate. In a total of 1323 potential participants, 903 were eligible to participate and 541 participated. Reasons for non-participation included busyness of participant/family member, lack of interest, family members not feeling qualified to respond on behalf of participant, and lack of return of consent form and questionnaire.

## Variables

The outcomes of interest were number of hospitalizations and associated costs. Hospitalizations were measured retrospectively as the number of hospital separations (including day separations) during the 12-month period immediately prior to the participant data collection.

Cost of hospitalizations was estimated based on the Australian Refined Diagnosis Related Groups (AR-DRGs), a clinical classification system developed and used in Australia to reflect clinical practice and hospital resource use ([Australian Consortium for Classification Development, 2016](#_ENREF_4)). Each hospital separation was assigned to a specific AR-DRG and costed using the 2013-14 (Round 18) cost weights produced by the National Hospital Cost Data Collection ([Independent Hospital Pricing Authority, 2016](#_ENREF_21)). All costs were reported in Australian dollars (AU$) after adjusting to 2016 prices using the implicit price deflator for the health sector ([AIHW, 2016](#_ENREF_2)).

The main covariates of interest were cognitive impairment and dementia. Cognitive impairment was measured using the Psychogeriatric Assessment Scales - Cognitive Impairment Scale (PAS-Cog)([Jorm et al., 1995](#_ENREF_22)). The PAS-Cog measures cognitive impairment on a scale from 0 to 21 with higher scores indicating severe cognitive impairment. Dementia was defined as having a diagnosis of dementia in the medical records or a PAS-Cog score of ≥5 indicating likely dementia (hereafter referred to as dementia). Formal diagnosis of dementia is low in this setting, so this approach also captures residents likely to have undiagnosed dementia and better represents the entire population with dementia in this setting ([Lang et al., 2017](#_ENREF_23)).

The relationships between dementia/cognitive impairment and hospitalizations and costs were adjusted for age, sex and comorbidities. Comorbidities were measured using the Cohen-Mansfield index, a count of number of diagnostic disease groups (excluding dementia) ([Cohen-Mansfield, Marx, Regier, & Dakheel-Ali, 2009](#_ENREF_10)).

## Analysis

Descriptive characteristics of the sample are presented as means or proportions. Proportions of individuals who had at least one hospitalization along with mean costs in the full sample and the sample who had at least one hospitalization are presented by cognitive function status.

The relationships between dementia or cognitive impairment and hospitalizations and hospitalization costs were examined using marginalized two-part models. These models estimate the effects of covariates on the overall marginal mean in highly skewed distributions while accounting for the probability of zero hospitalizations or costs ([Preisser, Das, Long, & Divaris, 2016](#_ENREF_29); [Smith, Preisser, Neelon, & Maciejewski, 2014](#_ENREF_33); [Teusner, Smith, Gnanamanickam, & Brennan, 2017](#_ENREF_35)). They provide the opportunity to determine the average effect of dementia/cognitive status on both the distributions represented by the hospitalization counts, namely the structural zeroes and the negative binomial counts. This approach was used in preference to Zero-inflated negative binomial (ZINB) regression models as the model fit was better (Akaike information criterion (AIC) smaller) than the traditional ZINB or other two-part models and required no post-processing computations.

Odds ratios were generated by logistic regression models (first part). Incidence rate ratios were calculated using a marginalized zero-inflated negative binomial (second part) regression. The ratio of mean costs was calculated using log normal regression models. Statistical significance was based on 95% confidence intervals and, or P-value <0.05.

Mean cost and length of hospital stay per hospitalization and a listing of the most common diagnostic reasons for the hospitalizations are presented as proportions of total hospitalizations. All statistical analyses were performed using SAS 9.4 (SAS Institute, Cary, NC, USA).

# Results

## Study participants

A total of 541 individuals with a mean age of 86 years participated in this study (Table 1). Approximately 75% were female. With respect to cognitive function, 84% had likely dementia, and almost half the sample had a PAS-Cog score ≥ 18 indicating severe cognitive impairment ([Jorm, et al., 1995](#_ENREF_22)). Mean number of comorbidities excluding dementia were 3.7. One participant did not provide valid consent to link hospital data and hence excluded from the analysis. Overall, the mean number of hospitalizations per participant was 0.5 with a mean cost of AUD $3156.

## Hospitalizations

Overall, 24% of the study participants (n=131) had at least one hospitalization during the 12-month study period (Table 2). A significantly lower proportion of those with dementia had a hospitalization (21%) compared to those without dementia (39%). A higher proportion of those with no or minimal cognitive impairment (PAS-Cog<4) had a hospitalization (37%) compared to those with severe cognitive impairment (PAS-Cog>15, 18%). The proportion of individuals who had a hospitalization did not differ significantly by age, sex, or current marital status (Not tabulated).

Participants with dementia had lower odds of hospitalization than those without (adjusted OR: 0.43, 95% CI 0.27, 0.71; Table 3). Those with worse cognitive impairment as indicated by the PAS-Cog score also had reduced odds of hospitalization (adjusted OR: 0.96, 95% CI 0.94, 0.99).

Participants with dementia had 57% fewer hospitalizations compared to those without dementia (adjusted incidence rate ratio: 0.43, 95% CI 0.27, 0.69) (Table 3). Similarly, for each unit increase in the PAS-Cog score (indicating worse cognitive function), participants had 5% fewer hospitalizations (adjusted incidence rate ratio: 0.95, 95% CI 0.93, 0.97).

The rate of hospitalizations among individuals with no dementia (91/100 person-years vs 54/100) and no or minimal cognitive impairment (92/100 person-years vs <65/100) was higher (Figure 1). The mean length of stay per hospitalizations for those with dementia, was higher (5.5 days dementia versus 3.1 without dementia (P=0.05); 4.3-7.9 cognitive impairment versus 3.4 (95% CI 2.4-4.4) no cognitive impairment; Figure 1). The mean length of stay though highest for individuals with mild cognitive impairment was not significantly higher compared to any of the other groups.

## Costs

The unadjusted mean of total hospitalization cost per individual was approximately $3200 in the total sample. Among those hospitalized at least once, the mean cost per individual was approximately $13100 (Table 2). As there were fewer hospitalizations for those with dementia, the costs of hospitalizations per resident on average over 12 months were higher for those without dementia ($4849, 95% CI 2748-6951 versus $2830, 95% CI 1976-3684 for those with dementia) and for those with no or minimal cognitive impairment ($4519, 95% CI 2585-6453 versus $2369, 95% CI 1439 - 3298 severe cognitive impairment) (Table 2). The mean costs per unit hospital admissions were significantly higher for those with dementia ($15,783 versus $10,478 without dementia, P=0.005; Figure 1), and moderate to severe cognitive impairment ($15,153 versus $10,018 no cognitive impairment).

Considering the overall costs incurred per participant, those with dementia had 41% lower mean costs compared to those without (adjusted ratio of mean costs: 0.59, 95%CI 0.36, 0.98; Table 3) due to the fewer hospitalizations in this group. Adjusted hospitalization costs, though 3% lower for each unit increase in PAS-Cog score (indicating worse cognitive function), were not statistically significantly lower per single unit change in score.

The most common primary reasons for hospitalizations in the dementia group were for musculoskeletal system and connective tissue disorders (19%, Figure 2). These were predominantly fractures (14%) with 9.1% of hospitalizations likely to be hip fractures (fractures of the femur). Among those without dementia, the most common reasons for hospitalization were digestive system disorders (17%). These were predominantly attention to artificial openings, accounting for 10% of hospitalizations.

# Discussion

In an Australian nursing home population, there were fewer hospitalizations in individuals with dementia. Consistent with this, there were lower hospitalizations for those with worse cognitive function. This study confirms previous findings that hospitalizations for those living with dementia are reduced, even in a country with universal healthcare coverage. In addition, for individuals with dementia the mean cost per hospitalization was more than 50% higher than for those without dementia. The higher costs per hospitalization were reflected in the longer length of hospital stay among individuals with dementia and cognitive impairment, specifically the group with mild cognitive impairment.

This study builds upon and strengthens previous findings in populations living in nursing homes or residential care. Two US studies have demonstrated lower rates of hospitalization for high care residents with dementia and residents with cognitive impairment in different care settings ([Burton, et al., 2001](#_ENREF_8); [Wiener, et al., 2014](#_ENREF_37)). A third study that examined hospital use across dementia severity found a lower probability of hospitalization amongst those with advanced dementia living in ‘institutions’ ([Fillenbaum, et al., 2001](#_ENREF_16)). This study also reported lower hospitalization costs for those with more severe dementia ([Fillenbaum, et al., 2001](#_ENREF_16)). Length of stay was similar between those with and without dementia in one study ([Burton, et al., 2001](#_ENREF_8)) but decreased with worsening stages of dementia in another ([Fillenbaum, et al., 2001](#_ENREF_16)). Our study confirms the previous findings with a definition of dementia that includes recent cognitive assessment, to capture individuals with likely dementia, to address the under diagnosis of dementia in this setting ([Dyer, Gnanamanickam, Liu, Whitehead, & Crotty, 2018](#_ENREF_14); [Lang, et al., 2017](#_ENREF_23)). Sensitivity analysis defining dementia only based on recorded diagnosis and defining dementia based on dementia diagnosis and or severe cognitive impairment (Pas-Cog ≥ 16) showed similar results (Supplementary Tables 1 and 2). The findings of this study also confirms previous reports of lower hospitalizations for people living with dementia in a non-US industrialized country with universal coverage for health care.

## Policy Implications

The reasons for the lower rate of hospitalizations in those with cognitive impairment or dementia are varied, all with significant policy implications. It is possible that those living in nursing homes have a different profile of non-cognitive conditions associated with an increased chance of hospitalization. Our analysis adjusts for the number of other comorbidities, but does not take into consideration the relative severity of different disease profiles nor their relative contribution to the likelihood of hospitalization. The primary diagnostic reasons for hospitalization for those with dementia is consistent with findings from previous studies i.e., the most frequent reasons for hospitalizations were fractures, including hip fracture, most likely due to falls and other dementia related conditions such as convulsions ([Toot, Devine, Akporobaro, & Orrell, 2013](#_ENREF_36)). Fractures are a major cause of morbidity and mortality in this population, thus implementing policies to reduce fractures in this population can both improve resident outcomes and further reduce costs ([Dyer et al., 2016](#_ENREF_13)). There has recently been a global call to action to improve care and management of fragility fractures and this is particularly relevant in this population ([Dreinhöfer et al., 2018](#_ENREF_12)).

A recorded diagnosis of dementia may result in better quality of care and primary healthcare leading to better management of symptoms and comorbidities, reducing the need for hospitalization. Furthermore, individuals with dementia may be prescribed less intense treatments and fewer interventions, which might reduce hospitalizations ([Liu et al., 2017](#_ENREF_24); [Rao, Suliman, Vuik, Aylin, & Darzi, 2016](#_ENREF_31)). Both of these can be achieved through adequate policy measures.

A number of the people living with dementia in this study resided in homes providing specialized dementia care. Well managed specialized care for people with dementia has the potential to provide savings in reduced hospitalizations ([McCormick et al., 2001](#_ENREF_26)).Those with dementia or worse cognition are also more likely to have advanced care directives which request reduced transfers to hospital ([Martin, Hayes, Gregorevic, & Lim, 2016](#_ENREF_25); [Street, Ottmann, Johnstone, Considine, & Livingston, 2015](#_ENREF_34)).

In Australia, potentially preventable hospitalizations (i.e. those that can be prevented with better primary care) defined by the AIHW include 22 chronic, acute or vaccine preventable conditions ([Australian Institute of Health and Welfare, 2016](#_ENREF_5). Overall in this study, the rate of potentially preventable hospitalizations was 7% ), below the national benchmark of 8.5% ([Gnanamanickam, et al., 2018](#_ENREF_19)). Local and national policies that provide funding to increase access to specialized dementia care units are required in order to benefit from the reduced hospitalizations and costs observed in this study.

Understanding the patterns of hospitalization can enable better planning for interventions and services by government and providers to reduce and better manage hospitalizations in nursing home populations. Residents living with dementia have lower hospitalization rates and hence lower costs on average, however costs per unit admissions are higher for those with impaired cognition, due to the longer duration of hospital stay in this group. As the predominant reasons for hospitalization in this population are fractures, this study provides support that investment in policies to reduce falls and fractures in this population can both improve resident outcomes and further reduce costs ([Dyer, et al., 2016](#_ENREF_13)).

## Strengths and Limitations

The study spans several Australian states enrolling a large proportion of individuals with dementia. Whilst these individuals include only a small proportion people living in nursing homes in Australia, it is the second largest study in terms of participating facilities in Australia and the sample is generally similar to the wider population of individuals living in nursing homes in Australia ([Gnanamanickam, et al., 2018](#_ENREF_19)). However, the study population is only representative of people living in facilities for 12 months or more and that are not under immediate palliative care. Thus, these data do not capture mortality or the costs associated with end-of-life care.

Our study included several organizations that have expertise in the care of residents with dementia. While other studies have examined the associations between cognitive function and hospitalizations, this study examined the independent association of both cognitive impairment and likely dementia in the same population. Likewise, we have examined both hospitalization rates and costs per individual and costs per hospitalization. While reporting hospitalizations provides an understanding of overall hospital service use, reporting of costs provides an understanding of the financial impact of hospital use in this population. Reporting costs per hospitalization has highlighted the inverse differences in the unit cost of care between the two groups.

The hospital utilization data in this study was obtained through linkage of individuals to administrative data. While these data have been used routinely to measure hospital use in health services research there may be under reporting due to less than 100% participation by private hospitals in the hospital data collections. As the study is cross-sectional the possibility that unmeasured factors could have a confounding effect on the observed associations remains.

This analysis has used marginalized two-part regression models to study adjusted relationships for both hospitalizations and their costs. These models accommodate highly skewed hospitalization and cost data thus giving a population level perspective of hospital use capturing both users and non-users of hospital services unlike previous studies. This is important for drawing policy conclusions on the entire population of individuals living long-term in nursing homes and enables the use of these rates and costs in healthcare expenditure modelling. However, these are not hierarchical models and hence the effects of facility level characteristics were not assessed.

**Conclusion**

This study demonstrates that in a country with a universal healthcare, there were fewer hospitalizations among those with worse cognitive function including those with likely undiagnosed dementia. However, the cost per hospitalization was higher. The most common reason for hospitalization for those with dementia was fractures. Given the high prevalence of people with dementia or cognitive impairment in nursing homes, interventions to reduce fractures in this population are warranted to further reduce the associated hospitalizations and costs.

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# Declaration of interest

The Authors declare that there is no conflict of interest.

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# Statement of Ethics

Human research ethics approval was obtained from the Flinders University Social and Behavioural ethics committee (references, 6594, 6732, 6753) and by federal and state custodians of hospital data: the Department of Veterans’ Affairs Human Research Ethics Committee (reference, E015/014), the SA Department for Health and Ageing Human Research Ethics Committee (reference, SSA/16/SAH/29), the Department of Health WA Human Research Ethics Committee (reference, 2015/59), the Queensland Department of Health (reference, RD006096), and the NSW Population and Health Services Research Ethics Committee (reference, HREC/15/CIHS/35). Self-consent by patients to participation was obtained when possible; for participants with more severe cognitive impairment, proxy consent for participation was provided (usually by a close family member).

# Author Contributions

ESG was responsible for the preparation of data, analysis of data and drafting of the manuscript, SMD contributed substantially to drafting of the manuscript, SLH and EL contributed to analysis and drafting of the manuscript, CW was responsible for intellectual input to the manuscript and MC is the lead investigator of the INSPIRED Study and contributed to the design of the study and was also responsible for intellectual input of the manuscript. All authors read, edited and approved the final manuscript.

# References

Access Economics. (2011). *Caring places: planning for aged care and dementia 2010-2050*: Access Economics.

AIHW. (2016). *Health Expenditure Australia 2014-15*. AIHW.

Arendts, G., & Howard, K. (2010). The interface between residential aged care and the emergency department: a systematic review. *J Age Ageing, 39*(3), pp. 306-312. Retrieved from <https://academic.oup.com/ageing/article/39/3/306/40673>

Australian Consortium for Classification Development. (2016). AR-DRG. Retrieved Date Accessed, 2017 from <https://www.accd.net.au/ArDrg.aspx>.

Bail, K., Goss, J., Draper, B., Berry, H., Karmel, R., & Gibson, D. (2015). The cost of hospital-acquired complications for older people with and without dementia; a retrospective cohort study. [journal article]. *BMC Health Services Research, 15*(1), p 91. doi:10.1186/s12913-015-0743-1 Retrieved from <http://dx.doi.org/10.1186/s12913-015-0743-1>

Biggs, A. (2013). *Health in Australia: a quick guide*: Parliamentary Library.

Brown, L., Hansnata, E., & La, H. (2017). Economic cost of dementia in Australia 2016-2056. *Alzheimer’s Australia. Canberra: Institute for Governance and Policy Analysis, University of Canberra*

Burton, L. C., German, P. S., Gruber‐Baldini, A. L., Hebel, J. R., Zimmerman, S., Magaziner, J., & Society, E. o. D. i. N. H. R. G. J. J. o. t. A. G. (2001). Medical care for nursing home residents: differences by dementia status. *49*(2), pp. 142-147.

Bynum, J. P. W., Rabins, P. V., Weller, W., Niefeld, M., Anderson, G. F., & Wu, A. W. (2004). The Relationship Between a Dementia Diagnosis, Chronic Illness, Medicare Expenditures, and Hospital Use. *Journal of the American Geriatrics Society, 52*(2), pp. 187-194. doi:10.1111/j.1532-5415.2004.52054.x Retrieved from <http://dx.doi.org/10.1111/j.1532-5415.2004.52054.x>

Cohen-Mansfield, J., Marx, M. S., Regier, N. G., & Dakheel-Ali, M. (2009). The impact of personal characteristics on engagement in nursing home residents with dementia. *Int J Geriatr Psychiatry, 24*(7), pp. 755-763. doi:10.1002/gps.2192 Retrieved from <https://www.ncbi.nlm.nih.gov/pubmed/19156701>

Daras, L. C., Feng, Z., Wiener, J. M., & Kaganova, Y. (2017). Medicare Expenditures Associated With Hospital and Emergency Department Use Among Beneficiaries With Dementia. *INQUIRY: The Journal of Health Care Organization, Provision, and Financing, 54*, p 0046958017696757. doi:10.1177/0046958017696757 Retrieved from <https://journals.sagepub.com/doi/abs/10.1177/0046958017696757>

Dreinhöfer, K. E., Mitchell, P., Bégué, T., Cooper, C., Costa, M., Falaschi, P., . . . Nana, A. (2018). A global call to action to improve the care of people with fragility fractures. *Injury, 49*(8), pp. 1393-1397.

Dyer, S. M., Crotty, M., Fairhall, N., Magaziner, J., Beaupre, L. A., Cameron, I. D., & Sherrington, C. (2016). A critical review of the long-term disability outcomes following hip fracture. *J BMC geriatrics, 16*(1), p 158.

Dyer, S. M., Gnanamanickam, E. S., Liu, E., Whitehead, C., & Crotty, M. (2018). Diagnosis of dementia in residential aged care settings in Australia: An opportunity for improvements in quality of care? *Australasian journal on ageing*doi:10.1111/ajag.12580 Retrieved from <http://europepmc.org/abstract/MED/30188008>

<https://doi.org/10.1111/ajag.12580>

Dyer, S. M., Liu, E., Gnanamanickam, E. S., Milte, R., Easton, T., Harrison, S. L., . . . Crotty, M. (2018). Clustered domestic residential aged care in Australia: fewer hospitalisations and better quality of life. [Research]. *Med J Aust, 208*(10), pp. 1-8. doi:10.5694/mja17.00861

Fillenbaum, G., Heyman, A., Peterson, B., Pieper, C., & Weiman, A. J. N. (2001). Use and cost of hospitalization of patients with AD by stage and living arrangement CERAD XXI. *56*(2), pp. 201-206. Retrieved from <http://n.neurology.org/content/56/2/201.long>

Fong, T. G., Jones, R. N., Marcantonio, E. R., Tommet, D., Gross, A. L., Habtemariam, D., . . . Inouye, S. K. (2012). Adverse Outcomes After Hospitalization and Delirium in Persons With Alzheimer Disease. *Annals of internal medicine, 156*(12), pp. 848-W296. doi:10.7326/0003-4819-156-12-201206190-00005 Retrieved from <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3556489/>

Gimm, G. W., & Kitsantas, P. (2016). Falls, depression, and other hospitalization risk factors for adults in residential care facilities. *Int J Aging Hum Dev, 83*(1), pp. 44-62.

Gnanamanickam, E. S., Dyer, S. M., Milte, R., Harrison, S. L., Liu, E., Easton, T., . . . Crotty, M. (2018). Direct health and residential care costs of people living with dementia in Australian residential aged care. *International Journal of Geriatric Psychiatry, 0*(0)doi:doi:10.1002/gps.4842 Retrieved from <https://onlinelibrary.wiley.com/doi/abs/10.1002/gps.4842>

Grove, A. (2016). Aged Care: a quick guide: Parliamentary Library, Parliament of Australia. Available at: www. aph. gov ….

Independent Hospital Pricing Authority. (2016). *Australian public hospitals cost report 2013-14 Round 18*. <https://www.ihpa.gov.au/publications/australian-public-hospitals-cost-report-2013-2014-round-18>

Jorm, A. F., Mackinnon, A. J., Henderson, A. S., Scott, R., Christensen, H., Korten, A. E., . . . Mulligan, R. (1995). The Psychogeriatric Assessment Scales: a multidimensional alternative to categorical diagnoses of dementia and depression in the elderly. *Psychological Medicine, 25*(03), p 447. doi:10.1017/s0033291700033377

Lang, L., Clifford, A., Wei, L., Zhang, D., Leung, D., Augustine, G., . . . Chen, R. (2017). Prevalence and determinants of undetected dementia in the community: a systematic literature review and a meta-analysis. *BMJ Open, 7*(2), p e011146. doi:10.1136/bmjopen-2016-011146 Retrieved from <https://www.ncbi.nlm.nih.gov/pubmed/28159845>

Liu, E., Dyer, S. M., O'Donnell, L. K., Milte, R., Bradley, C. E., Harrison, S. L., . . . Crotty, M. (2017). Association of cardiovascular system medications with cognitive function and dementia in older adults living in nursing homes in Australia. *Journal of geriatric cardiology: JGC, 14*(6), p 407.

Martin, R. S., Hayes, B., Gregorevic, K., & Lim, W. K. (2016). The Effects of Advance Care Planning Interventions on Nursing Home Residents: A Systematic Review. *Journal of the American Medical Directors Association, 17*(4), pp. 284-293. doi:<https://doi.org/10.1016/j.jamda.2015.12.017> Retrieved from <http://www.sciencedirect.com/science/article/pii/S1525861015007768>

McCormick, W. C., Hardy, J., Kukull, W. A., Bowen, J. D., Teri, L., Zitzer, S., & Larson, E. B. (2001). Healthcare Utilization and Costs in Managed Care Patients with Alzheimer's Disease During the Last Few Years of Life. *Journal of the American Geriatrics Society, 49*(9), pp. 1156-1160. doi:10.1046/j.1532-5415.2001.49231.x Retrieved from <http://dx.doi.org/10.1046/j.1532-5415.2001.49231.x>

Mukadam, N., & Sampson, E. L. (2011). A systematic review of the prevalence, associations and outcomes of dementia in older general hospital inpatients. *International Psychogeriatrics, 23*(3), pp. 344-355.

Phelan, E. A., Borson, S., Grothaus, L., Balch, S., & Larson, E. B. (2012). Association of incident dementia with hospitalizations. *JAMA, 307*(2), pp. 165-172. doi:10.1001/jama.2011.1964 Retrieved from <http://jama.jamanetwork.com/pdfaccess.ashx?url=/data/journals/jama/22485/joc15155_165_172.pdf>

Preisser, J. S., Das, K., Long, D. L., & Divaris, K. (2016). Marginalized zero‐inflated negative binomial regression with application to dental caries. *Statistics in medicine, 35*(10), pp. 1722-1735. Retrieved from <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4826785/pdf/nihms-736488.pdf>

Prince, M., Comas-Herrera, A., Knapp, M., Guerchet, M., & Karagiannidou, M. (2016). World Alzheimer report 2016: improving healthcare for people living with dementia: coverage, quality and costs now and in the future.

Rao, A., Suliman, A., Vuik, S., Aylin, P., & Darzi, A. (2016). Outcomes of dementia: Systematic review and meta-analysis of hospital administrative database studies. *Archives of Gerontology and Geriatrics, 66*, pp. 198-204. doi:<http://dx.doi.org/10.1016/j.archger.2016.06.008> Retrieved from <http://www.sciencedirect.com/science/article/pii/S0167494316301091>

Schaller, S., Mauskopf, J., Kriza, C., Wahlster, P., & Kolominsky-Rabas, P. L. (2015). The main cost drivers in dementia: a systematic review. *International Journal of Geriatric Psychiatry, 30*(2), pp. 111-129. doi:10.1002/gps.4198 Retrieved from <http://dx.doi.org/10.1002/gps.4198>

Smith, V. A., Preisser, J. S., Neelon, B., & Maciejewski, M. L. (2014). A marginalized two-part model for semicontinuous data. *Statistics in medicine, 33*(28), pp. 4891-4903. doi:10.1002/sim.6263 Retrieved from <http://dx.doi.org/10.1002/sim.6263>

Street, M., Ottmann, G., Johnstone, M.-J., Considine, J., & Livingston, P. M. (2015). Advance care planning for older people in Australia presenting to the emergency department from the community or residential aged care facilities. *23*(5), pp. 513-522. doi:doi:10.1111/hsc.12162 Retrieved from <https://onlinelibrary.wiley.com/doi/abs/10.1111/hsc.12162>

Teusner, D., Smith, V., Gnanamanickam, E., & Brennan, D. (2017). Examining dental expenditure and dental insurance accounting for probability of incurring expenses. *Community Dentistry and Oral Epidemiology, 45*(2), pp. 101-111. doi:10.1111/cdoe.12264 Retrieved from <http://dx.doi.org/10.1111/cdoe.12264>

Toot, S., Devine, M., Akporobaro, A., & Orrell, M. (2013). Causes of hospital admission for people with dementia: a systematic review and meta-analysis. *Journal of the American Medical Directors Association, 14*(7), pp. 463-470.

Wiener, J. M., Feng, Z., Coots, L. A., & Johnson, R. (2014). *What is the effect of dementia on hospitalization and emergency department use in residential care facilities*.

Wimo, A., Guerchet, M., Ali, G.-C., Wu, Y.-T., Prina, A. M., Winblad, B., . . . Prince, M. (2017). The worldwide costs of dementia 2015 and comparisons with 2010. *Alzheimer's & Dementia, 13*(1), pp. 1-7. doi:<https://doi.org/10.1016/j.jalz.2016.07.150> Retrieved from <http://www.sciencedirect.com/science/article/pii/S1552526016300437>